3 Training and Education in Robotic Surgery: Recommendations of ERUS (EAU Robotic Urology Section)

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Introduction

The classic and well recognized Halstedian apprenticeship of "view one- do one- teach one" has come to its end in the surgical field. Nowadays learning curves in humans are unacceptable, not only due to ethical reasons and patient safety, but also because of the modern tools for surgical training that are available. Surgical simulators are a great example.

For 30 years, robots have been helping surgeons in their practice. Since then, we have performed a huge number of robot-assisted surgeries, most of them, thanks to the introduction of today's most commercialized surgical robot, the Da Vinci by Intuitive Surgical (Sun Valley, CA, USA) [1].

Compared to other surgeries, urological surgery and in particular pelvic surgery is very complex because of the deep, narrow and small operating field. Since the early 2000s robot-assisted radical prostatectomy (RARP) has been rapidly adopted in many hospitals of developed countries as the first choice surgical treatment for prostate cancer. Published data suggests that long-term oncological outcomes of RARP are comparable to those of open prostatectomy (OP) with a huge advantage of surgical outcomes such as estimated blood loss, complication rate, catheterization time and hospitalization. Furthermore, other surgical techniques such as robot-assisted partial nephrectomy (RAPN) and robot-assisted radical cystectomy (RARC) are also becoming very attractive for the robotic approach [2, 3].

With the fast development of technology and large demand for minimally invasive surgery, in particular robotic surgery, the question of how to train urologists arise. Many efforts have been made all around the world to create a standard and trustworthy curriculum able to provide the necessary education and skill acquisition, in order to allow a safe and efficient management

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of patients with prostate cancer. However, to this date none of such programs has been universally recognized and adopted.

Virtual Simulation in Urology

Originally developed for gaming, virtual reality is now spreading in other fields. Thanks to the huge technological improvements of the last years, a wide array of surgical simulators based on virtual reality are available, finding their application in most of the surgical fields and in particular in urology. Many of them are designed for basic skill acquisition as for example needle driving, peg transferring, circle cutting, while others are designed for specific tasks acquisition as the transurethral resection, cystoscopy, ureterorenoscopy and renal percutaneous puncture models [4–6].

The introduction of virtual reality let us to acquire basic skills that are essential before starting dry and wet lab training. The newest simulators are able to recreate an entire surgical procedure as for example a RARP. It has been stated that virtual simulators improve surgical outcomes in a risk-free environment [7, 8]. Various virtual reality simulators with very different features are available on the market. Apart from the well known Da Vinci Skills Simulator (dV-SS), other companies such as Mimic Technologies (dV-Trainer), 3-D systems (Robotix Mentor™) and Simulated Surgical Systems LLC (New RoSS II) offers different options for this purpose [1, 9] (Fig. 3.1).

The latest *Robotix Mentor*™ (3-D Systems Beit, Golan, Israel) is a simulator that integrates basic tasks and also full clinical procedures simulation. The RoSS II (Simulated Surgical Systems LLC, San Jose, CA) features a portable, stand-alone console able to provide in-vivo virtual operative steps with different levels of complexity. The Mimic—da Vinci Trainer (Mimic Technologies Inc., Seattle, WA) powers the exercises that permits to create, import and export customized training protocols for different specialties.

Simulators should fulfill both, objective and subjective requirements. The subjective aspects generally consist of *face* and *content* validity. *Face* refers to the similarity and accuracy of the model to the real surgical procedure. *Content* refers to the usefulness of the performed tasks in a clinical scenario. The objective evaluation stipulate if the task is able to assess the participants' levels of expertise (*construct validity*), if the test scores reflects the performance in a real procedure (*concurrent validity*), and if it can foretell the operating room performance (*predictive validity*) [10, 11].

The Perspective in Creating a Universal Curriculum

In centers with an ongoing robotic program, heterogeneous scenarios are seen around the world. Ranging from modern and technologically-advanced robotic training centers to institutions with limited amount of resources or training spaces. A well known problem is the limited access and time-of-use of simulators due to the priority given to other daily surgical activities. The importance of scheduling a specific planned period at a certified training center before starting a robotic program is often underestimated. Nonetheless, available resources should be maximized in order to guarantee surgeons to start safely and effectively the robotic procedures [11–13].

