What Role Should Simulation Play In The Selection And Training of Urologists?

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Abstract

Changing patterns of health care provision and rapid evolution of urological surgical techniques have resulted in trainees seldom receiving independent surgical experience. A drive toward senior-led care and restrictions on working hours have required a greater breadth of skills to be mastered in a shorter training period. Simulation affords the opportunity to compensate for this reduction in operative experience, developing surgical skills while minimising patient risk, financial expenditure and operating theatre use. A variety of simulation models may be used from cadaveric, synthetic and animal models to advanced virtual reality. While this form of training has limitations, it has potential to significantly aid procedural competence prior to real-life practice. Clear benefits, including improvements to equipment familiarity and trainee confidence, have been demonstrated, although direct transferability to operating-theatre performance is not conclusively evidenced. With advances in technology, simulation is likely to significantly aid the current and future selection and training of urologists.

I. Introduction

Urologist training has evolved considerably since the Halstedian apprenticeships of the early surgeons. At present expertise is developed through a complex programme of teaching and assessments. Yet as trainee numbers rise, opportunities to advance procedural and technical skills become increasingly scarce. Concurrently the widespread development of novel techniques and a trend toward minimally invasive urological procedures has required mastery of a progressively broader repertoire of specialist skills (Wignall et al. 2008). Gaining of proficiency in ureteroscopy, for example, is rendered more challenging due to the loss of depth perception and tactile feedback available in traditional 3-dimensional procedures (McDougall 2007) .

Furthermore, implementation of the European Working Time Directive (EWTD)(The Association of Surgeons of Great Britain and Ireland 2008) across Europe and introduction of the 80 hour per week limit by the Accreditation Council For Graduate Medical Education (ACGME)(Philibert et al. 2002) in the USA have limited the number of training hours available during the designated training period. A move to reduce ‘out of hours’ operating, increasing patient reluctance to being ‘practiced on’(Gallagher & Traynor 2008) and a paradigm shift from consultant-led to consultant-delivered care in the UK has resulted in trainees seldom gaining independent surgical experience. Taken together, the number of hours of training a surgical trainee may expect to have completed prior to consultancy has fallen from 30,000 to 8,000 (Chikwe et al. 2004). These constraints have forced adjustment to a more rigorous, competency-focused assessment of proficiency, rather than an assumption of aptitude through experience.

Innovation broadening the number of occasions where surgical intervention may be indicated, coupled with an ageing population more expectant of remedial treatment, has heightened demand leading to a conflict between service provision and training. Reform is therefore necessary to ensure that surgical trainees are sufficiently equipped to act autonomously upon completion of their training and subsequently deliver instruction. Several solutions, including e-learning and compulsory fellowship training programs, have been proposed to augment

TABLE I. The advantages and disadvantages of the main simulation modalities available to urology trainees

Model	Examples	Advantages	Disadvantages	Uses
Cadaveric simulation	Fresh frozen human cadavers	High fidelity Shown to develop transferable operative skills Permits understanding of relevant clinical anatomy and surgical approaches Entire operations can be practiced	Cost Not easily accessible Specialist storage demands Time-consuming preparation Relies on tissue donation Risk of disease transmission Lack of uniformity amongst specimens Single use	Continuing medical education Advanced procedural knowledge and dissection
Synthetic simulation	Peg boards Inanimate models Synthetic suturing mats	Widely available Portable Reusable Wide range of procedures may be possible Modern simulators can provide haptic feedback Relatively inexpensive Develop understanding and familiarity with surgical instruments and equipment Able to record progress and assess motion analysis Allows for development of hand-eye co-ordination and triangulation	Often low fidelity High initial setup cost Lack of true haptic feedback	Basic skills for novice learners Discrete skills
Virtual reality	Computer-based simulation models	Reusable Minimal setup time Instant performance feedback Able to record progress and assess motion analysis Wide range of procedures may be possible Allows for scenario simulation of a whole task	Maintenance High initial setup cost Unreliable hepatics	Discrete skills Procedural training
Animal	Discrete skills Procedural training	High fidelity Complete procedure simulation	Not reusable Animal anatomical differences Cost Special facilities required Ethical concerns	Advanced procedural knowledge Dissection skills
Cognitive simulation	Mentally rehearsing	Potentially cost free Point of care education Accessible on mobile devices	Limited evidence to support improvement in technical procedural skills or use in clinical training	Basic procedural understanding

