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(REVIEW ARTICLE)

The road to becoming a certified robotic surgeon

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Abstract

Surgical educators are challenged with introducing new technologies into general surgery training. There has been a rapid and widespread adoption of the robotic surgical system with a lag in the development of a comprehensive training and credentialing framework. A literature search on robotic surgical training techniques and benchmarks were conducted to provide an evidence-based road map for the development of a robotic surgical skills for the novice robotic surgeon. A structured training curriculum is suggested incorporating evidence-based training techniques and benchmarks for progress. This usually involves sequential progression from observation, case assisting, acquisition of basic robotic skills in the dry and wet lab setting along with achievement of individual and team-based non-technical skills, modular console training under supervision, and finally independent practice. There is a need for a standardized curriculum for training and assessment of robotic surgeons to proficiency, followed by high stakes testing for certification. A standardized process for certifying the skills of a robotic surgeon has begun to emerge.

Keywords: Surgical Procedures; Minimally Invasive; Robotic surgery; Continuing medical education

1. Introduction

Achieving surgical competence is a complex process that involves the attainment of knowledge, judgment, professionalism, and surgical skill. [1].

Robotic surgery has improved minimally invasive surgery, shortening the learning curve, and conferring increased dexterity for surgeons. The platform is very different from other forms of surgery, and if training is not comprehensive and well structured, patients can be put at risk [2, 3].

Since its approval by the US Food and Drug Administration (FDA) in 2000, the use of robot assisted laparoscopic surgery has surpassed that of pure laparoscopy for not only radical prostatectomy but also dismembered pyeloplasty and partial nephrectomy [4, 5]. Between 2007 and 2011, the annual number of total robotics cases according to Intuitive Surgical increased by nearly 400% in the United States (Fig. 1) [6].

2. Robotic Platforms Currently Available for Practice

Currently, there are several Food and Drug Administration (FDA) approved systems that are available to practicing surgeons and surgical trainees. A brief overview of these systems and future platforms is provided to lay a foundation for the complex task of creating and incorporating a universal robotics-training program into General Surgery education [7].

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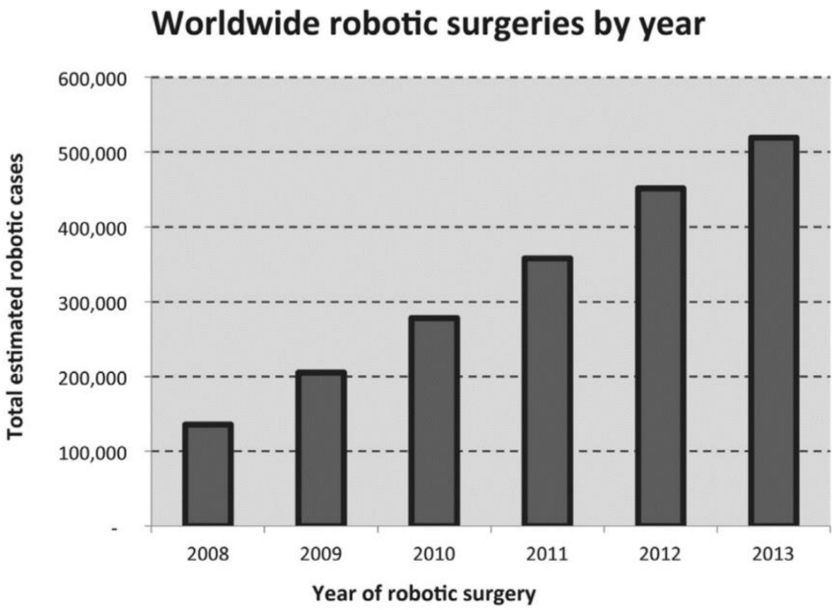

Figure 1. Estimated number of robot-assisted cases worldwide. (Data from Intuitive Surgical investor presentation, 2014. Available at http://investor.intuitivesurgical.com/phoenix.zhtml?c5122359&p5irol-irhome.