The huge heterogeneity between the different available training programs is a major problem. In fact there are huge differences in terms of duration, structure and tasks used for training. Some courses are delivered in very short periods, as for example one weekend courses, providing to the trainee only basic information. Meanwhile other courses lasts longer and are structured in different modules in order to allow the trainee to acquire all the information and skills that are essential before starting with real cases [12, 14–16].

For the creation of a robotic program many aspects should be considered. Ahmed [17] proposed to summarize them as the 5 "**P**′s"*:* "***Place***" which is a physical space equipped with a wide range of tools and resources with the possibility to be shared by a network of hospitals or academic institutions. ***People*** referring to human resources

Fig. 3.1 Current simulation consoles. (**a**) Da-Vinci Skill Simulator (*Upper left*). (**b**) Ross II (*Upper right*). (**c**) Mimic (*lower left*). (**d**) Robotix mentor (*lower right*)

starting with motivated trainees to a director who would ideally be an established urologist holding an extensive academic background and leadership. **P**ounds, the economical aspect, in fact training centers are usually expensive facilities and searching for sponsors or allies will be fundamental. ***P**rograms and **P**roducts* is the elaboration of a curriculum along with faculty and other clinical experts to set the specific end-points. ***P**ositioning,* acknowledging the importance of the program among the clinical, academic and hospital authorities is essential. The training sessions into resident's daily activities must be granted.

It must be made clear for all that investment in training hours and simulation facilities will translate in future savings by reducing complications, decreasing operating hours and increasing efficiency.

Curricula

Implementing a program with pre-defined tasks, and its repetition through time will benefit participants in acquiring skills and reducing time to perform them. Although very different in most of the structure, today's robotic programs share a common origin; some of them have emerged from Fundamental of Laparoscopic Surgery (FLS) [18] curriculum as its predecessor. The Fundamentals in Robotic Surgery (FRS) [19] is an example of multi-specialty, technical skills competency base curriculum divided in four different modules: introduction to surgical robotic systems, didactic instructions for robotic surgical systems, psychomotor skills curriculum and team training and finally communication skills. The Fundamental skills of robotic surgery (FSRS) [20] is a curriculum developed and based on the RoSS virtual reality simulator (Simulated Surgical Systems LLC, San Jose, CA) where three different tasks are performed and has showed significant improvement in robotic skills. The BSTC (Basic Skills Training Curriculum) [21] is a 4-week simulation program including an introductive part, a self-directed online modules, a da-Vinci skills Simulator (dVSS) sessions and a console hands-on trainings with the aim to provide a better acquisition of basic robotic surgical skills [22–25].

The surgical background of the trainee is also an important aspect when choosing the different types of exercises. For this reason, the trainer must take always under consideration the baseline expertise level of the trainee, understanding that in the case of an unexperienced surgeon, basic exercises will be sufficient. The proposed initial tasks can include: peg transfer, suturing and knot, pattern cutting, running suture and dome with four towers for ambidexterity. Then the participants can be introduced to the dry and wet lab training with unanimated and animated models and finally progress to clinical modular training with specific procedures of increasing complexity performed under supervision. Prior to perform a specific procedure, either in laboratory or in vivo may be useful to show a video or some photos with step by step explanations of the surgical technique to grant the trainee a valid reference. The bedside assistance experience improves even more the knowledge of the trainee that is approaching to the console modular training (Figs. 3.2 and 3.3).

To accomplish the goal of performing a robotic surgery the trainees could have two different types of mentors either a proctor or a preceptor. Proctor refers to an observer responsible for overseeing and assessing the skills and knowledge of the surgical trainees. The proctor also cares for safety and effectiveness of the procedure providing advices and guidance throughout the surgery but he has no active role during the performance of the procedure. On the other hand, the preceptor is an experienced surgeon that "scrubs" and supervises the surgery. He is the primary responsible for the well-being of the patient and must take over the procedure when the situation requires it [2, 9, 11, 13].