learning opportunities within existing resource restraints. One such solution, simulation, affords the opportunity to repeatedly practice a novel procedure before operating on patients while improving confidence, maintaining patient-safety (Dawe et al. 2014) and bypassing the error-prone phase of the learning curve (Aggarwal & Darzi 2006). With high-fidelity simulators it may even be possible for non-technical skills including communication, leadership and multi-disciplinary teamwork to be practiced to complement procedural proficiency (Arora et al. 2011). As the benefits are well recognized in many specialties including anesthetics (Gaba et al. 1996), emergency medicine (Small et al. 1999) and general surgery (Reznick & MacRae 2006), simulation is advocated by many royal colleges and governing medical bodies in the UK (Donaldson 2008).

As several simulator modalities are available, with disparate advantages and disadvantages, each must undergo thorough evaluation through validation studies (Wignall et al. 2008) prior to utilisation. A summary of currently available simulation models for urology surgery can been seen in Table I.

II. CURRENT SELECTION PROCESS

There are at present 31 core surgical posts themed toward urology in the UK. Entry to specialty training is highly competitive, with selection predicated on the candidate's application form, references and interview/selection centre performance. The interviews include a portfolio assessment, a simulated clinical scenario, an appraisal of communication skills and an evaluation of practical proficiency. The domains assessed include (Anon. 2016):

- Clinical knowledge and expertise
- Contributions towards research, auditing and teaching
- Organisation, leadership and problem solving
- Professional probity
- Evidence of a personal and learning commitment to urology

Thus aptitude for practical skills, attendance at relevant courses, evidence of relevant research achievements, demonstration of judgment under pressure and a realistic insight into urology are all prerequisite. Although integration of simulation in surgical training is not a new concept (e.g. cadaveric dissection) the relative infancy (Sairam 2015) of modern simulation techniques renders the use of simulation in assessment of prospective trainees controversial. This uncertainty necessitates their strict validation as a predicative tool, as minor simulation infidelity could result in improper candidate selection (Macmillan & Cuschieri 1999).

Nevertheless, Virtual Reality (VR) has been suggested to adequately predict operative skill of prospective specialist applicants (Jacomides et al. 2004). Video-assessment and motion capture may objectively and reliably correlate to surgical performance, although wide-scale evidence for this is limited (Khan et al. 2013). Using a variety of simulation modalities including VR, Robotic Simulators and Bench-top models, senior clinicians performed significantly better than their junior colleagues in all sessions ($P < 0.001$) (Khan et al. 2013). Indeed a number of assessment tools to objectively evaluate technical skills learnt via surgical simulation have been developed including the Global Rating Scale Of Performance (GRS) and the Objective Structured Assessment Of Technical Skills (OSATS). Each involves scoring against pre-set criteria by a trained assessor. Specifically, the GRS checklist is comprised of specific surgical behaviours while OSATS focuses on a set of manoeuvres considered essential elements of a procedure. Each tool has been demonstrated to reduce the bias associated with direct observation by experts alone (Reznick et al. 1997)·(Doyle et al. 2007).

III. UTILISING SIMULATION

For many procedures the benefits of simulation are already well recognised. Numerous high-fidelity simulators, including the Uro-Scopic Trainer (Limbs and Things, UK), have been validated for use in endourological procedural practice (White et al. 2010). Indeed, repeated training for semi-rigid ureteroscopy with bench-top simulators significantly improves trainee confidence and performance (Brehmer & Swartz 2005). Similarly, novice exposure to the VR URO-Mentor (Simbionix, USA) for flexible cystoscopy improves time to procedure completion, increases global rating scores and decreases rates of trauma (Schout et al. 2010). Performance on real patients also improves (Schout et al. 2010). Intriguingly, progress using simulation is comparable between different simulators despite high variance in cost (Chou et al. 2006), (Matsumoto et al. 2002).