3. Da Vinci: Intuitive Surgical

FDA approved since 2000, Intuitive Surgical's da Vinci robot gained popularity as the first system to house both surgical instruments and advanced imaging for general laparoscopic surgery. The most recent iterations of the da Vinci system are the da Vinci SP which is a single port operating platform and the da Vinci Ion which is a bronchoscope. The most commonly used platform is the da Vinci XI (Fig. 2) which consists of a closed master console with two cameras that generate a 3D/HD view of the operative site, a patient cart with four robotic arms with wristed instruments, and a vision cart. In addition, the high-definition 3D optics, tremor filtration, motion scaling and a comfortable user interface optimize the precision of the system [8]. Finally, the presence of Firefly near-infrared technology provides image-guided identification of key landmarks such as blood vessels and biliary structures using tissue fluorescence [9].

Figure 2 Da Vinci Image, Xi, Trio of System Components. Image of complete da Vinci Xi System including the patient side cart, vision cart and the surgeon console.

4. Requirements for Robotics Certification

In 2007, the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and the Minimally Invasive Robotic Association (MIRA) published a consensus statement putting forth guidelines for the educational requirements and certification for robotic surgery. With the broader adaptation of robotic surgery from pelvic specialties such as urology and gynecology into general surgery, it was critical to confirm that the training to support an expanded role of robotic surgery ensured patient safety [10].

5. Certificate of da Vinci® System Training

The Certificate of da Vinci System Training is not a replacement for any hospital's credentialing requirements and is not a representation of clinical competence, as Intuitive only trains on the use of the da Vinci system.