Fig. 3.2 Dry lab for urethral anastomosis

Dual console can be used in two different collaborative modes, either in swap nor in nudge mode. The "swap" mode allows two surgeons to simultaneously operate and actively swap control of the robot's four arms, and the "nudge" mode allows them to share control of two of the robot's arms. "*Telementoring*" represents an attractive option especially where limited human and

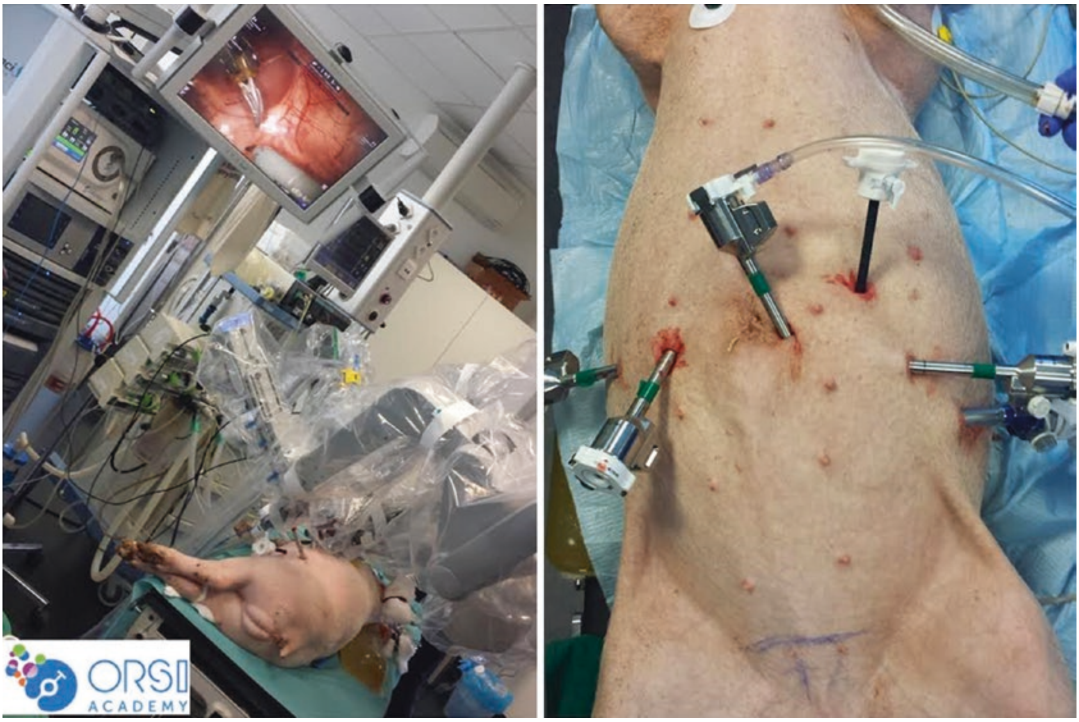

Fig. 3.3 Wet lab with animated model (pig)

Fig. 3.4 Dual Console for mentoring

economical resources exist. It can easily bring the surgeon and the proctor together. Recently new interphases are being created in order to allowed telementoring in a safe and effective manner [9, 11, 13, 26] (Fig. 3.4).

Evaluation

Continuous assessment of participants' performance and their improvement during the course is a fundamental step in any program. The surgeon needs to have continuous feedback, to be encouraged for keeping with the good practices and modifying the conducts that do not generate satisfactory results.

A comprehensive evaluation approach can be reached dividing the examination into preoperative, intraoperative and postoperative aspects [23, 27].

Preoperative issues should teach common features of the robotic device *per se* like getting familiarized with equipment (basically the da-Vinci robotic system). This can be supplemented with didactic lectures, online tutorials and functional aspects such as setting up the equipment and other activities before starting with console surgery [27].

