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9 Robotic Urologic Surgery: How to Make an Effective Robotic Program—A European Perspective

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Abstract

Over the last decade the introduction of novel technologies substantially changed our approach to patients with urologic pathologies. Worldwide the number of robotic procedures performed per year is rapidly increasing. In current literature the relevance of robotic surgical training is progressively increasing although it is not easy to define and validate standardized paths for surgeons that are approaching for the first time to robotic surgery. In this context, the European Association of Urology Robotic Urology Section (ERUS) made several efforts in order to develop and validate an educational program for surgeons starting their robotic career.

Keywords

Robotic surgery · Robotic curriculum · Training · Robot-assisted radical prostatectomy

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Introduction

The continuous and incessant implementation of technological updates revolutionized the practice in the field of most medical and surgical specialties. In particular, the introduction of novel technologies substantially changed our approach to patients with urologic pathologies over the last decade, where profound changes in the management of individuals with prostate, kidney, and bladder diseases were observed. For example, when considering the case of prostate cancer, available data suggest that robot-assisted radical prostatectomy (RARP) is able to provide substantial benefits in terms of perioperative outcomes as compared to open radical prostatectomy (ORP) without compromising oncologic control [1–3]. Moreover, retrospective analyses demonstrated that RARP might be associated with significant benefits in terms of perioperative results and functional outcomes such as continence preservation and potency recovery compared to the open and

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laparoscopic approaches [4–7]. As a consequence, the majority (80%) of radical prostatectomies are currently performed robotically in United States alone [8]. Similarly, the number of robotic procedures performed per year is rapidly increasing also in Europe. On the other hand, it should be highlighted that these benefits are evident in particular in the hands of experienced surgeons in high-volume centers. This is mainly related to the "learning curve" phenomenon typical of the introduction of a novel technology, which might still limit the benefits associated with the use of minimally invasive techniques such as robotic surgery on a large scale. Thomson and colleagues demonstrated that, also for a highly experienced surgeon, RARP has a relatively long "learning curve" period. In particular, the authors were able to demonstrate that the outcomes of the minimally invasive approach in the first cases were worse as compared to what observed in patients treated with open surgery by the same high-volume surgeon. However, the results of RARP improved progressively and surpassed the ones of ORP in terms of quality of life and positive surgical margins after a certain number of procedures [9]. This applies also to other procedures, where a higher number of cases done by a single surgeon or by an institution might be associated with improved results in patients treated with robot-assisted surgery. Various training methods aiming at reducing the learning curve phase and, therefore, at improving surgical outcomes in a rapid fashion have been developed in different countries and healthcare systems [10–14]. Nonetheless, it is not easy to define and validate standardized paths for surgeons that are approaching for the first time to robotic surgery, where the lack of long-term results and validation studies often precluded the diffusion of these initiatives [15].

In this context, the European Association of Urology Robotic Urology Section (ERUS) made several efforts in order to develop and validate an educational program for surgeons starting their robotic career. This resulted into the implementation of a novel educational program dedicated to urologists at the beginning of their career with robotic surgery that includes a basic training, a 6-month fellowship period, and a final evaluation done by experts. Of note, this represents nowadays the only validated training for robotic surgeons. This chapter will review the basic principles of the establishment of a robotic training program and will describe the strengths of the ERUS robotic curriculum for RARP.

The Importance of a Robotic Program

To start with a successful and self-sustaining robotic program, a well-structured plan is required. First, an accurate market analysis that should include the estimated surgical volume and competing entities equipped with robots in the surrounding area is mandatory to understand if a single institution can support and maintain a robotic program. For example, it has been demonstrated that, in order to be cost-effective, a single hospital should perform approximately more than 300 cases per year [16]. Subsequently the planning of a proper robotic team with multiple members with specific roles is required to familiarize with the technology itself. This could be conducted trough a multidisciplinary panel including members of different groups (e.g., hospital administrators, anesthesiologists, nurse coordinators, and obviously surgeons). A well-trained surgeon able to perform the procedure and keep the robotic program afloat is mandatory otherwise an expert surgeon should be enrolled to ensure the safe introduction of this technology.

