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Simulation: The Dawn of a New Era for Urological Training?

Abstract

The future training of urological surgeons balances on the verge of curricular revolution. Traditional Halstedian principles are no longer compatible with facilitating effective urological training within modernising surgical environments. Minimally invasive laparoscopic and endourological procedures remain dominant operative approaches for the treatment of many urological pathologies and continue to define the technologically advanced nature of the speciality. Indeed, it is expected that such procedures will continue to evolve, thereby increasing operational complexity and patient expectations of post-surgical outcome alike. The initial move to minimally invasive surgery, in conjunction with heightened patient expectations, has contributed to a concerning decline in primary operator exposure of the junior urologist, prompting educators to seek novel training techniques to compensate for operational experience deficits. Simulation is gaining a positive evidence-based reputation amongst the surgical community. Simulation has been shown to benefit both the junior and senior urologist, aiding acquisition of both technical and non-technical skills vital for safe and effective intraoperative performance prior to actual operation on patients. Whilst not a substitute for clinical practice, with optimised integration, simulation will prove a valuable adjunct to the selection and training of the urologist in the increasingly restrictive educational environment of modern surgery.

Introduction

The surgical trainee traditionally accumulated operative experience through adherence to the Halstedian master-apprenticeship philosophy of “see one, do one, teach one.” However, whilst this traditional construct bred surgical excellence for over a century, the current generation of educators has called into question the compatibility of Halsted learning theory (*Reznick et al. (2006)*). Over the past decade, there has been marked decline in trainee operating exposure time: a consequence of multifactorial origin. Introduction of the Calman Report for Specialist Training (2005) and integration of the European Working Time Directive into junior doctor contracts have facilitated the formulation of highly structured postgraduate training pathways at the expense of total time spent in training (*Shah et al. (2001)*). Furthermore, with the advent of minimally invasive surgery (MIS), multiple surgical specialties have witnessed an increase in operative complexity. Rising operative sophistication, in conjunction with the declining primary operator experiences of junior surgeons, is of mounting concern and a subject of growing debate amongst surgical educators: How might we ensure that the future generation of surgeons receive adequate primary operator exposure without jeopardising patient safety? Is it ethical in modern surgical practice to train on patients given MIS complexity, heightened patient expectations and intraoperative error risk inherent to junior led operation (*Preece (2015)*)? How might we train modern surgeons in ever-increasing restrictive educational environments without falling short of the standards of excellence set by our predecessors of Halstedian ethos? The answer is surgical simulation. The aim of this essay is to discuss the role of simulation in the future of surgical training, with specific application to the field of urology.

Success of Simulation in Non-Clinical Professions

Simulation, defined as the imitation or enactment of a defined real-world process (*Lallas (2016)*), is a valuable and well utilised training tool amongst many highly skilled professions. The aviation industry is a prime example in which simulation has been used to achieve workforce excellence; commercial and military pilots are required to pass mandatory full flight simulation modules before authorisation to in-flight training is permitted. Albeit a rather clichéd analogy, one cannot deny the similarities between the pilot and surgeon; both work in real-time three dimensional environments under physiological and psychological stress commanding expensive equipment with error ultimately measured in cost to human life (*Sommer (2014)*). Given the magnitude of overlap between the occupations and the demonstrated long-term success of simulation within aviation, one may ponder why simulation has not solidified a role within the selection and training urological surgeons.

Simulation in Surgical Training: A Changing Attitude?

It has been consistently demonstrated by multiple randomised control trials that "part task" simulation has significant augmentative training potential throughout many surgical specialties (urology, general and colorectal surgery, obstetrics and gynaecology (**Table 1**)). Why then has there been a paradoxical disagreement amongst educators concerning the suitability of simulation for surgical learning? Firstly, with a myriad of simulators available, each possessing a range of advantages and disadvantage in terms of cost, faculty requirements and fidelity (realism), there has been difficulty in assessing which simulators actually optimise training. Secondly, there are no universally accepted criteria at present to formally validate the training potential of individual simulators. Thirdly, general opinion of the surgical community was that, whilst simulation was advantageous in that it allowed for training without exposing patients to risk, there were gross oversimplifications of actual intraoperative reality, thereby inadequately preparing trainees for the pressures of the operating theatre. As argument endured, so has the delay of integrating simulation into the urology curriculum, however, with advances in simulative technologies, attitudes towards simulation are changing.