The intraoperative section will focus on critical psychomotor skills, ideally performed in a 3D nature, with defined objectives similar to real-life tasks. Finally learning how to shut down the robot and to undock it will be considered the postoperative assessment [27].

Scores of the virtual reality tasks allows an objective technical evaluation of the participants and the measurement quantification of the improvement that the trainee has obtain since from the beginning till the end of the course [4–6].

For the practical evaluation, Alvin et al. have developed a standardized assessment tool for robotic surgical skills, the Global Evaluative Assessment of Robotic Skills (GEARS), which has been validated and adopted in many centers. It is based on a 5 point anchored Likert scale across six different domains that include; depth perception, bimanual dexterity, efficiency, force sensitivity, autonomy and robotic control. This score was validated during prostatectomies demonstrating it is an optimal tool for measurement of progress and giving objective feedback [18].

Finally we cannot miss the importance of non-technical skills which have been related to patient safety and clinical effectiveness. The Non-Technical Skills for Surgeons (NOTSS) represent an effective tool to evaluate four different aspects; situation awareness, decision-making, communication and teamwork and leadership of the surgeon in the operating room [28, 29].

Is It Useful to Go Through Laparoscopic Training Before Robots?

For some aspects, evidence has shown that previous laparoscopic training is beneficial for surgeons starting a robotic curriculum because some steps are common for both techniques. This includes activities such as the trocar placement and bedside assistance with the responsibility of retracting, suctioning, grasping and the introduction of sutures or any other surgical supply. A previous laparoscopic background could be also beneficial for example in patients with previous surgeries where the laparoscopic adherensiolysis is needed in order to complete the robotic port placement.

Meanwhile, others underestimate the usefulness of a laparoscopic skills, thinking that is feasible to start directly with robotics without the need of a previous laparoscopic background. Some experts consider robotics a completely independent technique with unique features like 3-D view, seven degrees of motion, elimination of tremor and articulating instruments [9].

Certification and Credentialing

A lot of robotic training programs are available all around the world in several training centers and hospitals. Some hospitals require from their consultants to complete one of them in order to be allowed to start a robotic program. Most of these courses are proposed by the robot manufacturers and not by institutions with academic recognition.

Not all the hospitals require the completion of a well-structured and complete program including advanced tasks and also a procedure specific modular training [24, 30–33].

It is a fact that surgeons should be continuously evaluated to ensure their clinical competency by certification and re-certification processes. Credentialing is one of the nodular themes, but today there are plenty of unanswered questions: Who should be the corresponding authority to certify the correct acquisition of the skills and its correct implementation during clinical practice? What would be the selection criteria for a certified training center? Which are the criteria to define a high volume center?

So far there is no universal agreement to define the requirements to become a high volume center and the number of procedures to be performed by a surgeon in order to complete his learning curve in RARP or other procedures. What we can assume is that experienced surgeons have decreased odds of complications and shorten the hospital stay [34].

In 2007, Valvo and colleagues proposed a policy for performing RARP and suggested to evaluate each candidate according to his surgical background in terms of hours of robotic training, clinical experience, and also a minimum caseload suggested in order to obtain certification as a robotic surgeon. The policy contemplates the need of re-assessment if the surgeon interrupts his robotic practice for a periods longer than 6 months [35].

In summary there is a desperate need for an universal accreditation scheme to be developed by experts because of the extreme variability and inconsistency between the currently available programs. An academic driven more than an industry-driven governing body should be created in order to guarantee the quality of care during robotic procedures [12, 36, 37].

ERUS Program

ERUS-curriculum was developed by a panel of international experts. The program was validated by a pilot validation study, that included 12 surgeons and consisted of a 12-weeks length training course. It started with an online theoretical training module, followed by simulation, live case observation and a mixed setting of virtual reality simulation, also with dry and wet lab training. It included also active participation as a table assistant and sitting in the dual console while surgeries were performed. During the training participants' technical and non-technical skills were periodically evaluated by their mentors using the GEARS and NOTSS scales respectively. At the end, in order to get the certification, a complete procedure record underwent blind revision by a committee of expert surgeons. In the initial study up to 80% of the participants were able to perform a RARP independently at the end of the course. For this reason and in order to achieve the objectives in all participants, it was suggested to extend the length of program to 6 month [38].