The next step should be focused on maintenance and growth initiatives to maximize the benefits of the robotic program. For example, it is very important to prospectively collect data in order to track the outcomes and to implement measures aimed at further improving your own results. Indeed, continuous monitoring of the results of the procedures performed, interaction with colleagues, and a regular update with new technologies are essential measures to maintain and ameliorating the quality of care at your own institution. Finally, recent studies have shown that patients' interest in robotic surgery is rapidly growing [17]. For this reason, the impact of a robotic program at your institution could be improved with initiatives aimed at improving patient awareness regarding the potential benefits associated with the robotic technology in different settings.

Training: Worldwide Situation

Nowadays, the main available curricula for robotic surgeons are the FRS (Fundamentals of Robotic Surgery) in the US, the FSRS (Fundamental Skills of Robotic Surgery) in the US, the BSTC (basic skills training curriculum) in Canada and the ERUS initiative in Europe. They are at various stages of validation and offer different combination of theoretical and practical training, using various simulators and models. It should be stressed that validation studies are mandatory to obtain a gold standard curriculum that possibly would have also a cross application and multispecialty features [15]. As already happened in the field of laparoscopy with the FLS (Foundamentals of Laparoscopic Surgery), it is expected that one of these may become the model for further surgical training in order to standardize training nationally and even internationally. This step would also allow for certifying surgeons as being able to safely and efficiently perform specific robotic procedures at a national or international level [18]. It is therefore important at this time that surgical educational figures worldwide would work together to promote the development and finalization of initiatives aimed at surgical education in the setting of robotic approaches.

The Erus Proposal: A "Structured Curriculum"

Prevalently, there are two main types of learning scenarios in surgery where the patient is at an increased risk for adverse outcomes. The former is when a novice surgeon is learning a specific procedure or when an experienced surgeon is performing novel approaches for the first time. The latter is when a pioneering surgeon seeks to innovate or develop a new technique [14]. Of note, the former is a common situation that could be prevented by introducing an adequate procedure-specific training program. Recently, it has been shown that surgeons adopting robotic surgery have a substantial learning phase that varies according to the task being learnt [19]. There is also growing evidence that non-technical skills (NTS) that affect patient safety and outcomes are related to surgical experience [20]. Therefore, there is a need for integration of these components within one structured curriculum. Since a few years the ERUS educational working group is developing a structured training curriculum in Urology focused on surgeons with limited robotic experience that are willing to perform RARP at their institutions [21]. The concept of a structured training program means that it is composed of different steps and tasks that the participant has to accomplish in a given sequence. This approach leads to a more progressive and exhaustive training that could be applicable to surgeons with different surgical experience, eventually resulting into excellent outcomes. In fact, this method includes all the available simulation training modalities as the e-learning, virtual reality, laboratory training with various models ranging from synthetic, animal and cadaveric models and finally the supervised modular console training. It is also the first structured training program on RARP to incorporate the use of cadaveric models, "in vivo" lab activities, and a non-technical skills module [15]. Of note everything is included into a fellowship-style training program of the length of 6 months, which provide the most comprehensive training that couldn't be attained with other modalities such as short-term courses, mini-fellowships, and mentored skill courses [14]. This training has proven to be a valid, acceptable and effective tool able to shorten the trainee learning curve and improve patient safety with promising results [10].

Validation: Pilot Study

The first validation study of the ERUS robotic curriculum included ten participants coming from different institutions undergoing a 12-week training program that included e-learning, operating room observation, bedside assistance, and double-console observation, an advanced robotic skills course, and modular robotic training with the aim of being able to complete a full procedure autonomously at the end of the training period.

Most of the participants had minimal experience with robotic surgery with a median time of involvement as a console surgeon of only 4 months. At the end of the training, approximately 80% of them were judged to be able to perform a RARP independently and safety. The two participants who did not achieve the minimum average score were residents and it was hypothesized that they were not able to perform a sufficient number of cases during the training period. Therefore, the length of the fellowship has been increased to 6 months to allow the trainee to be exposed to an adequate number of cases, as detailed in the following section on the current version of the ERUS Curriculum.