Study	***Simulator Platform***	***Aim of Study Design***	***Results***
Hamilton et al.(2002)	MIST-VR™ and laparoscopic box trainer	Laparoscopic cholecystectomy performed on patients prior to and after simulated training with either part-task laparoscopic box trainer or VR	Intraoperative performance significantly better and complication risk lower with prior training on both simple box and VR simulator
Grantcharov et al.(2004)	MIST-VR™	Laparoscopic cholecystectomy performed on patients prior to and after training on VR simulator or with no VR training (control group)	Operators in receipt of simulated training demonstrated enhanced intraoperative performance over the VR naïve control group
Sedlack et al.(2004)	VR sigmoidoscopy	Flexible sigmoidoscopy on patients performed by trainees exposed to simulation training vs those without prior exposure (control)	Trainees with simulation experience induced less patient discomfort than the simulation naïve trainees (control group)
Larson et al.(2009)	Lap-SIM™	Laparoscopic salpingectomy performed by trainees	Total intraoperative time was shorter and surgical performance was better

		with simulation vs those with normal clinical exposure (control)	in the VR trained group in comparison to the control
Kallstrom et al.(2010)	PelvicVision™	TURP performed on patients before and after simulation training or no prior exposure to simulation training	Improved surgical performance noted in those exposed to simulation
Feifer et al.(2010)	LapSIm™ + ProMIS™	20 urological operation naïve medical students received training on LapSIM, ProMIS or both, or neither (control), with performance measured before and after training	Conjunctive use of ProMIS and LapSIM improved robotic console performance in novice medical students compared to use of ProMIS and LapSIM in isolation
Franzeck et al.(2012)	ProMIS™ and LapSIM™	Assessment of laparoscope navigation skills on patients after exposure to simulation vs supervised practice on patients only (control)	Simulation trained group demonstrated greater skill than the theatre trained only control group

Table 1) Sample of randomised control trials demonstrating the augmentative role of virtual reality simulation in the development of laparoscopic psychomotor skills. In all trials, minimally invasive technical skills learnt in simulation were transferable to the operating theatre environment with improved intraoperative performance and patient safety metrics in comparison to simulation naïve control groups. One study even demonstrated significant improvement in basic MIS skills required for robotic assisted urology procedures in an operation naïve medical student cohort, reflecting the power of simulation as a training adjunct particularly within the infancy of surgical careers (adapted from Brewin et al.) (MIST-VR = Minimally Invasive Surgical Trainer – Virtual Reality, VR = Virtual Reality)

Evidence Favouring Simulation in Urological Training

Urology is well suited to simulation training as many common urological procedures are performed using MIS techniques, utilising either endourological (e.g. cystoscopy, TURP, PCNL, ureteroscopy) laparoscopic (nephrectomy) or robotic assisted (prostatectomy) approaches (*Brewin et al (2013)*). These operative techniques can now be mimicked with considerable authenticity due to evolution of MIS simulation technologies. Simulators can be simple (mechanical (synthetic/bench), cadaveric and animal tissue). Whilst cost-effective and widely available, these simulators demonstrate a low fidelity index i.e. are poorly reflective of real-life conditions. Conversely, complex simulators (hybrid (mechanical models with computer tracking), virtual reality (VR)) are expensive but benefit from high fidelity (*Gallagher et al. (2005)*).

Over the years, numerous urology specific training simulators of varying fidelity have been developed (**Table 2**). Three recent systematic reviews have been published that appraise the evidence for the use of simulation in the British and American urology training curricula. Schout et al. published a review of endourological simulators. Ahmed at al. reviewed all simulators and Abboudi et al. evaluated robotic simulators only. Collating the results of the three reviews revealed a consistent theme; whilst there are no validation criteria to distinguish between which simulators optimise training, practice with even low fidelity part-task urological simulators aided acquisition of laparoscopic psychomotor skills within the novice surgeon population. Importantly, 2 urology simulators in particular were associated with enhanced junior performance in the operating theatre; the VR-pelvic vision TURP simulator and URO mentor ureteroscopy simulator respectively (**Table 2**). The authors concluded that, if used in the early part of the learning curve, simulation can equip junior urologists with the basic psychomotor skills traits vital for conducting safe MIS prior to first operation on patients. Additionally, basic minimally invasive technical skills common to many urology procedures can be taught using low fidelity simulators (e.g. laparoscopic box trainer). Simulation can thus be a cost-effective adjunct to clinical training. These studies have significantly heightened the interest of surgical educational bodies in incorporating simulation into the UK urological training curriculum.

