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Editorial

Introduction, availability and role of simulation in surgical education and training: Review of current evidence and recommendations from the Association of Surgeons in Training

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A B S T R A C T

The utility of simulation in surgical training is now well-established, with proven validity and demonstrable transfer of skills to the clinical setting. Through a reduction in the technical learning curve, simulation can prepare surgeons for actual practice and in doing so it has the potential to improve both patient safety and service efficiency. More broadly, multi-disciplinary simulation of the theatre environment can aid development of non-technical skills and assist in preparing theatre teams for infrequently encountered scenarios such as surgical emergencies. The role of simulation in the formal training curriculum is less well-established, and availability of facilities for this is currently unknown. This paper reviews the contemporary evidence supporting simulation in surgical training and reports trainee access to such capabilities. Our national surgical trainee survey with 1130 complete responses indicated only 41.2% had access to skills simulator facilities. Of those with access, 16.3% had availability out-of-hours and only 54.0% had local access (i.e. current work place). These results highlight the paucity in current provision of surgical skills simulator facilities, and availability (or awareness of availability) varies widely between region, grade and specialty. Based on these findings and current best-evidence, the Association of Surgeons in Training propose 22 action-points for the introduction, availability and role of simulation in surgical training. Adoption of these should guide trainers, trainees and training bodies alike to ensure equitable provision of appropriate equipment, time and resources to allow the full integration of simulation into the surgical curriculum.

1. Introduction to ASiT

The Association of Surgeons in Training (ASiT) is a professional body and registered charity working to promote excellence in surgical training for the benefit of junior doctors and patients alike. With a membership of over 2000 surgical trainees from all 10 surgical specialities, the association provides support at both regional and national levels throughout the United Kingdom and Republic of Ireland. Originally founded in 1976, ASiT is independent of the National Health Service (NHS), Surgical Royal Colleges, and specialty associations. Governed by an elected Executive and Council, the association is run by trainees for trainees.

2. Background to simulation in surgical training and education statement

Simulation in surgical training has gained much interest in recent years. This paper discusses the potential for integrating simulation into the various facets of surgical practice, and its role in both the recruitment process and on-going training of Core and Speciality surgical trainees. Simulation may also have roles in revalidation of licensed doctors although this falls outside of our remit.

In the United Kingdom (UK) the Joint Committee on Surgical Training (JCST) has agreed to integrate simulation into the Intercollegiate Surgical Curriculum Project (ISCP) across all specialties, and this paper is therefore timely.

Although primarily discussing the role of simulation within the setting of UK surgical training, the topics and recommendations herein reflect the current debate in many countries as new technologies and educational methods are integrated into training. We therefore hope this statement will aid discussions on trainee perspectives regarding the future role of simulated surgical practice across the range of international stake holding training organisations.

The relevant structure and pathways through surgical training in the UK have been described in a previous ASiT statement addressing the future of surgical training.[1]

3. Simulated surgical practice

Simulated surgical practice encompasses any activity which aims to imitate a system or environment with the aim of assessing, informing and modifying skills and behaviours. The multitude of research articles on simulation in surgical selection and training attest to the interest and wide application of simulated methods that can be

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Glossary of abbreviations used

ASiT	Association of Surgeons in Training
CCT	Certificate of Completion of Training
CEX	Clinical Evaluation Exercise
CST	Core Surgical Training
EWTD	European Working Time Directive
FRCS	Fellowship of the Royal College of Surgeons
GMC	General Medical Council
ISCP	Intercollegiate Surgical Curriculum Project
JCST	Joint Committee on Surgical Training
MRCS	Membership of the Royal College of Surgeons
NHS	National Health Service
PBA	Procedural-based Assessment
SAC	Specialist Advisory Committee
SBA	Simulation-based Assessments
WBA	Workplace-based Assessment

utilised. A Cochrane review identified over 30 randomised controlled trials studying different aspects of surgical simulation,[2] while other systematic reviews have confirmed both the effectiveness of training[3] and transfer of skills to the operative setting.[4] At a basic level, simulation fidelity is less important with no significant difference in laparoscopic skills acquisition between box-trainers and virtual reality simulation.[5,6] Box training is, however, more cost-effective while virtual reality training is more efficient.[7]

Simulation in surgical practice includes both operative and non-operative models and may incorporate multi-speciality and multi-disciplinary scenarios. Current examples of these include the EMERGO/MAJAX major incident training days.[8] Operatively, simulation may occur in many locations including: dedicated wet or dry labs in specialist simulation laboratories, within working theatres and even in the trainee's home either using cheap, basic jigs, or increasingly sophisticated computer equipment.