The ERUS-curriculum is targeted for surgeons with all grade robotic experience and is conceived as a progressive and exhaustive training program. Its modular nature demands the trainee to complete a specific task in other to continue to the next more demanding step following a predetermined plan (Fig. 3.5) [38].

The curriculum starts with an **e-learning theoretical course** which is an online course that participants can complete independently at home.

The core of the course is the 5-day intensive **advanced robotic skills program** consisting of a **theoretical training course**, one day of **live case observation** and an intensive lab training.

The theoretical training course aims to provide the fundamental knowledge of robotic surgery. The main topics are the components and main features of the robotic system, principles of endoscopic surgery, surgical anatomy and an overall view of the main procedures. A multiple-choice examination is performed at the end of each chapter of the e-course to verify if the participant got the most important points.

Live case observation represent an essential step to better understand the relation between the

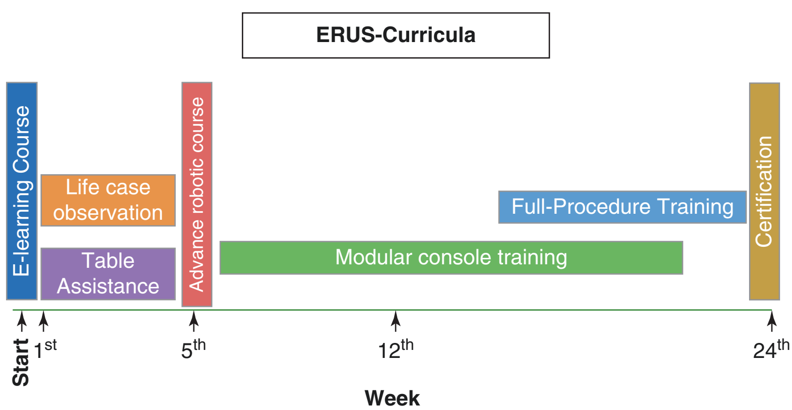

Fig. 3.5 ERUS curricula for RARP

Fig. 3.6 3-D Live case observation

theoretical and clinical aspects. It also enables to share opinions and opens the opportunity to debate with mentors and experts about clinical decisions. Dual console feature is important to allow the trainee to have the same 3D vision as the surgeon (Fig. 3.6).

During the **intensive lab training** various training methods are used from virtual reality simulation to wet lab and training on cadaveric models. During the first day an introductive course is given by a specialized technician who explains all the main features of the robotic system in order to familiarize the trainees with the equipment. Situations designed to face troubleshooting are also included. The program continues with the hands-on training, that permits to acquire directly on the field the features of the console like 3-D vision and the wristed instruments.

Virtual reality simulation is used for specific tasks to improve aspects like moving the camera and clutching, manipulating the endowrist, energy use for dissection and needle driving.

The dry lab section includes practice in synthetic models and animals models. Tasks such as peg transfer, vertical and horizontal suturing are performed under mentor's supervision. An anastomosis model using the Venezuelan chicken accurately simulate the human's vesicourethral anastomosis. Wet lab models as dogs or pigs are very useful for training because they provide a realistic setting for complex exercises despite the higher costs compared to other models [38] (Fig. 3.7).

For **non-technical skills**, the ERUS program incorporates cognitive skills training with decision-making and awareness exercises. It also encourages social skills encouraging communication, team working and leadership abilities development. The participants are continuously evaluated using the NOTSS (non-technical skills for surgeons) scoring system.

During the **modular training** the participant starts to perform surgical steps on the patient following a precise sequence. Only when he is able to perform the easiest steps safely and effectively he can progressively move to a more complex step.

The ERUS curriculum proposed an increasing complexity approach and considers a series of individual steps for RARP:

1. Bladder detachment
2. Endopelvic fascia incision
3. Bladder neck incision
4. Dissection of the vasa and seminal vesicles
5. Posterior prostatic release
6. Anterolateral release of the neurovascular bundles
7. Preparation and section of prostatic pedicle
8. Ligation of dorsal vein complex
9. Apical dissection
10. Urethrovescical anastomosis.