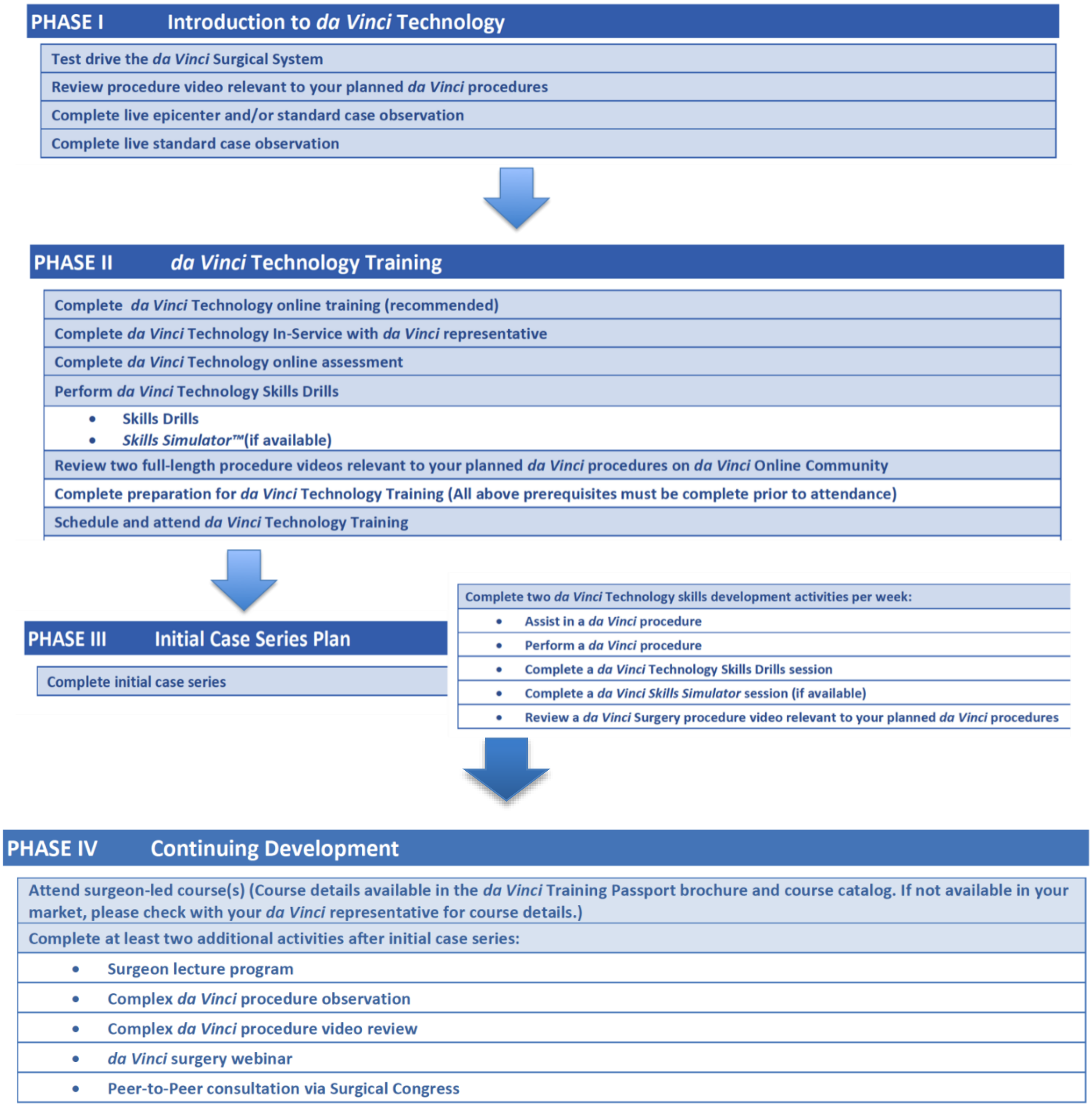

Figure 3 Da Vinci Phases to Certification

In order to qualify for a Certificate of da Vinci System Training, must satisfy all of the phases listed below (Figs. 3).

- Introduction to da Vinci Technology
- Da Vinci Technology Training
- Initial Case Series Plan
- Continuing Development

In our experience new robotic surgeons who perform at least one case per week for the first 12-13 weeks typically advance through their learning curve more quickly and develop more confidence and familiarity with the use of the technology than those who perform their initial cases less frequently. In addition, we have observed, a proctor provides important guided training in the early robotic cases. One role of a proctor is to guide the surgeon and his/her surgery team through their initial cases to assist with their mastery of the technology [11].

6. 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. 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 [12].

6.1. Simulation Training

A simulator is an educational tool that allows interactive performance of a particular task in an environment that recreates or replicates a real-world clinical scenario. Surgical simulator training can be separated into two broad categories: physical (mechanical) simulators, wherein the task is performed under videoscopic guidance in the real-world environment and "virtual reality" (VR) simulators, wherein the task is performed on a computer-based platform using an artificially generated virtual environment [13].

