REVIEW PAPER

UROLITHIASIS

# The current role of simulation in urological training

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**Introduction** Simulation is becoming an increasingly popular educational tool in numerous surgical specialities, including urology. This article reviews the current role of urological simulators; discussing their need, availability, incorporation and current limitations.

**Material and methods** A literature review of the electronic databases Medline, Embase and Google Scholar was performed.

**Results** For increasingly limited urological training programs, simulation can act as a valuable adjunct to clinical training. Evidence suggests that simulation enables the trainee to bypass the early, error-prone part of the surgical learning curve. It should be incorporated into proficiency-based curricula, with junior trainees initially beginning with low fidelity simulators to grasp basic surgical skills before moving onto full-procedural simulation as they progress through their training. A wide variety of simulators of differing fidelity are currently available, teaching both technical (eg. cystoscopy) and non-technical (eg. communication) urological surgical skills. Whist numerous studies have assessed the face, content and construct validity of various urological simulators, further work needs to be undertaken to determine whether the skills learnt actually improve trainee performance in the operating room. Then, educators will be able to make informed decisions about whether these resource demanding (financially and in terms of demands on faculty) simulators are a worthwhile educational tool.

**Conclusions** Although further investigation is required, urological simulators appear to have a considerable role for developing both technical and non-technical urological skills in an increasingly restricted educational environment in modern urogynecology.

Key Words: educational models ‹› simulation ‹› training ‹› urology

## INTRODUCTION

Urologists have traditionally received their surgical training through the Halstedian apprenticeship model of 'see one, do one, teach one'. Despite the original success of this model, it relied heavily upon the accumulation of considerable operating experience gathered during several years of demanding training.

Over the last few decades, there has been a significant increase in the number of minimally invasive urological procedures. As these complex operations often possess steep learning curves, it is of some concern that trainee operating exposure has recently been limited by the introduction of initiatives such as the European Working Time Directive [1]. Furthermore, with a growing debate about whether it is safe and/or ethical to train on patients [2], there is a clear need for change to traditional surgical education.

Simulation is an appealing tool for modern urology training, allowing trainees to repeatedly practice a procedure, as a result bypassing the early, error-prone phase of the learning curve in an environment which does not jeopardize patient safety [3]. Furthermore, with high fidelity simulators, it is possible to also teach non-technical skills, such as leadership, communication and teamwork which complement technical urological skills [4].

This article will review the current role of urological simulators by discussing how they can best be


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incorporated into training programs, by assessing the availability and validity of current models and by considering what current challenges and limitations they face.

## MATERIAL AND METHODS

The author performed a thorough literature review of the electronic databases Medline, Embase and Google Scholar. All articles published before February 2015 were included. Reference lists of included articles were also searched for relevant studies. No ethical approval was required for this review.

## RESULTS AND DISCUSSION

### How should simulation be incorporated into surgical education?

It is important to stress that simulation is an adjunct rather than a replacement of clinical training. To fully exploit the benefit of simulation, it should be incorporated into modern proficiency-based curricula [5]. Simulation thus becomes a safe means to maximize the effectiveness of training in the restricted number of hours possible [5].

An optimal simulation program would involve trainees receiving repeated exposure to the simulator over an extended period of time [6]. It is vital that the student receives feedback on their performance, enabling them to target their learning appropriately [6]. Trainees can often start with low fidelity simulators to grasp basic surgical skills before moving onto full-procedural simulations as they progress through their training [6].

In the UK, trainees can now log simulator experience into the Intercollegiate Surgical Curriculum Program logbook [7]. Furthermore, the feasibility and acceptability of a centrally-coordinated simulation-based urology training program named SIMULATE has been determined, describing a potential way in which to deliver technical and non-technical skills in a structured manner [8].

### Currently available urological simulators

### Cystoscopy and ureterorenoscopy

For the endourological procedures of cystoscopy and ureterorenoscopy, numerous high-fidelity bench-top models and virtual reality (VR) simulators have been created.