All participants were asked to fill a questionnaire. They found all the parts of the training to be useful. More than 70% of them considered the advanced part of the course including dry and wet lab extremely important and more than 90% of them would recommend this fellowship to other colleagues. Thanks to these encouraging results, ERUS group is working to endorse more training programs with the aim to certify surgeons for urologic procedures [10].

Erus Curriculum Today

The idea of the ERUS educational group starts from the concept that the human being is not the ideal training module. This is particularly true in the setting of robotic skills development. Nowadays, several alternative training models exist and it is of extreme importance to optimize their use for educational purposes. The ERUS curriculum has the aim to develop both theoretical and technical knowledge, improving performance, shortening the learning curve, and achieving proficiency in the use the robotic system ameliorating patient safety and outcomes. Under this light, it should be stressed that the total duration of the curriculum was extended to 6 months to expose the trainees to an adequate number of cases during the modular training. Moreover, only high-volume centers that fulfill selected criteria and would be able to provide a sufficient number of cases and qualitative mentoring of the fellow during the modular training are considered as host centers. Table 9.1 lists the requirements to be fulfilled in order to be eligible as host center for the ERUS curriculum program (Table 9.1). Of note, the curriculum is not restricted on the basis of previous experience with open surgery because both novice and experienced open surgeons require mentoring during the initial phases of robotic surgery skill acquisition [14].

Erus Curriculum Structure

The ERUS robotic curriculum lasts 6 months and is structured in four main parts (Fig. 9.1). The first is the theoretical part, which can be performed independently by the participant also at their host institution and consists of theoretical training and e-learning. The second part consists of a 4-week period of live case observation and tableside assistance at the host center. The third part represents a very important step forward for the trainee because he will participate to a 5-day intensive advanced skill course at a dedicated training center where could also interact with his peers participating to the ERUS curriculum in other host centers. The last part of the curriculum is the most durable and important step that include up to 5 months of modular robot-assisted prostatectomy console training at the host center. The ERUS robotic curriculum is then concluded after the trainee performs a full-procedure autonomously at his host center. This procedure will be

Table 9.1 Host center criteria to be eligible as host center for the ERUS curriculum program

Two or more robotic surgeons with extended experience (>250 robot-assisted radical prostatectomies performed in total and > 100 cases in the host center during the past 12 months)
Five or more peer-reviewed publications in the past 5 years from the center
Commitment to train properly and allow the trainee access to the robot
Availability of simulators and/or dry lab for training