As the mean number of Transurethral Resection of the Prostate (TURP) operations performed by a trainee prior to consultancy halved from 1990-2000 (Sweet et al. 2002), a simulation model, TURPsim™ VR simulator (Simbionix, USA) has been introduced to compensate for lost operative experience. Experts using this model perform significantly better than novices, while the latter improve gradually with repeated attempts (Bright et al. 2012). Similarly in one study, following practice using the PelvicVision TURP VR simulator (Meleritmedical AB), 65% more trainees were able to perform TURP (Källström et al. 2010).

A further role for simulation has been established in percutaneous nephrolithotomy, a procedure in which only 11% of urologists routinely gain percutaneous renal access without radiologist assistance (Bird et al. 2003). Using the PERC Mentor™ VR renal access simulator (Mentor Graphcs, USA), novice performance improved for several metrics including fluoroscopy time (Mishra et al. 2010). Subsequent to this practice, all trainees were able to safely obtain access in a pig model (Mishra et al. 2010).

The increasing adoption of robotic-assisted urological techniques lends itself to practice via simulation (Hung et al. 2011). For example, VR modeling using the DV-Trainer (Mimic Technologies, Inc., Seattle, WA) improves surgeon proficiency using the da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA)(Cho et al. 2013). There are however limits to the utility of some simulation models. While laparoscopy training using low-fidelity box-simulators improves specific skills (e.g. suturing) (Laguna et al. 2006) overall operative proficiency remains unchanged (Traxer et al. 2001). Conversely, VR-simulation of laparscopy has been rated both useful and of above average realism (Brewin et al. 2010).

Encouragingly, between 94-100% of trainees consider simulations including the whole surgical team in mock operating theaters useful for development of non-technical skills (Gettman et al. 2009). Significant improvements in equipment setup and teamwork ratings have been described. As non-technical skills do not necessarily correlate with seniority (Lee et al. 2012), more experienced trainees may also benefit from this modality of simulation.

IV. Challenges

As the selection and training applications of modern simulation are in their relative infancy, little consensus on how they might be validated has been reached. While many approaches have been adopted, the difficulty, expense and ethical uncertainty associated with conducting randomized trials to establish the impact of specific simulators has obligated educators to select methods on personal preference (Brewin et al. 2014). Furthermore, use of simulation demands additional equipment, a suitable environment and faculty resources (Ahmed et al. 2011).

It should be noted that the requirements for certification upon completion of training will not be met by simulation alone. The learning curve associated with more complex urological procedures, such as the avoidance of prostate cancer recurrence following radical prostatectomy, has been shown to plateau only after performing around 250 procedures (Vickers et al. 2007), and may not therefore be possible to bypass.

V. Incorporating Simulation

While there is little doubt that simulation has a significant role to play in both the recruitment and training of urologists, it will likely act as an adjunct to, rather than replacement of, traditional techniques. Continued advances in technology will further enhance realism and availability and thus help to compensate for reduced real-time theatre experience (Kneebone et al. 2004). Simulation should be included in modern proficiency-based curricula, with trainees ideally receiving repeated exposure over an extended period (McGaghie et al. 2010).
Feedback on performance would thereby enable appropriate targeted learning, with basic surgical skills taught via low-fidelity models prior to

progressing onto full-procedural simulations (McGaghie et al. 2010). At present, trainees in the UK may record simulation experience into the Intercollegiate Surgical Curriculum Program Logbook (Anon n.d.). A centrally-coordinated urology simulation programme, SIMULATE, that describes a potential structured delivery method of non-technical and technical skills is now considered feasible, acceptable and able to display construct validity (Khan et al. 2013).