High-fidelity simulators, such as the Uro-Scopic Trainer (Limbs and Things, UK), consist of physical mannequins and allow trainees to practice using the standard operating instruments. Brehmer and Swartz found that repeated training on a bench-top simulator for semi-rigid ureteroscopy significantly improved resident performance and made trainees feel more comfortable with the instruments and procedures [9]. Other studies have confirmed the face, content and construct validity of numerous high fidelity ureterorenoscopy and cystoscopy simulators [10].

Virtual reality trainers, such as the URO-Mentor™ (Simbionix, USA), simulate surgical procedures through interactions with computer interfaces. Schout et al. demonstrated that repeated exposure of novices to the URO-Mentor simulator (for flexible cystoscopy) produced encouraging results; global rating scale score and time for procedure completion improved, with a decrease in the amount of trauma caused [11]. Additionally, good construct validity was noted [11].

An essential factor in determining the usefulness of simulation as an educational tool is whether the skills learnt from simulation are actually transferable to the clinical setting. In a randomised controlled trial, Schout et al. showed that trainees who received cysto-urethroscopy training on the URO-Mentor VR performed significantly better than those with no VR training when performing cysto-urethroscopy on real patients [12].

When comparing simulators, Chou et al. showed that there was no significant difference in ureteroscopy performance (on a porcine model) between medical students trained on the URO-Mentor VR simulator compared to a high fidelity model [13].

Interestingly, some authors have queried whether these highly-technical expensive models are necessary. Matsumoto et al. showed that whilst simulation improves endourological performance, there was no significant difference between the groups that trained with a low fidelity model which cost €14 compared to the high fidelity model costing €2600 [14].

### Transurethral resection of the prostate/bladder tumour (TURP/TURBT)

TURP is a commonly performed, but challenging procedure [15]. As errors during this procedure can cause serious complications, it is concerning that the mean number of TURPs completed by residents over the course of their training was halved from 120 to 60 between the time period of 1990 and 2000 [16]. As a result, a simulation model has been sought to bridge this experiential gap.

Bright et al. demonstrated the face and construct validity of the TURPsim™ VR simulator (Simbionix, USA) with novices improving TURP performance upon repeated training, but experts still performing significantly better [17]. Källström et al. showed that following training on the PelvicVision

TURP VR simulator (MeleritMedical AB), trainees performed significantly better TURP on patients, with a 65% increase in the number of residents able to perform a TURP [18]. Aydin et al. recently confirmed the construct validity of the Greenlight™ Simulator (American Medical Systems Inc, USA) for photoselective vaporization of the prostate [19]. Likewise, the face and content validity for a new holmium laser enucleation of the prostate (HoLEP) simulator has been determined, with 84% of the participants believing that the simulator would be useful for training [20].

## Percutaneous renal access

It has been reported that during percutaneous nephrolithotomy, as few as 11% of urologists routinely obtain percutaneous renal access without the aid of a radiologist [21]. Therefore, as trainees may not receive training from their seniors on how to achieve access, simulation could potentially enhance training in this area.

Mishra et al. proved the validity of the PERC Mentor™ VR renal access simulator (Mentor Graphics, USA) [22]. They found that while experts were faster and more efficient at gaining access on the simulator, novices improved their performance over the course of training for numerous metrics, such as fluoroscopy time [22]. Furthermore, they then compared the abilities of five novices to attain renal access in a pig before and after training on the VR simulator. Whereas only one of the pre-trained group achieved access, all five did so safely after training, thus confirming predictive validity [22]. An inexpensive, fluoro-less, physical C-arm trainer (SimPORTAL) has also been described, but awaits validation [23]. Future studies are required to assess whether these simulators can improve real operating performance.