Procedure	***Simulator Technology Subgroup***	***Name/Manufacturer of Simulator***	***Evidence of Skills Transfer to Theatre***
Cystoscopy	VR Bench	URO mentor (Symbionix) URO trainer Limbs and Things Mediskills	
TURP	VR Bench	Pelvic vision UW-TURP trainer Limbs and Things	Yes
TURBT	VR Bench	URO mentor (Symbionix) Limbs and Things	
Ureteroscopy	VR Bench Models	URO mentor (Symbionix) Limbs and Things Mediskills University Toronto model	Yes
PCNL	VR Bench	PERC mentor (Symbionix) Limbs and Things Mediskills	
Laparoscopic Nephrectomy	VR	Procedicus MIST (Mentice) LAP mentor (Symbionix)	
Robotic Surgery	VR	dV-trainer (Mimic) dVSS (Intuitive Surgical) RoSS (simulated surgical systems)	

		SEP (Sim Surgery) ProMIS (CAE Healthcare) Surgical SIM RSS (METI)	
TRUS with prostate biopsy	VR	University of Western Ontario	

Table 2) List of urology specific training simulators subjected to evaluation by Schout et al., Ahmed et al. and Abouddi et al. These studies proved simulation to be highly beneficial to training and strongly support its integration into the current urological training curriculum. Additionally, 2 urological simulators (highlighted) were found to improve basic urological operative skill and demonstrated skill transference to the theatre environment, improving junior surgeon led intraoperative metrics. (Adapted from Brewin et al.) (TURP = Transurethral resection of prostate, TURBT = transurethral resection bladder tumour, TRUS = trans-rectal ultrasound, PCNL = percutaneous nephrolithotomy VR = virtual reality)

Simulation: A Selection Tool for Junior Urologist Recruitment?

The above evidence suggests early use of simulation endows the trainee with the basic MIS skills common to successful practice of urological surgery. By extrapolation, could simulation therefore help trainers to select candidates for urology training programmes?

As discussed previously, early use of simulation engenders trainees with technical skills in an environment that is patient risk-free, thereby bypassing the error prone early steps of the learning curve. This leads us onto the concept of the "pre-trained novice," whom demonstrates sufficient exposure to simulative training such that the psychomotor and spatial judgement skills needed for the practice of safe and effective MIS common to urological practice have been "automated" (**fig 1**). The pre-trained novice does not waste valuable operating time on initial refinement of technical skills, but instead dedicates a greater quantity of attentional resources to the learning of operative steps and the management of complications, thereby maximising uptake of higher surgical training experience per unit time of operation (*Gallagher et al (2005)*). Selection of urology trainees could thus be based upon candidates being able to demonstrate pre-trained novice competency in simulated urology themed MIS tasks prior to recruitment. These simulated urology modules could be completed as part of core surgical training, documented in the trainee's operative logbook prior to specialist training application (*Samia at al (2013)*). Selection based on such criteria would be advantageous to patient, trainee and trainer alike given the increasingly restrictive educational environment of modern surgery.