Non-technical simulation has traditionally received less recognition but as non-technical skills are increasingly assessed in surgical practice this is likely to reflect an area of future development.[9] The non-technical aspects of surgeons' performance in the operating theatre is an evolving area of research although a recent systematic review suggested that certain non-technical skills can enhance or detract from technical performance.[10] Considerable work has been undertaken in order to develop methods that objectively assess non-technical skills. The NOTSS (NOn-Technical Skills for Surgeons), NOTECHS (NOn-TECHnical Skills) and OTAS (Observational Teamwork Assessment in Surgery) have all been utilised and validated in centres around the world.[11] Increasing patient safety through simulation in non-technical skills will become crucial.

In recent years direct comparisons have been drawn between the management of risk in surgical practice and the aviation industry,[12] which recognises that over 80% of errors occur due to human factors.[13] The safety culture promoted by the airline industry provides an environment that encourages the reporting and analysis of errors. As part of this, their use of simulated training has made for many effective collaborations allowing cross-over of information and techniques with surgery. Whilst similarities between the aviation industry and surgery exist, especially in the study of human factors in risk management, care must be taken to sensibly apply tailored solutions, specific and relevant to surgical practice. Lessons from other professions including the armed forces and the fire brigade which depend upon intensive simulation training prior to real exposure may also benefit surgical training.

4. The need for simulation in surgical practice

ASiT has already strongly endorsed the opinion that high quality simulation programmes must be part of future surgical training.[1] Trainees are positive about the benefits of simulation and have been shown to value skills acquisition from simulation training. Trainees are keen to emphasise that simulation is only an adjunct to and not a replacement for clinical operative training.[14,15]

European Working Time Regulations (EWTR) have substantially reduced the duty-hours and subsequent clinical exposure of surgical trainees.[16,17] Surgery, as an experience dependent craft-speciality is affected more than others in medicine. There is a need for exposure to a wide range of procedures for a trainee to gain the competencies required to operate safely and independently. Reduced working hours have a significant impact on the amount of time a surgeon in training can spend in the operating theatre prior to their Certificate of Completion of Training (CCT). The need to attain specific operative competencies within a restricted and curtailed training period leaves trainees needing to seek out novel and innovative methods to help ensure the adequacy of their training.

Trainees want to maximise all training opportunities in the clinical setting and having pre-developed basic skills acquired on a simulator can help facilitate this. It is becoming apparent that self-directed simulation training away from patients may be an alternative to compensate for reduced time under direct supervision.

Recent efforts to emphasise the crucial role of the surgical trainer seek to redress the realisation that this function is often undervalued and forgotten. Training requires dedicated and motivated trainers to succeed. However, time allowed for training in consultant job plans is often poorly recognised. ASiT has long commended excellence in surgical training through the annual ASiT Silver Scalpel 'Surgical Trainer of the Year' Award. The concept of better promoting, recognising and rewarding excellence in training has recently been embraced by the Royal College of Surgeons of Edinburgh with the much needed introduction of the Faculty of Surgical Trainers.[18]

The well-being of the patient is paramount in all clinical encounters, both to trainers and trainees. Trainees do not want to be immersed in a situation in which they feel their training has not been adequate for a given task and where patients may ultimately suffer. Therefore, preparedness for clinical scenarios gained through simulation can be beneficial to trainees' confidence, well-being and ultimately the safety of patients.