Abbreviation: *ERUS* European Association of Urology Robotic Urology Section

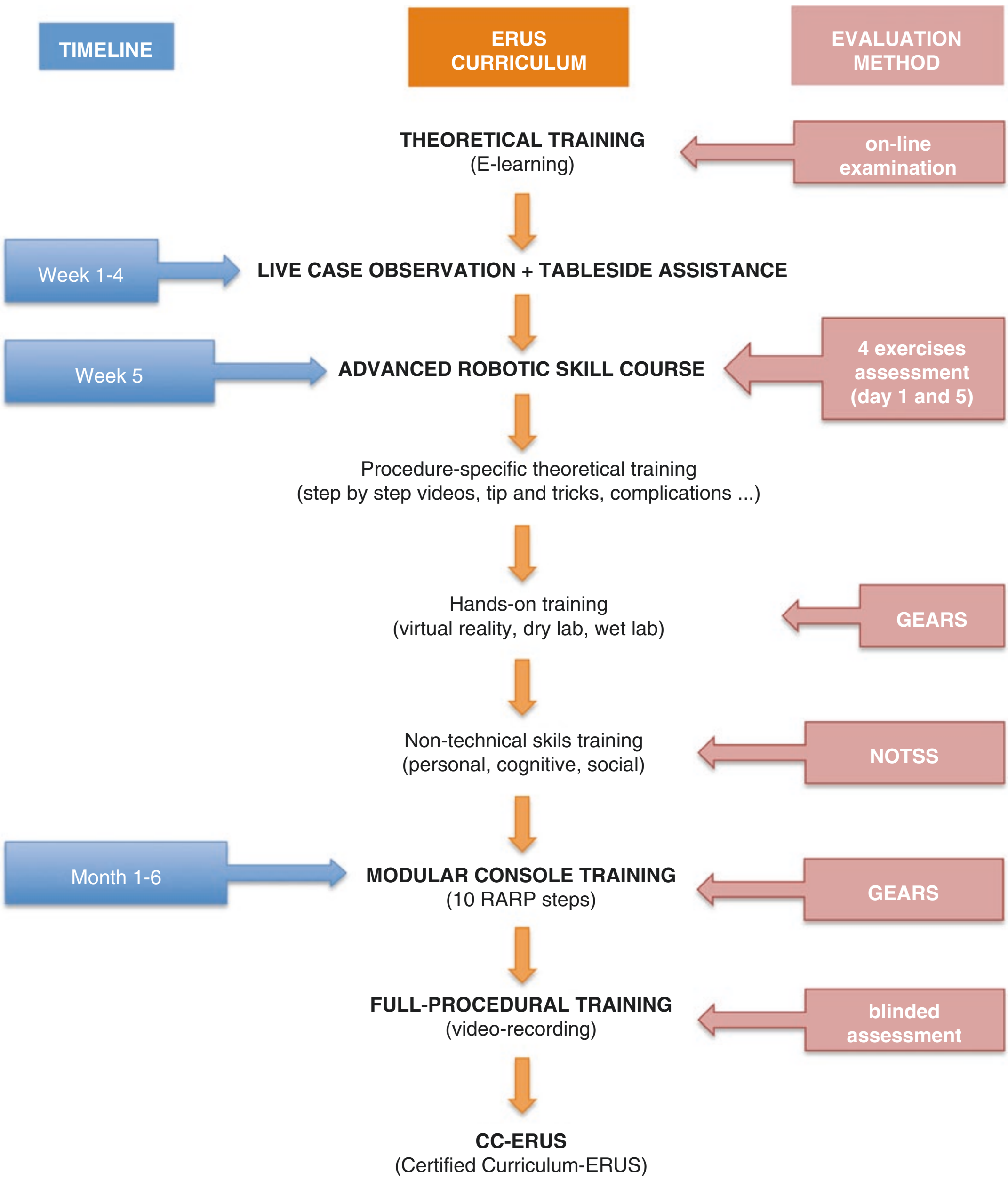

Fig. 9.1 Structure of the ERUS curriculum with evaluation method used in each phase. *ERUS* European Association of Urology Robotic Urology Section, *GEARS* Global Evaluative Assessment of Robotic Skills, *NOTSS* Non-technical skills for surgeons, *CC-ERUS* ERUS certified curriculum

then evaluated by a specific committee of independent blind reviewers, who will assign a score to each step of the surgery. A minimum score is necessary in order to be considered able to safely and efficiently perform a RARP and, therefore, to successfully accomplish the training.

Theoretical Training

For a successful performance of any surgical task the participant needs to know what to do (domain knowledge) and how to do it (technical knowledge) [22]. For this reason, the theoretical training is of extreme importance. We choose the e-learning modality because of its practicality. It comprises notions regarding components and main features of the robotic system, basic principles of endoscopic surgery, surgical anatomy and surgical procedures. Of note, this step is concluded by an examination via multiple-choice questions that the participant must pass to get the access to hands-on and modular training.

Live Case Observation and Tableside Assistance

Live case observation allows for the participant to better understand what learned during the theoretical course. There is the possibility to directly interact with mentors/trainers with specific questions and discussions. At the same time, the participant is continuously stimulated to pay attention to important details that must be acquired. 3D screens and double consol facilities could improve capturing information during live case observation allowing the same vision as the surgeon (Fig. 9.2a, b). It is also demonstrated that tableside assistance might be beneficial for console surgeons [14]. For example, Thiel and colleagues reported that assistants substantially improve their intra-abdominal spatial orientation after a three-phase specific training including the basics of robot functionality, a step-by-step video of the procedure, and a hands-on practice session [23].