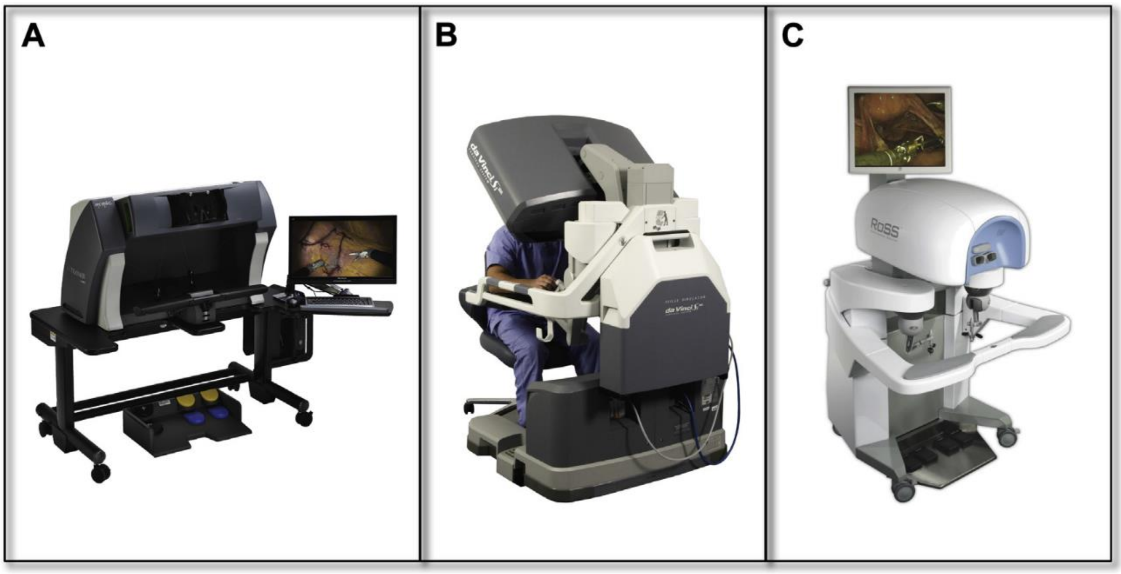

Figure 4 Three commercially available virtual reality simulator platforms. (A) dV Trainer; (B) da Vinci Skills Simulator; (C) Robotic Surgery Simulator**.**

There are five VR simulators currently available for robotic training. **(**Fig. 4**)** These include the Robotic Surgical Simulator (RoSS™; Simulated Surgical Systems, Buffalo, NY); dV-Trainer™ (Mimic Technologies, Inc., Seattle, WA); SEP Robot™ (SimSurgery™, Norway); the da Vinci Skills Simulator (Intuitive Surgical, Sunnyvale, CA) and more recently the Robotix mentor™ (3D systems, formerly Symbionix, Israel). All these simulators have been evaluated to have face validity (looks like what it simulates), content validity (accurately simulates the test condition) and construct validity [14-21].

The da Vinci Skills Simulator® dVSS **(**Fig. 5**)** consists of a small case that generates the virtual environment. The case is annexed to an existing da Vinci surgeon console, thereby transforming it into a simulation platform. The primary features are built-in metrics that enable the trainee to assess skills and to measure the improvement in a given exercise, with real-time feedback and progress tracking [16]. Exercises range from beginning to advanced and cover the following five categories: EndoWrist® manipulation, camera and clutching, fourth arm integration, system setting, needle control and driving, as well as energy and dissection. During the developmental stages, several studies have shown face, construct, and content validity for the dVSS [17, 22-26]. Recently, Hung et al. [19] were able to demonstrate concurrent and predictive validity in a group of trainees who underwent a 10-week simulation course with dVSS by evaluating ex vivo tissue performance and final tissue performance after completion of the course. The dVSS uses the same console used for operative procedures, thus making it advantageous. However, the cost and logistics for securing a console of training purposes may be a prohibitive factor in some institutions [19].