VI. Concluding Remarks

Nevertheless, evidence for the value of simulation as a transferable measure of proficiency in the operating theatre remains limited. Simulation often focuses on the technical aspect of surgery in isolation, failing to adequately replicate the many other components that must be managed for operative success. This restriction may be ameliorated through greater emphasis on integration of other elements including consent and pre-operative planning, consideration of alternative management options and intra-operative communication. Further research should assess the transfer of skills from simulation into practical settings, the impact on patient safety and validation of simulation fidelity.

References

Aggarwal, R. & Darzi, A., 2006. Technical-skills training in the 21st century. *The New England journal of medicine*, 355(25), pp.2695–6. Available at: http://www.ncbi.nlm.nih.gov/pubmed/17182997 [Accessed April 2, 2016].

Ahmed, K. et al., 2011. How to develop a simulation programme in urology. *BJU international*, 108(11), pp.1698–702. Available at: http://www.ncbi.nlm.nih.gov/pubmed/21871051 [Accessed April 3, 2016].

Anon, Intercollegiate Surgical Curriculum Programme (ISCP). Available at: https://www.iscp.ac.uk/.

Anon, PERSON SPECIFICATION 2016 UROLOGY – ST3.

Arora, S. et al., 2011. Framework for incorporating simulation into urology training. *BJU international*, 107(5), pp.806–10. Available at: http://www.ncbi.nlm.nih.gov/pubmed/20868386 [Accessed April 2, 2016].

Bird, V.G., Fallon, B. & Winfield, H.N., 2003. Practice patterns in the treatment of large renal stones. *Journal of endourology / Endourological Society*, 17(6), pp.355–63. Available at: http://www.ncbi.nlm.nih.gov/pubmed/12965059 [Accessed April 3, 2016].

Brehmer, M. & Swartz, R., 2005. Training on bench models improves dexterity in ureteroscopy. *European urology*, 48(3), pp.458–63; discussion 463. Available at: http://www.ncbi.nlm.nih.gov/pubmed/15964129 [Accessed April 3, 2016].

Brewin, J. et al., 2010. Face, content and construct validation of the first virtual reality laparoscopic nephrectomy simulator. *BJU international*, 106(6), pp.850–4. Available at: http://www.ncbi.nlm.nih.gov/pubmed/20128776 [Accessed April 3, 2016].

Brewin, J., Ahmed, K. & Challacombe, B., 2014. An update and review of simulation in urological training. *International journal of surgery (London, England)*, 12(2), pp.103–8. Available at: http://www.ncbi.nlm.nih.gov/pubmed/24316286 [Accessed April 3, 2016].

Bright, E. et al., 2012. Face validity, construct validity and training benefits of a virtual reality TURP simulator. *International journal of surgery (London, England)*, 10(3), pp.163–6. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22366646 [Accessed April 3, 2016].

Chikwe, J., Souza, A.C. de & Pepper, J.R., 2004. No time to train the surgeons. *BMJ*, 328(7437), pp.418–419. Available at: http://www.bmj.com/cgi/doi/10.1136/bmj.328.7437.418 [Accessed April 2, 2016].

Cho, J.S. et al., 2013. Virtual reality training improves da Vinci performance: a prospective trial. *Journal of laparoendoscopic & advanced surgical techniques. Part A*, 23(12), pp.992–8. Available at: http://www.ncbi.nlm.nih.gov/pubmed/24138400 [Accessed April 3, 2016].

Chou, D.S. et al., 2006. Comparison of results of virtual-reality simulator and training model for basic ureteroscopy training. *Journal of endourology / Endourological Society*, 20(4), pp.266–71. Available at: http://www.ncbi.nlm.nih.gov/pubmed/16646655 [Accessed April 3, 2016].

Dawe, S.R. et al., 2014. Systematic review of skills transfer after surgical simulation-based training. *The British journal of surgery*, 101(9), pp.1063–76. Available at: http://www.ncbi.nlm.nih.gov/pubmed/24827930 [Accessed April 2, 2016].