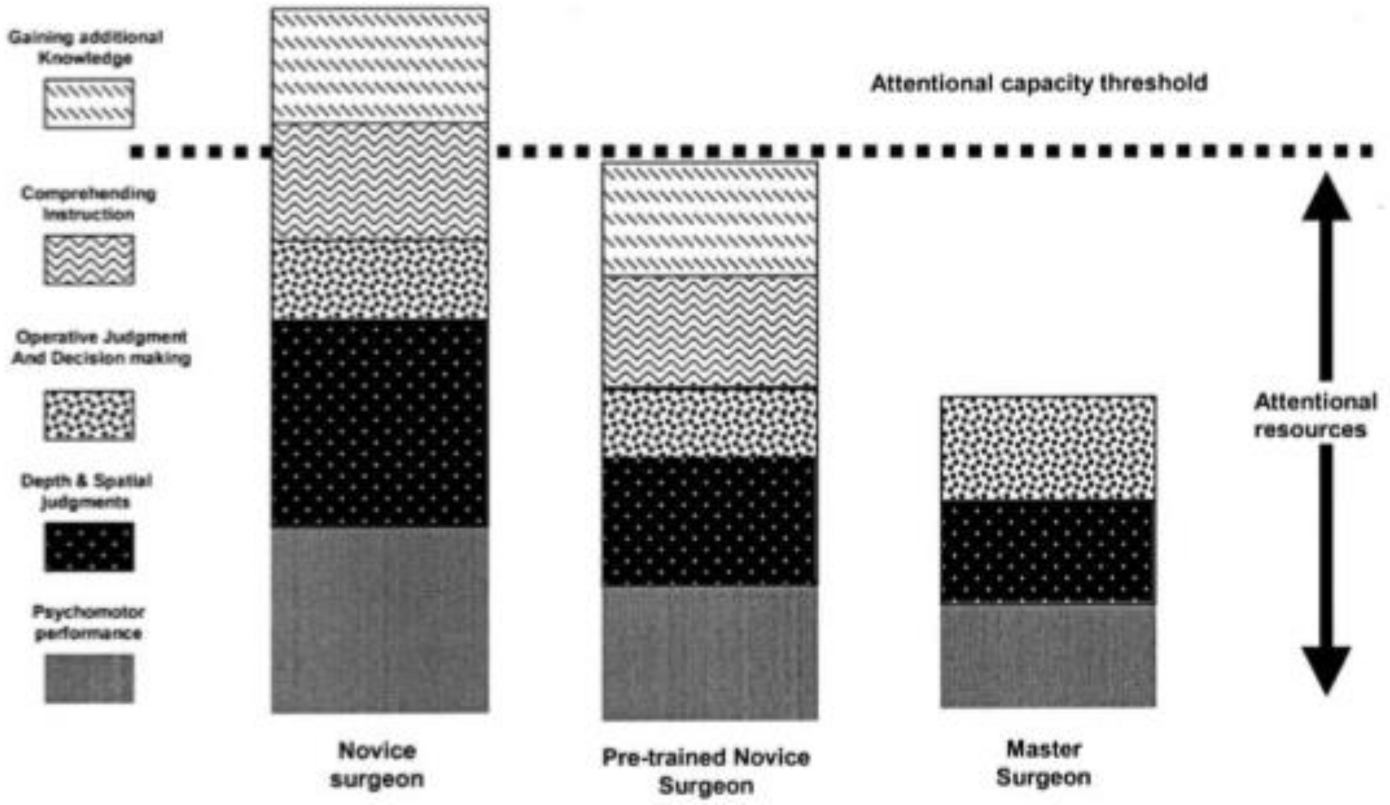

Fig 1.) Diagrammatic representation of attentional resources used by the master surgeon, the novice surgeon and the simulation exposed "pre-trained novice." When the novice trains to acquire new skills such as those needed for MIS, he utilises greater attentional resources to monitor his psychomotor performance, spatial judgements and operative decision making in comparison to the master surgeon, resulting in rapid saturation of the novice's attentional capacity and limitation of surgical training gain per unit of operation time. Simulation engenders the trainee with additional attentional resources; automation of basic psychomotor surgical competences allows the "pre-trained novice" to operate with increased educational gain with enhanced patient safety. (From Gallagher et al.)

Benefits of Simulated Training to the Senior Urologist

Whilst one cannot deny that enhanced patient safety and better post-operative outcomes are intimately associated with increased surgical technical skill, non-technical skills (NTS), comprising of cognitive, social and personal resource factors, are also vital for safe and effective surgical practice (**Table 3**). Human factor research has demonstrated that deficiencies in NTS account for a greater proportion of intraoperative errors than technical skill deficits (*Gawande et al (2003)*). Could simulation have a role to play in the development of surgical NTS?

Non-technical Skill (NTS)	***Description of NTS***	***Examples of good use of NTS***

		in theatre environment
Communication (social factor)	Ability to accurately deliver and clearly interpret information	Gives clear, concise instructions
Teamwork (social factor)	Coordination of team members to optimise team performance	Supports other team members Values and utilises other team members contributions to problem solving
Leadership (social factor)	Ability of primary surgeon/team leader to optimise team performance	Appropriate utilisation of resources Good time-management Authoritarian yet respectful
Situational awareness (cognitive factor)	Ability of the surgical team to accurately perceive the environment	Continual monitoring of patient Verbalises what is needed in the future
Decision making (cognitive factor)	The process of reaching a conclusive judgement/course of action with no ambiguity	Verbalises problem Communicates with others and implements decision Reviews and monitors decision outcome

Table 3) Examples of in-theatre non-technical skills vital for safe and effective surgical practice. Simulation has been shown to benefit the NTS repertoire of both junior and senior urologists, suggesting simulation may have augmentative potential at even the latter stages of the urological training curriculum (adapted from Brewin et al)

