Review Article: Surgery: Urological Surgery

A review on training models in urology

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Abstract: Simulation-based training is increasingly being recognised as a valuable resource to training in urology and other surgical disciplines. It allows the trainees to practice and achieve adequate skills in a safe setting, before to start managing real patients. In the last few decades, the surgical simulation in urology has made considerable progress, with increasing numbers of new models being developed and validated. Technical skills can be acquired using various different simulation modalities including virtual reality (VR) simulators, bench-top models, animal tissue or live animals, and human cadavers, each with their own advantages and disadvantages. Nowadays, various types of models are available for different type of urologic surgery. Endourology is one of the fields with more available simulators, with several and different simulators for most procedures: percutaneous nephrolithotomy (PCNL), retrograde intrarenal surgery (RIRS), Ureteroscopies and transurethral resection of the prostate (TURP). However, training models are available also for laparoscopic, robotic and open surgery. Most of laparoscopic simulators have been developed using inanimate box trainers or computer-based VR platforms. Cadaveric training models using fresh frozen cadavers for several common operations including have been proposed over the years and might be used for both minimally invasive and open surgical training. To date, it is not universally established how to judge the usefulness of training simulators nor are specific and validated training programs established where the trainees must get over different simulation modalities before to start performing real surgery. In most cases, the usefulness of training models is evaluated with a reduction in execution times, greater precision in the execution of manual gestures and through questionnaires. This review will provide an overview of the different types of simulation-based training tools available in endoscopic, laparoscopic, robotic, and open urological surgery.

Keywords: Training models; training urology; models urology; simulators urology; simulation surgery

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Introduction

Training and practice are the basis of any discipline, especially surgery. Nowadays being a surgeon means not only knowing guidelines, steps of surgery but also being able to perform a technically correct and safe procedure.

Historically, teaching was based on Halsted's principle model of "see one, do one, teach one" (1); however, as technology evolves and the complexity of surgeries increases, this mentality can no longer be considered timely.

To obtain these high standards, urologist must undergo several hours of surgical training in order to get over learning curves and achieve expertise in a wide range of operations.

Limitations on the number of weekly working hours (2), increased consciousness of patient safety and greater patient expectations are just some of the motivations that led to the

Table 1 Definition of validity for surgical simulation

Validity	Definition
Face validity	Realism of the simulator rated by experts and users (usually through surveys)
Content validity	Experts' opinions about the simulator and its appropriateness for training
Construct validity	Ability of the simulator to differentiate between the levels of experience of users or groups
Concurrent validity	Comparison of the new simulator with the available validated gold standard
Predictive validity	Ability of a simulator to predict performance in real surgery

development of simulators.

Simulation-based training is increasingly being recognised as a valuable resource to training in urology and other surgical disciplines. It offers trainees the opportunity to practice basic skills in a safe and pressure free setting, defending patient safety and promoting a progress in personal skills at least in the early phase of the learning curve.

Technical skills can be acquired using various different simulation modalities including virtual reality (VR) simulators, bench-top models, animal tissue or live animals, and human cadavers, each with their own advantages and disadvantages.

To meet these new needs, the European Association of Urology (EAU) has created a path to develop the basic skills of laparoscopy with a simulator (3). These initiatives, of course, have almost spread all over the world and almost at any latitude there is a program like the European one, which aims to increase confidence in the laparoscopic technique (4,5).

This review will provide an overview of the different types of simulation-based training tools available in endoscopic, laparoscopic, robotic, and open urological surgery.

Methods

A non-systematic literature search of PubMed and EMBASE databases was carried out in September 2020 in order to select relevant papers published between 1990 and 2020, providing data on simulation and model training in urology. The inclusion criteria were studies published in English language and studies reporting results, training and outcomes regarding endoscopic, laparoscopic, robotic, and open simulation training model in urological surgery.

Discussion

"I run on the road, long before I dance under the lights". This is a famous phrase by Muhammad Ali that represent training. As the boxing champion had to train on the road for years and years before to get to play under the lights of the boxing rings, similarly, young surgeons should train with simulators before getting the lights of the operatory room. As in every sport and activity, surgery has specific learning curves which are a visual representation of how long it takes to acquire new skills or knowledge (6). However, several hours of surgical training are not enough to obtain these high standards since surgeon's personal skills such as problem solving, stamina, patience, manual dexterity are fundamental and not always being teachable.

In recent years, changes in surgical education and training have resulted in an increasing focus on simulation. Simulation surgical training should provide the opportunity to learn and practice the basic skill as well as reduce the learning curve. The range of urology simulators has grown rapidly and it is important to know how to choose the appropriate simulator for the skill you want to acquire.

Definition of "training model" and "simulator"

Simulation is defined as a technique to "replace or amplify real experience with guided experiences that evoke or replicate substantial aspects of real world in a fully interactive manner" (7). A simulator is a tool or device, used for training purposes, which can imitate real-life scenarios. Surgical simulator must have specific attributes (8,9). In particular, simulators must have a face, content, predictive, construct and concurrent validity (*Table 1*). Simulation modalities including 3D simulators (virtual, printed or augmented-reality), bench models, animal tissue or live animals, and human cadavers. The main advantage of human cadavers is the perfect mixture of real human anatomy and tissue feeling, which are present in a minor way also with animal models. Their main disadvantages are the little availability and ethical and regulatory problems.