Advanced Robotic Skill Course

The advanced robotic skill course is an intensive 5-day course performed at a certified center able to offer to the participant all the technology and technical facilities needed. Indeed, the ERUS robotic curriculum contemplates virtual reality simulation, dry lab, and web lab sessions during this phase. The first day of the course include a half-day **introductive course** given by a technician who will explain all the main features of the robotic system in order to familiarize with the equipment and face troubleshooting.

During all the week there are sessions dedicated to **procedure specific theoretical training** where trainers show specific procedural step-by-step videos, explain main tips and tricks, and alert on possible complications and their management.

Hands-on training represents the core of the advanced robotic skill course. The first step is virtual reality simulation, which has been demonstrated to improve surgical performances [10, 12, 24–26] (Fig. 9.3). It is particularly useful to familiarize with the console, three-dimensional vision, and wristed instruments. All the participants are assessed on day 1 before starting hands-on training and on the last day. During the ERUS validation study the scores on four different simulator exercises significantly increased after 5 days of training particularly in trainees with low baseline robotic skills [10]. Virtual reality simulation is able to substantially improve performances on dry and wet lab exercises, which are

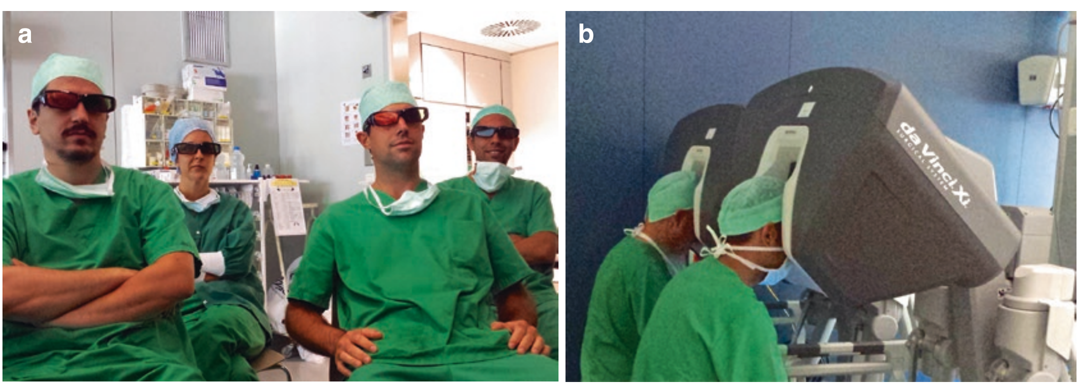

Fig. 9.2 (**a**) Live case observation with 3D screen and glasses. (**b**) Double consol live case observation