Donaldson, L C.M.O., 150 years of the Annual Report of the Chief Medical Officer: On the state of public health 2008

Doyle, J.D., Webber, E.M. & Sidhu, R.S., 2007. A universal global rating scale for the evaluation of technical skills in the operating room. *American journal of surgery*, 193(5), pp.551–5; discussion 555. Available at: http://www.ncbi.nlm.nih.gov/pubmed/17434353 [Accessed April 3, 2016].

Gaba, D.M. et al., 1996. Simulation-based training in anesthesia crisis resource management (ACRM): A decade of experience. *Gaba & DeAnda Good & Gravenstein*.

Gallagher, A.G. & Traynor, O., 2008. Simulation in surgery: opportunity or threat? *Irish Journal of Medical Science*, 177(4), pp.283–287. Available at: http://link.springer.com/10.1007/s11845-008-0204-5 [Accessed April 2, 2016].

Gettman, M.T. et al., 2009. Use of high fidelity operating room simulation to assess and teach communication, teamwork and laparoscopic skills: initial experience. *The Journal of urology*, 181(3), pp.1289–96. Available at: http://www.ncbi.nlm.nih.gov/pubmed/19152929 [Accessed April 3, 2016].

Hung, A.J. et al., 2011. Face, content and construct validity of a novel robotic surgery simulator. *The Journal of urology*, 186(3), pp.1019–24. Available at: http://www.ncbi.nlm.nih.gov/pubmed/21784469 [Accessed April 3, 2016].

Jacomides, L. et al., 2004. Use of a Virtual Reality Simulator for Ureteroscopy Training. *The Journal of Urology*, 171(1), pp.320–323. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0022534705627255 [Accessed April 3, 2016].

Källström, R., Hjertberg, H. & Svanvik, J., 2010. Impact of virtual reality-simulated training on urology residents' performance of transurethral resection of the prostate. *Journal of endourology / Endourological Society*, 24(9), pp.1521–8. Available at: http://www.ncbi.nlm.nih.gov/pubmed/20677993 [Accessed April 3, 2016].

Khan, S. et al., 2013. Development and implementation of centralized simulation training: evaluation of feasibility, acceptability and construct validity. *BJU International*, 111(3), pp.518–523. Available at: http://doi.wiley.com/10.1111/j.1464-410X.2012.11204.x [Accessed April 3, 2016].

Khan,S., 2015. Simulation - the need for a paradigm shift in urological training. *Central European journal of urology*, 68(2), p.213. Available at: http://www.ncbi.nlm.nih.gov/pubmed/26251747 [Accessed April 3, 2016].

Kneebone, R.L. et al., 2004. Simulation and clinical practice: strengthening the relationship. *Medical education*, 38(10),