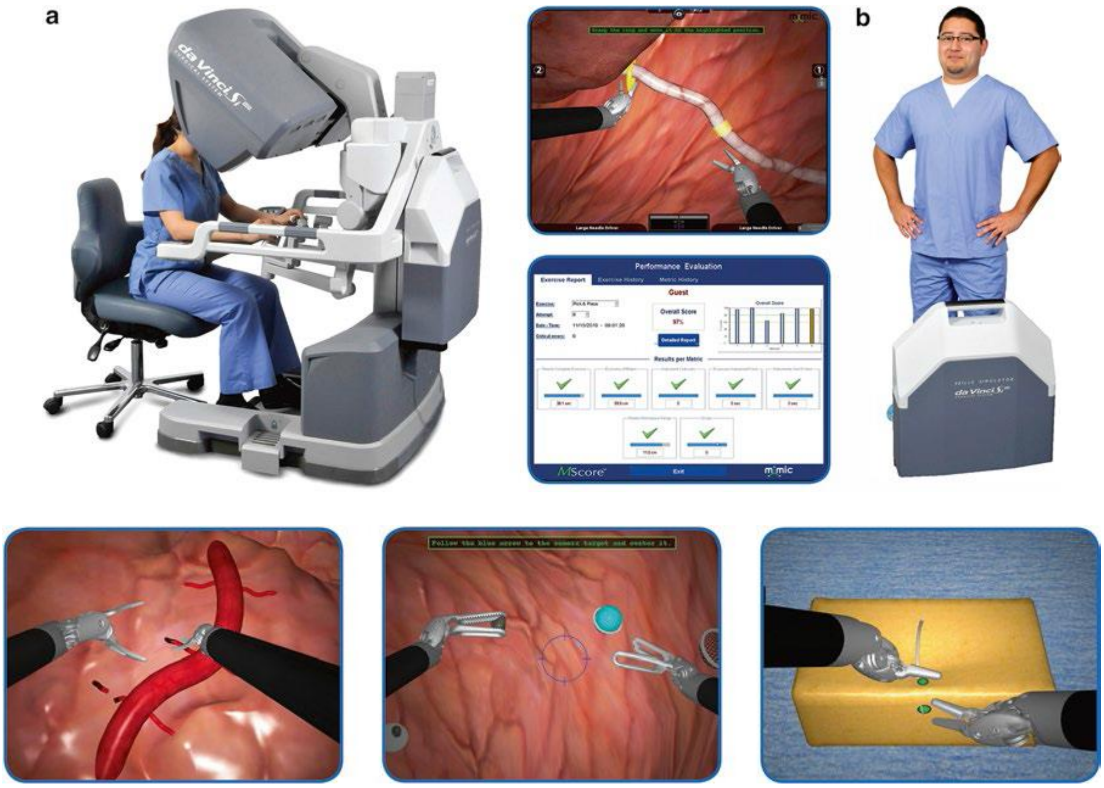

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Figure 5 da Vinci® surgeon console (a) and da Vinci® Skills Simulator (b) (Copyright © 2014 Intuitive Surgical, Inc. Used with permission)

6.2. Dry Lab Training

Dry lab simulation is cost effective and can reliably simulate cutting, suturing and grasping exercises. As the user is actually sitting on the daVinci™ surgical system (dVSS) console and using robotic instruments to complete tasks, the fidelity of simulations is very high. The consumables for dry lab exercises can be as simple as routine beads/needles/sutures, to sophisticated vascular and bowel models. Dry lab exercises are however limited in that it is difficult to maintain a standardized record or method of assessment, something that is essential in the early stage. Objective assessments made by a keen observing trainer are required in order for the trainee to have any benefit from the system [27-29].

6.3. Wet Lab Training

Handling of tissues and understanding the reaction of tissues to instrument touch cannot be learnt in dry labs. Further, use of diathermy and vascular control can only be learnt in wet labs. Experience in the wet lab soon teaches the trainee to recognize the consistency of tissues based solely on visual clues. Robotic wet labs provide excellent training ground for near live surgical exposure. Wet labs can provide three different types of training material. Frozen animal parts [30, 31], frozen human body parts [32] and live animals [33] with the cost increasing proportionately. Embalmed body parts allow vascular identification and dissection but alas do not provide a learning ground for vascular control. Live anesthetized or euthanized animal models are expensive and limited with regard to number of times they can be used, but have an advantage of bleeding simulation.

6.4. Training in the Operating Room

Once signed off on simulated skills, the trainee should be competent to learn the steps of the procedure on the console safely. This should follow a modular approach. The role of a mentor is crucial in this process. The trainee must enter into an agreement with the mentor who will oversee training. The modular process begins with the trainee performing the simplest part of the procedure, and progressively taking on increasingly difficult bits as the mentor sees fit. **(**Table 1**)** The transition of mentor from to proctor usually indicates that a trainee is progressing [34].