Fig. 9.3 Virtual reality; trainees using daVinci simulator

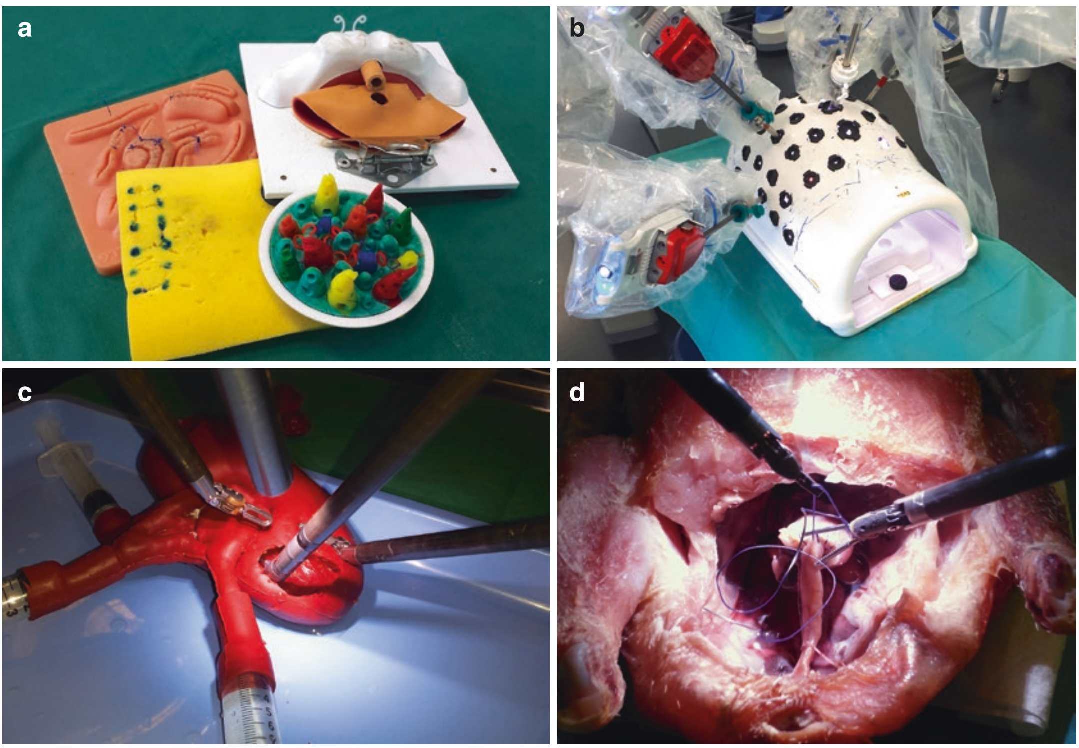

Fig. 9.4 (**a**) Exercises used during dry lab hands-on training (peg transfer, suturing and anastomosis model). (**b**) Dry lab hands-on training box. (**c**) Dry lab kidney training model for partial nephrectomy practice. (**d**) Dry lab chicken model; for anastomosis practice

the next hands-on training model proposed [25]. Therefore, it is mandatory to accomplish this step before moving forward to more complex exercises in the dry and wet lab.

Various dry lab synthetic and animal models are available (Fig. 9.4a–d). Dry lab exercises as peg transfer, vertical and horizontal suturing and anastomosis models are widely used with particular attention of the mentor to explain technical issues to the participant. Is essential to start with a simple model and to change it with a more demanding one only when the trainee is able to perform it in a technically correct way and with an appropriate timing. Regarding animal models, the Venezuelan chicken is a very useful and cheap model for the uretro-vescical anastomosis that mimics the "in vivo" procedure and allow for several consecutive surgical simulations [27]. Conversely, the dog cadaver model is very useful particularly for urologist because of the similarity of the dog prostate to the humans. This, in particular, allows participants to train also very demanding steps of the radical prostatectomy such as the bladder neck and apical dissection, the nerve-sparing dissection and the uretro-vescical anastomosis. As such, the wet lab represent the most sublime, but also the most expensive model that permit to practice complex exercises in a realistic setting due to the similar anatomy of some organs between animals and humans [11, 12, 28, 29] (Fig. 9.5). All participants are assessed continuously during dry and wet lab exercises. Differently from the virtual reality simulation, dry and wet labs lack objective assessment tools. However, validated non-objective tools as the GEARS (Global Evaluative Assessment of Robotic Skills) have been proven to reliably differentiate between different robotic skill levels [30]. Recently a study demonstrated that skills developed during lab training would directly improve performance during live human surgery. In this study a group of gynecologic surgeons naive to robotics practiced at simulators until reaching the expert's benchmarks. Before performing their first-ever human robotic surgery hysterectomy they completed also robotic pig laboratory training. The comparison of perioperative outcomes as operative time, blood loss and blinded assessments of surgical skill between experts and non-experts yielded similar results [31]. These findings are encouraging, even if further studies are needed to strengthen this evidence also in the context of urologic procedures.

Non-technical Skills

Most of the existing training programs, such as the FSRS and the FRS, lacks a non-technical component. On the other hand, one of the main advantages of the ERUS robotic curriculum compared to other available training paths is the inclusion of a non-technical skill theoretical course that is incorporated in the theoretical training and a non-technical course, which is planned during the advanced robotic skill course.