## Laparoscopic and robotic urological simulation

As laparoscopic procedures become more common in urology, a variety of simulators have been developed. While the training of general laparoscopic skills on low-fidelity box trainers may improve performance of individual skills such as suturing time [24], studies suggest that it has limited impact on the overall operative performance of trainees during *in vivo* laparoscopic nephrectomy [25].

Brewin et al. confirmed the validity of the first VR laparoscopic nephrectomy simulator with experts rating it to be a useful training tool with above average realism [26]. With repetition, trainees improved their overall simulator performance, with faster, more efficient and safer task execution [26].

Given the increasing adoption of complex robotic-assisted urological procedures with steep learning curves, the role of simulation to train qualified and trainee urologists in these skills is sure to play a big part in the future of urological simulation [27]. Cho et al. demonstrated that virtual reality simulation with the DV-Trainer (Mimic Technologies, Inc., Seattle, WA) improved surgeon performance on the da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA) [28]. These novel robotic simulators will also need studies to investigate their predictive validity [27].

## Non-technical urological skills

It is now apparent that for a positive patient outcome in urological surgery, technical surgical ability must be complemented by excellent, non-technical skills such as decision making, teamwork and communication [29]. Poor non-technical skills are a very common contributory factor to surgical errors [30].

Non-technical skills can be improved by simulation in mock operating theatres with full-participation from the entire surgical, anaesthetic and nursing teams [31]. Between 94-100% of trainees noted this type of high fidelity simulation to be useful for developing communication skills [32]. Furthermore, significant increases in teamwork ratings and equipment setup have been noted [31]. Interestingly, non-technical skills have not been found to necessarily correlate with experience, suggesting that more advanced trainees may also benefit from training upon these simulators [32]. Structured, simulation-based curricula, incorporating both technical and non-technical skills has been shown to be feasible and effective for teaching ureteroscopy to trainees [33]. Life-threatening emergency situations can also be simulated with studies demonstrating a significant reduction in the time taken to initiate resuscitation protocols [34].

## Challenges of simulation training

One consideration tutors need to consider is that simulation can be resource demanding, with a need for faculty, equipment and a location to be provided [35].

Another consideration is that there is no agreed consensus on how to validate simulation tools, with different investigators adopting different approaches [36]. Given the difficult, expensive and potential ethical challenges of conducting randomised trials to determine whether specific simulators actually improve the operating performance of trainees, educators often have to select simulators based on their own judgement [36]. More work is needed to compare different simulators and to identify which ones are more effective at training students.

It is well established that certain urological procedures possess larger learning curves. For example, the learning curve for prostate cancer recurrence after radical prostatectomy does not plateau until approximately 250 procedures have been performed [37]. Therefore, it is important to appreciate that simulation training alone will not be sufficient for trainees to bypass this curve and to meet the requirements for certification at the end of training. Rather, simulation should complement other essential components of urology training programs such as participation in mentorship schemes and clinical fellowships, which also aid progression along the learning curve.

Urology trainees consistently claim clinical fellowships to be a necessary undertaking in order to achieve clinical competence [38]. Fellowships help trainees to improve both procedural confidence and competence, while also allowing the development of super-specialist skills [38]. Indeed, 5-day mini fellowship programs are effective at teaching urologists new procedures such as robot-assisted laparoscopic prostatectomy, with skills learnt retained in both the short and long-term [39]. Indeed, fellowships undertaken at high-volume centers of excellence are useful to ensure trainees accumulate an adequate procedural caseload necessary to develop the surgical skills essential for a positive surgical outcome [40, 41].

## CONCLUSIONS

To conclude, there are numerous simulators available to teach both technical and non-technical urological skills. Despite the need for more validation and comparative studies, evidence suggests that these simulators help trainees to bypass the early steps of the learning curve. In order to maximize the efficiency of these simulators, they should be incorporated within proficiency-based curricula alongside other initiatives such as clinical fellowships. By deepening the understanding of how simulation improves trainee performance, we can be sure to optimize the training for urology trainees in an increasingly restrictive educational environment.

### CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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