5. Surgical simulation: availability and access in the UK

In order to assess current availability and access to surgical simulation and skills training facilities, specific questions were included in an electronic, 47-item, self-administered national training survey. All junior doctors in surgical training (i.e. pre-CCT) in the UK were invited to participate in this anonymous, non-mandatory survey through surgical mailing lists and websites by the Association of Surgeons in Training and Specialty Associations. Responses were collected through the SurveyMonkey web-survey portal (SurveyMonkey.com, LLC, Palo Alto, California, USA).

Of 1295 questionnaires submitted, 1130 were appropriately completed sufficient for further analysis. Overall only 466 (41.2%) of respondent had access to a skills simulator facility. Of those with access, only 111 (16.3%) had availability out-of-hours (i.e. after 5 pm weekdays and at weekends), while 295 (43.3%) did not and 275 (40.4%) did not know. Of those with surgical simulation and skills training facilities 337 (54.0%) had local access (i.e. current

place of work), 252 (40.4%) had access regionally and 35 (5.6%) only had access outside of their own training region.

These results indicate that overall, there is a paucity in the current provision of surgical skills simulator facilities, and availability (or awareness of availability) varies widely between regions, as detailed in Table 1.

The penetrance of surgical skills simulation also differs markedly between surgical specialties. While none have evidence of uniform deployment of simulation training, the majority of paediatric (63.0%) and urological (53.3%) trainees report access to simulation training facilities, compared to only a small minority of plastic surgery (21.0%) and neurosurgical trainees (16.0%). This data is presented in Table 2.

Considering grades of trainee in recognised training posts, at all levels of training the majority of respondents do not have access to simulation training facilities. Access was most frequently reported by those in the first 3-years of higher surgical specialty training where up to 45.5% have facilities available to them (Table 3).

These findings suggest considerable room for improvement in the provision of surgical skills simulation facilities across the UK. Where facilities do exist, the results may also reflect a lack of awareness amongst trainees and therefore improvements in regional publicity may be required. Similarly concerning is the provision of facilities that then cannot be accessed out-of-hours, preventing opportunities for self-directed learning outside the busy daily schedule of routine clinical practice and limiting educational return on investment.

6. Surgical simulation: role in training

ASiT endorses simulation as a supplement to clinical surgical training as part of a balanced curriculum. We emphasize our support is for its role as an adjunct and not a substitute for effective clinical education. This sentiment echoes the findings of a previous literature review.[2] We note that simulation is included in the ISCP curriculum from 2012 and there will be a phased integration into all surgical training programmes within the UK.

Simulated practice occurs not just in surgery but is often a component of undergraduate practice and Foundation training.

Table 1
National availability of access to surgical skills simulator facilities across all surgical specialties ranked by training region.

Which Deanery do you work in? (All surgical specialties)	Do you have access to a skills simulator facility?		
	Yes (*n*)	Total responses (*n*)	Yes %
Scotland – East	15	21	71.4
East Midlands (Trent and Leicester)	46	70	65.7
Scotland – North	13	20	65.0
Oxford Deanery	21	36	58.3
Yorkshire and Humber	50	97	51.5
KSS	17	34	50.0
Wessex	21	47	44.7
London	91	206	44.2
Northern Ireland	10	23	43.5
Wales	32	75	42.7
Scotland – West	19	47	40.4
Mersey	26	67	38.8
Peninsula/South West	13	35	37.1
Scotland – Southeast	10	27	37.0
Severn	21	60	35.0
Northern	18	56	32.1
East of England	18	59	30.5
West Midlands	20	107	18.7
North West	5	43	11.6
Total	466	1130	Mean 41.2

Table 2
National availability of access to surgical skills simulator facilities across all training regions ranked by surgical specialty.

In which surgical speciality do you work?	Do you have access to a skills simulator facility?		
	Yes (*n*)	Total responses (*n*)	Yes %
Paediatric surgery	34	54	63.0
Urology	32	60	53.3
General surgery	290	584	49.7
ENT	25	76	32.9
Cardiothoracic surgery	8	25	32.0
OMFS	3	10	30.0
Trauma and orthopaedics	49	184	26.6
Plastic surgery	13	62	21.0
Neurosurgery	12	75	16.0
Total	466	1130	Mean 41.2

Therefore, future cohorts of surgical trainees will be consistently exposed to simulated practice throughout all phases of their medical training from medical school, the Foundation Programme, Core and Speciality training.