Non-technical skills could be divided in three distinct categories. The first one is cognitive skills that include the decision-making process

Fig. 9.5 Wet lab pig training model that permits to practice complex exercises in a realistic setting

and situation awareness, the second one is social skills that incorporate communication, teamwork and leadership abilities and the last one is personal resource factor including individual's ability to cope with stress and fatigue.

Two principal modalities are used to deliver non-technical skills, the former is classroom teaching and the latter is simulation-based training. For example, live observation of own practice videos and mistakes represents an excellent teaching method. Debriefing after critical incidents is useful to consolidate non-technical skills. During classroom teaching the participant is continuously assessed using specific rating systems. For example, the NOTSS (Non-Technical Skills for Surgeons) is a rating system used to assess the cognitive and social skills in the workplace; it follows the same hierarchical structure of categories, elements and behaviors as systems used in other professions such as anesthetists (ANTS) and aviators/aircraft pilots (NOTECHS) [32].

Non-technical skills should be integrated in previously validated simulation-based curriculums in order to develop skillsets in a structured and safe environment.

Modular Training in Robot-Assisted Radical Prostatectomy

In 2006, Stolzenburg and colleagues proposed the concept of modular training for laparoscopic radical prostatectomy with the aim to establish a teaching program that would ascertain the safe and efficacious training for residents with no previous experience with open pelvic surgery. The procedure was divided in 12 steps with different levels of difficulty and the trainee starts gradually from the simplest. The modular training allows fellows to perform surgical steps of the procedure with increasing level of complexity in a progressive, supervised and proficiency-based way.

In the ERUS robotic curriculum the robot-assisted extraperitoneal radical prostatectomy was similarly divided into individual steps listed here:

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

The fellow starts performing the step corresponding to his skill level and the mentor should complete the remaining part of the procedure (Fig. 9.6). With this approach the fellow progressively improves and acquires the capability to pass to a more complex module. Once he is able to perform independently and safety all the steps, the aim is to allow the fellow to perform the entire procedure by himself. At the end of 6 months participants are required to video-record a full-length procedure and to send it to experts for a blind evaluation. The mentor would give the accreditation to the fellow only if the quality of the recorded case is considered satisfactory according to predefined criteria.

The availability of a dual console facility represents a further modality to intensify the education, because it allows direct proctoring during the procedure. Under this light, Morgan and colleagues compared the outcomes of RARP using dual-console versus single-consol and demonstrated that in a resident training program using intra-, peri- and postoperative measures dual-console may represent a safer and more efficient modality for robotic surgical education [33].

Once the ERUS robotic curriculum is successfully completed and the video is judged to be satisfactory according to the objective scores of the independent blind reviewers, the fellow would receive a certification for the specific procedure.

Credentialing

Currently there is no consensus on a robotic surgery credentialing process. Credentialing is important to certificate the trainee to overcome the technical learning curve so can deliver safe

Fig. 9.6 Modular training; the trainee has the access to a specific web platform in order to fill each performed procedural step

and effective care to the patients. This should be the result of a standardized, competency-based process regulated by robotic surgery experts. However, nowadays the risk is that credentialing would represent only an industrially driven process that is neither standardized nor competency based. At present there are no healthcare regulation entities that deal with credentialing guidelines for robotic surgery. Of note, the aim of credentialing shouldn't be to single out expert surgeons from the group, but to provide a certification confirming that the surgeon is able to deliver a safe and effective care to his patients. To do this, there are a lot of delicate issues to be clarified. For example, it is still unclear how to determine the minimum number of cases per each procedure to consider a trainee ready to start safely and efficaciously. Indeed, the literature reveals a wide range of minimum recommended number of cases required to overstep the learning curve of RARP ranging from 8–12 to 800 [34, 35]. Another problem is the definition of the learning curve. For example, there is a huge difference between the concept of technical learning curve that can be overcame during a defined training interval and the concept of outcome learning curve which is a process that could even last years [36]. Furthermore, important inter-individual differences exist such as surgeon's innate skill level, case density during the initial learning curve and the presence or absence of peer collaborative learning. In order to obtain a consensus for the right credentialing of robotic surgeons, standardization is needed and this could be obtained only trough well structured validation processes.

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