6.5. Patient Side Training

Like any surgical procedure, development of robotic skills follows a progression of observing, assisting, performing under supervision, and finally independent practice. Patient side training has a two-pronged benefit. It not only exposes the trainee to the steps of the operative procedure, but also necessitates the development of skills unique to the assistant. The assistant develops an understanding of the ergonomics and restriction of access created by the robotic arms. It is plausible that patient side skills are acquired relatively quickly, and that establishing a sign off of competency would enable progression to console in a relatively short duration [34].

Table 1 Relevant tasks for robotic surgery training and their rank order gathered by subject matter experts

Occurrence	**Task name**	**Rank order**
Pre-op		
	Situation awareness	1
	Closed loop communication	6
	Docking	7
	Robotic Trocars	8
	Ergonomic Positioning	9
	System settings	10
	Operating room set-up	11
Intra-OR	Respond to robot system error	12
	Eye-hand instrument coordination	2
	Needle driving	3
	Atraumatic handling	4
	Safety of operative field	5

7. Patient Positioning and Port Placement

Patient positioning and port placement play a key role in the ergonomics of the procedure. Proper patient positioning not only ensures that each member of the surgical team gets adequate access to the patient, but also maintains an optimal spatial configuration between the patient cart of the robot and the target organ in question. Similarly, correct port placement enables access to target organs, allowing for the required triangulation, without any extracorporeal or intracorporeal instrument clashes. [34].

8. Case Observation

It has been demonstrated that live case observation in an OR is an important component of the robotic training process. This phase of training affords the trainee the opportunity to watch more experienced surgeons perform live cases, thereby gaining an insight into the OR team dynamics, docking procedures, and troubleshooting of problems. The addition of a prerecorded video that can be watched with the teacher surgeon is another option. The video recording has the advantage that surgeries are selected in advance and the educational experiences can be preemptively planned [35].

9. Proctoring

Proctoring can take place during the initial phase of the learning curve as the surgeon begins to perform robotic cases. In proctoring, a master surgeon directly supervises and evaluates the skills and knowledge of a trainee. Proctoring can be an expensive form of training, but it provides a relatively safe way of introducing the new technique and serves as a transition phase to operating independently. In addition, the trainee can receive feedback and assessment from the proctor while performing the case. Proctoring can address important medico-legal aspects of training as well as have a role in institutional credentialing. [36].

10. Dual Console

Intuitive Surgical has developed a da Vinci® model 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: (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 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. 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 [37, 38].

11. Robotic Courses

Many guidelines have been published on how a robotic surgery course must be composed, 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 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 [39-41].

12. Credentialing Process

The final stage in the robotic education process is obtaining credentialing privileges to operate independently. At present, there is no standardized credentialing process for robotic surgeons. Most requirements vary from hospital to hospital and are not competency based but rather driven by a fixed number of proctored cases. The issue of credentialing is attracting increasing attention, as there have been recent reports of litigation directed at hospitals resulting from insufficient training and credentialing of their robotic surgeons. For conventional laparoscopy, the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) have created the FLS curriculum, which has been validated as a means of training and credentialing trainees. Completion of this course has been endorsed by the American College of Surgeons as a prerequisite for board certification [39].

13. Conclusion

The use of robot-assisted laparoscopic surgery has increased rapidly, and with it, the need to better define a structured curriculum and credentialing process. Numerous efforts have been made by surgical societies to define the requisite skills for robotic surgeons, but in the United States, individual institutions have the responsibility for granting privileges.

In conclusion based on our early experience, we would recommend a road map of training with assessment of competency at every level before progression.

Such a training program would be based on demonstration of proficiency and safety in executing basic robotic skills and procedural tasks as well as achievement of non-technical skills in the practice laboratory prior to proceeding to modular training, and finally to sign off and independent practice. Recently, efforts have focused on creating a standardized curriculum with competency-based assessments. A competency-based approach offers a better hope of honoring the principle of "above all, do no harm" and obtaining continued acceptance of new operative technologies such as robot-assisted surgery.

Compliance with ethical standards

Acknowledgments

None

Disclosure of conflict of interest

There are no conflicts of interest.

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