Contrary to popular belief, NTS are not innate products of personality. With appropriate training, NTS (and thus wider surgical team performance) can be improved. As in the aviation industry, simulation based team training has emerged as one of the best ways to improve surgical NTS (*Paige (2010)*). Much research effort has been invested within analysis of the effectiveness of simulation-based team training in surgery. Optimal NTS and team based training is dependent upon high fidelity simulation to recreate clinical scenarios of sufficient realism. Lee et al. and Gettmann et al. looked specifically at methods for encouraging urological NTS development. In both studies, urology trainees of various grades were required to conduct simulated laparoscopic nephrectomy and manage complications within a high fidelity simulated operating room upon a human patient manikin of an equal fidelity index (**Fig.2**). Realism was augmented with participation of members of the wider surgical team. In both studies, significant improvements in team performance were observed following participation in the simulated scenario. An additional finding of interest is that only technical performance, and not NTS performance, correlated with surgical seniority, suggesting that the practice of even senior urologists also benefit from simulation training. These studies reinforced the benefits of simulation as a valuable surgical training adjunct beyond the scope of junior training.

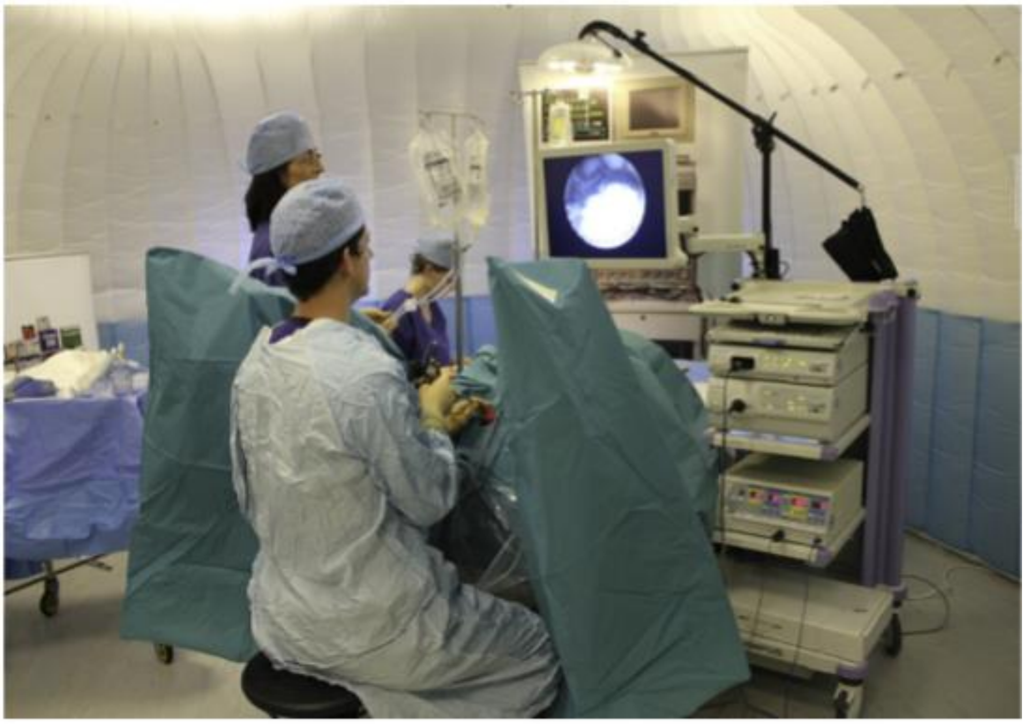

Fig 2.) Simulated urology operating suite portraying the outstanding fidelity level established in the NTS simulation training studies conducted by Lee et al. and Gettmann et al. Note the participation of the wider operating team, further enhancing simulator realism. Simulated NTS training has been shown to augment intraoperative practice of even the most senior urologist, reinforcing the power of simulation as a urological training adjunct (from et al).

Summary

There is a growing evidence base in support of simulation as a time efficient, cost effective and safe method of training. Junior trainee use of part-task simulators can shorten the learning curve associated with uptake of basic MIS technical skills in an environment that does not compromise patient safety. High fidelity team based simulation training can improve non-technical skills which are of equal importance to surgical trainees in ensuring excellent postoperative outcomes. Whilst further research is required regarding simulator validation, there is little doubt that simulation will revolutionise and optimise the selection and training of the future urologist in the increasingly restrictive educational environment that is modern surgical practice.

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