VS have the advantage of making possible to reproduce some clinical cases or critical situations with different levels of experience. Printed and augmented reality models allow a perfect representation of tumoral lesions and organ anatomy. However, they all lack of “tactile realism” and don’t allow to experience an adequate tissue feeling.

Endourology training models

Endourology is one of the fields with more available simulators.

The URO Mentor (Simbionix, USA) is a VR simulator with a computer interface and a mannequin model. The URO Mentor simulates patient anatomy and surgical scenarios (stones and stricture cases) for practicing semirigid and flexible ureteroscopy (URS) (10). This simulator model is usually combined with the PERC Mentor (Simbionix, USA), a similar platform for learning percutaneous nephrolithotomy (PCNL) (11,12).

VR technology is ideal also for training purposes on benign prostatic hypertrophy and bladder cancer.

The PelvicVision (Melerit Medical AB, Sweden) is another type of simulator introduced in 2005 by Källström *et al.* The PelvicVision consists of a modified resectoscope connected to a haptic device. The software reproduces the prostatic lumen and resectoscope tip, a haptic rendering that generates force feedback and a simulation module that computes the information from the haptic device, resectoscope fluid tap and handle and the foot pedals. The software is also capable to simulates bleeding (13).

Currently the most validated model is the one proposed by the University of Washington: TURP Trainer—available commercially as Surgical SIM TURP (METI, USA) (14). The simulator reproduces different scenarios and details such as operative errors, blood loss, foot pedal use and differential time spent with orientation, cutting or coagulation. A similar trainer is also the VirtaMed AG (Switzerland) (15-17).

Bench trainer technology also lends itself very well to Ureterorenoscopy. The Uro-Scopic Trainer (Limbs & Things, UK) is one of the most used models. It reproduces a pelvis with the whole urinary apparatus. It has an irrigation and drainage system and can be used with standard equipment enabling both rigid and flexible ureteroscopy training. Stones can be introduced within the renal pelvis, ureters or bladder, enabling stone fragmentation and extraction (18-22).

The K-Box (Porgés-Coloplast, France) and the Cook URS model (Cook Medical, USA) are two low-fidelity training model for flexible URS. Both simulators have the objective of gaining familiarity with the main movements during flexible ureteroscopy (23,24).

Laparoscopic training models

Laparoscopy is certainly one of the surgeries that better benefits from simulation training, due to some intrinsic characteristics such as different depth perception, altered tactile sensation, limited degrees of freedom, long instrumentation and different eye–hand coordination. Training with simulator models is therefore recommended and helpful (25).

Laparoscopic simulators have been developed using inanimate box trainers or computer-based VR platforms.

The LAP Mentor (Simbionix, USA) and LapSim (Surgical Science, Sweden) are commercially available VR simulators, which include programmes to train in basic camera and laparoscopic skills as well as procedure-specific modules such as laparoscopic nephrectomy (26-31).

Animal models within laparoscopic box-trainers have been used to simulate partial nephrectomy and pyeloplasty. Among proposed animal models, rabbits have been validated as models for improving basic surgical skills including suturing, knot-tying and dissection (32). Porcine models are also very used for technical skills improvement.

A chicken crop and oesophagus model to simulate the human renal pelvis and ureter have been proposed for anastomosis training exercise (33).

Robotic training models

Many VR simulators are available in robotic surgery. The most famous of them are the SimSurgery Educational Platform (SEP) Robot (SimSurgery, Norway), the Robotic Surgical Simulator (Simulated Surgical Systems, USA), the dV-Trainer (Mimic Technologies, USA), the da Vinci Skills Simulator (dVSS; Intuitive Surgical, USA), the ProMIS (CAE Healthcare, Canada) and the RobotiX Mentor (Simbionix, USA).

The dVSS is the only simulator to work directly with the da Vinci robot. The dVSS backpack is attached directly onto the console, enabling the user to practice operating on the da Vinci robot in a virtual environment. The main disadvantage of this simulator is that it can be used only when the DaVinci robot is available and free (34).

Open surgery training models

Open surgery remains a challenge for surgical simulation. However, some training models have been proposed for urologic open surgery.

The Adult Circumcision Trainer (Limbs & Things, UK) consists of an anatom¬ical penile piece and a synthetic double-layered bowel, to simulate the foreskin (35).

An unusual and cheap simulator model has been made by hot dogs and red vines candy to simulate acute ischemic priapism (36). The 77.8% of the users recommended its incorporation into resident training in order to better understand the management of priapism.

Cadaveric training models using fresh frozen cadavers for several common operations including circumcision, vasectomy, hydrocele repair, testicular fixation, and radical orchidectomy have been proposed over the years (37,38). Cadaveric models are also useful for training in emergency urological pro¬cedures such as open cystostomy, ureteric reimplantation and emergency nephrectomy (39).

Conclusions

The surgical simulation in urology has made considerable progress in the last few decades, with increasing numbers of new models being developed and validated. Nowadays, various types of models are available for robotic, laparoscopic, open and endoscopic surgery.

To date, it is not universally established how to judge the usefulness of training simulators nor are specific and validated training programs established where the trainees must get over different simulation modalities before to start performing real surgery. In most cases, the usefulness of training models is evaluated with a reduction in execution times, greater precision in the execution of manual gestures and through questionnaires (37,40).

Moreover, several urological societies are trying to outline specific Training Curricula that are validated and that guarantee the best possible preparation to trainees before trying their hand at real clinical practice (41).

In conclusion, surgical simulation has become a mandatory exercise for beginners in order to practice and achieve adequate skills in a safe setting, before to start managing real patients.

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