Flattening the learning curve of complex tasks through training on proven simulation models is an obvious benefit for trainees and patients.[19] Simulation of, and hence preparation for the "case of a lifetime", akin to pilots being tested during emergency conditions, is another benefit preparing trainees for cases that might not otherwise be encountered during reduced training hours.[20]

Easy day-to-day access to simulation facilities in a central location in the hospital can also optimise training efficiency by allowing surgeons to utilise even small periods of downtime during the working day by undertaking simulated operations or the steps of these.

Business models suggest it could be financially beneficial for hospitals to invest in provision of simulation, reducing the time and resources required to train surgeons so increasing efficiency and productivity.[21] This is in addition to reducing the likelihood of complications, particularly early in the learning curve, due to improved standards of operating. Outside of surgery, studies examining the financial implications of simulation training have demonstrated cost-savings resulting from improved clinical care.[22] Participation in simulation-based training can provide additional collateral benefits, with skills improvement also seen in co-workers who have not participated in the training.[23]

7. Surgical simulation: role in selection into training

Selection into surgical specialities already incorporates tests of basic dexterity and procedural skills. This has been carefully monitored and is an understandable pre-requisite to enter surgical practice

Table 3
National availability of access to surgical skills simulator facilities across all training regions ranked by training grade.

What is your current grade?	Do you have access to a skills simulator facility?		
	Yes (*n*)	Total responses (*n*)	Yes %
Core Training Year 1	43	115	37.4
Core Training Year 2	61	157	38.9
SpR 1/StR 3	62	141	44.0
SpR 2/StR 4	61	134	45.5
SpR 3/StR 5	55	122	45.1
SpR 4/StR 6	50	123	40.7
SpR 5/StR 7	53	140	37.9
SpR 6/StR 8	36	93	38.7
Total	421[a]	1025[a]	Mean 41.1[a]

[a] Results in Table 3 exclude 105 respondents not currently in a recognised training post.

which requires these aptitudes. Precedence for this can be seen from the work undertaken by the Royal College of Surgeons of Ireland.[24]

The type of simulated exercise required has been a source of some debate. The task must be equitable, valid and repeatable to be an effective selection tool. It is crucial that the potential of an individual is measured as opposed to a simple snapshot of their current level of skill. Their prior experience, level of training and access to facilities should be considered as mitigating factors. The experienced trainee performing a task based upon years of clinical experience is not comparable to someone with less clinical experience but clear potential to acquire these skills.

The level of competence which is designated as the differentiation point between acceptable and poor performance is also open to criticism. It is recognised some experienced surgeons may rate badly on simulated criteria which they have practised clinically for many years. The context- and construct-validity of such simulations should therefore relate to clinical practice.[25]

8. Surgical simulation: role in assessment

The role of simulation in assessment of trainees is controversial. Primarily this is due to the fear that it may reduce clinical training. Some Schools of Surgery require effective demonstration of an operative procedure on simulated patients prior to being allowed clinical exposure. ASiT acknowledges potential patient safety concerns if this task were to be completed unsupervised but stresses there is considerable evidence that supervised clinical operative training does not adversely affect patient outcomes.[26–28]

Successful completion of the MRCS 'entry' examination for surgical training requires completion of simulated non-technical clinical scenarios, which are now well-established. Introducing summative or high-stakes operative simulation in this context (particularly for the FRCS 'exit' examination and the CCT) is debatable. Presently, operative competency is judged on a trainee's logbook and their workplace-based assessments. ASiT is of the opinion that the currently available simulators do not have the appropriate level of technical sophistication to realistically simulate the necessary levels of operative complexity compatible with demonstrating the skills required for award of the CCT.

It is important to determine whether single tasks (e.g. suturing), parts of complex tasks (e.g. completing an anastomosis) or a full task (open reduction and internal fixation of a fracture) are used as part of on-going simulation-based assessments (SBAs), in a similar manner to which current Procedural Based Assessments (PBAs) and Clinical Evaluation Exercises (CEXs) are currently undertaken. Some specialties already incorporate simulated operative procedures as part of their FRCS examination assessments.