pp.1095–102. Available at: http://www.ncbi.nlm.nih.gov/pubmed/15461655 [Accessed April 3, 2016].
Laguna, M.P. et al., 2006. Construct validity of the chicken model in the simulation of laparoscopic radical prostatectomy suture. *Journal of endourology / Endourological Society*, 20(1), pp.69–73. Available at: http://www.ncbi.nlm.nih.gov/pubmed/16426137 [Accessed April 3, 2016].
Lee, J.Y. et al., 2012. High fidelity simulation based team training in urology: a preliminary interdisciplinary study of technical and nontechnical skills in laparoscopic complications management. *The Journal of urology*, 187(4), pp.1385–91. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22341287 [Accessed April 3, 2016].
Macmillan, A.I. & Cuschieri, A., 1999. Assessment of innate ability and skills for endoscopic manipulations by the Advanced Dundee Endoscopic Psychomotor Tester: predictive and concurrent validity. *American journal of surgery*, 177(3), pp.274–7. Available at: http://www.ncbi.nlm.nih.gov/pubmed/10219869 [Accessed April 3, 2016].
Matsumoto, E.D. et al., 2002. The effect of bench model fidelity on endourological skills: a randomized controlled study. *The Journal of urology*, 167(3), pp.1243–7. Available at: http://www.ncbi.nlm.nih.gov/pubmed/11832706 [Accessed April 3, 2016].
McDougall, E.M., 2007. Validation of Surgical Simulators. *Journal of Endourology*, 21(3), pp.244–247. Available at: http://www.liebertonline.com/doi/abs/10.1089/end.2007.9985 [Accessed April 2, 2016].
McGaghie, W.C. et al., 2010. A critical review of simulation-based medical education research: 2003-2009. *Medical education*, 44(1), pp.50–63. Available at: http://www.ncbi.nlm.nih.gov/pubmed/20078756 [Accessed April 3, 2016].
Mishra, S. et al., 2010. Validation of virtual reality simulation for percutaneous renal access training. *Journal of endourology / Endourological Society*, 24(4), pp.635–40. Available at: http://www.ncbi.nlm.nih.gov/pubmed/20218892 [Accessed April 3, 2016].
Philibert, I. et al., 2002. New requirements for resident duty hours. *JAMA*, 288(9), pp.1112–4. Available at: http://www.ncbi.nlm.nih.gov/pubmed/12204081 [Accessed April 2, 2016].
Reznick, R. et al., 1997. Testing technical skill via an innovative "bench station" examination. *American journal of surgery*, 173(3), pp.226–30. Available at: http://www.ncbi.nlm.nih.gov/pubmed/9124632 [Accessed April 3, 2016].
Reznick, R.K. & MacRae, H., 2006. Teaching surgical skills--changes in the wind. *The New England journal of medicine*, 355(25), pp.2664–9. Available at: http://www.ncbi.nlm.nih.gov/pubmed/17182991 [Accessed April 2, 2016].
Schout, B.M.A., Muijtjens, A.M.M., et al., 2010. Acquisition of flexible cystoscopy skills on a virtual reality simulator by experts and novices. *BJU international*, 105(2), pp.234–9. Available at: http://www.ncbi.nlm.nih.gov/pubmed/19583729 [Accessed April 3, 2016].
Schout, B.M.A., Ananias, H.J.K., et al., 2010. Transfer of cysto-urethroscopy skills from a virtual-reality simulator to the operating room: a randomized controlled trial. *BJU international*, 106(2), pp.226–31; discussion 231. Available at: http://www.ncbi.nlm.nih.gov/pubmed/19912184 [Accessed April 3, 2016].
Small, S.D. et al., 1999. Demonstration of high-fidelity simulation team training for emergency medicine. *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine*, 6(4), pp.312–23. Available at: http://www.ncbi.nlm.nih.gov/pubmed/10230983 [Accessed April 2, 2016].
Sweet, R. et al., 2002. Simulation of bleeding in endoscopic procedures using virtual reality. *Journal of endourology / Endourological Society*, 16(7), pp.451–5. Available at: http://www.ncbi.nlm.nih.gov/pubmed/12396436 [Accessed April 3, 2016].
The Association of Surgeons of Great Britain and Ireland, 2008. The Impact of EWTD on Delivery of Surgical Services: A Consensus Statement. , pp.1–24. Available at: http://www.asgbi.org.uk/download.cfm?docid=F3FAB184-01E1-414A-BA7C0CE07BBEDD7F.
Traxer, O. et al., 2001. The impact of intense laparoscopic skills training on the operative performance of urology residents. *The Journal of urology*, 166(5), pp.1658–61. Available at: http://www.ncbi.nlm.nih.gov/pubmed/11586196 [Accessed April 3, 2016].
Vickers, A.J. et al., 2007. The surgical learning curve for prostate cancer control after radical prostatectomy. *Journal of the National Cancer Institute*, 99(15), pp.1171–7. Available at: http://www.ncbi.nlm.nih.gov/pubmed/17652279 [Accessed April 3, 2016].
White, M.A. et al., 2010. Validation of a high fidelity adult ureteroscopy and renoscopy simulator. *The Journal of urology*, 183(2), pp.673–7. Available at: http://www.ncbi.nlm.nih.gov/pubmed/20022047 [Accessed April 3, 2016].
Wignall, G.R. et al., 2008. Surgical Simulation: A Urological Perspective. *The Journal of Urology*, 179(5), pp.1690–1699.

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