When the trainees are able to safely perform all the steps, they can proceed to perform the entire surgical procedure. The complete surgical procedure will be recorded and sum-

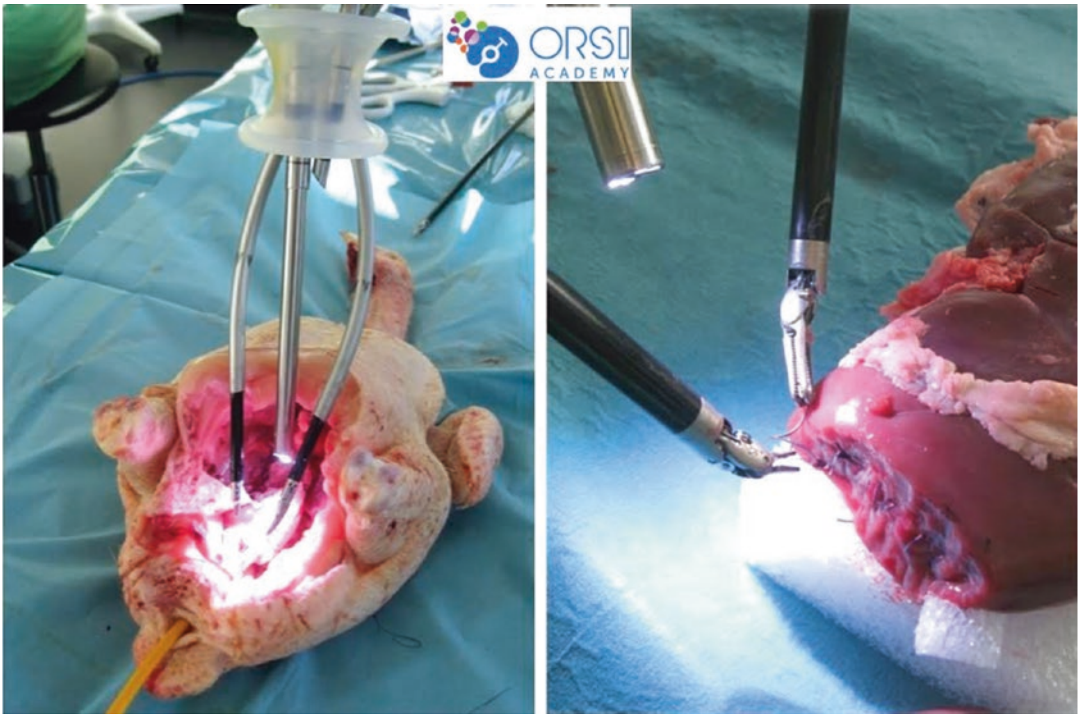

Fig. 3.7 Training models. Anastomotic model in Venezuelan Chicken (*left*) Kidney model for robot assisted- partial nephrectomy (RAPN), (*right*)

mited to a committee of experts for its blind evaluation.

Conclusion

The robotic era has brought outstanding changes in the surgical field. Advantages of investing in training facilities are nor seen just by patients and surgeons, but also by the institutions.

As a minimally invasive technique that has demonstrated comparable outcomes to open surgery, robotic surgery represents the preferred approach in many high volume centers. However some aspects are still pending concerning training uniformity, regulations and certification.

In order to have urologists with the same baseline knowledge and skills in clinical practice, it is essential to prioritize the implementation of universally validated curriculum. The ERUS-curriculum offers an attractive option that clearly covers each mandatory aspect of an ideal curriculum. It has an academic and pedagogical approach and its modular nature allows flexibility with increasing complexity of tasks that are encountered through the course.

In addition, the ERUS curriculum offers a well-structured platform for urologists in training, and can be considered as a standard. Its assessment process allows an objective comparison of candidates and identifies weak areas that need improvement.

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