9. Surgical simulation: pitfalls and concerns

As previously noted, disparities in the availability of simulation training facilities by region and specialty may impact on the future integration of simulation into the surgical curriculum. From discussion with trainers, it is apparent that they themselves may not be aware of the extent of their own facilities and availability of these, or may falsely believe these meet appropriate standards. In some centres that have invested heavily in simulation equipment, effective training programmes have not run as there is a lack of an identified, motivated or supported Consultant lead.

Financial restraints will limit many institutions' ability to acquire suitable simulation models. However, it is financially beneficial for hospitals to make these initial outlays as an investment in the future of the NHS on a short and long-term basis. Provision of such hospital based-facilities could also influence the relative attraction of different hospitals for training, therefore influencing the calibre of trainees wishing to work at an institution. However, scarce resources must be carefully spent and it is important that any equipment bought is appropriately validated for training purposes.[29]

The recent ASiT "Cost of Surgical Training" survey highlighted the rising financial hardships for surgical trainees.[30] ASiT does not support the part allocation of dedicated study leave funds towards the provision of simulation facilities. We therefore would express concerns regarding any programme which may transfer an even greater burden of training costs onto the trainee.

There have been acknowledged variances in work based assessment (WBA) requirements for specialty trainees and variable application of a simulation curriculum could lead to further disparities between training programmes. Ensuring a coordinated UK wide approach is therefore mandatory.

A common concern among trainers relates to a sentiment that trainees do not use existing facilities sufficiently to justify further expenditure. Where simulation facilities exist and their availability is advertised to trainees, uptake and utilisation can be variable. ASiT acknowledges that apathetic trainees may exist but feel that infrequent use more often relates to location, quality, accessibility, relevance, and training environment. Trainees may not appreciate the existence of facilities or may not be supported by appropriate tuition in their use, with this leading to further poor utilisation. Methods to improve uptake include more frequent allocation of dedicated training and practice sessions, and improving accessibility to such facilities, for instance by planning their placement in a central part of the hospital, such as on the operating corridor, and removing restrictions that prevent their use outside of standard working hours.

Trainees want access to high quality simulation facilities as part of a coordinated coherent structure instead of isolated, inadequate, or unfocussed facilities. Models for optimising the value of a simulated facility have been proposed which can therefore ensure optimal utilisation and appropriate return on the initial investment. These include incorporation of multi-disciplinary, multi-speciality facilities on the same site with easy access from clinical areas and open access to simulation training equipment. Strategies for coordinated development of skills centres have previously been published and adherence to these increases use, educational benefit and return on investment.[31,32]

10. Recommendations regarding the introduction, availability and use of simulation in surgical training

In light of this evidence, the views regarding the introduction and use of simulation in surgical training have been sought from trainees and surgical sub-specialty trainee organisations. The resulting consensus statement represents opinion following extensive discussion and ratification by ASiT Council. This therefore represents a definitive action list, detailing factors that would facilitate, support and encourage the use of simulation in surgical training and education.

10.1. Establishing the role and framework for simulation

1 ASiT proposes that simulation be fully integrated into the surgical curriculum to supplement clinical training, not replace it.
2 Structured simulation training should be integrated into surgical training programmes to reflect the requirements of the ISCP curriculum.
3 ASiT believes trainee participation in the planned addition of simulation to the curriculum is essential and feels that as the only pan-surgical specialty professional body for surgeons in training, ASiT is ideally placed to be a key stakeholder for provision of this support.

4 ASiT back and encourage Royal Surgical College appointment of clinicians with a specific remit to champion, support, and facilitate the provision of simulation in surgical training at a national level.
5 Specialty programme leads should be identified at national levels to take an active role in ensuring that trainees and trainers engage with provided resources to meet curriculum objectives within their own specialty.
6 Regional and local leads with responsibility for simulation training should be identified and given administrative support and adequate time within their job plans to ensure appropriate delivery of facilities and training.

10.2. Supporting the introduction of simulation

7 A national commitment from the Department of Health, NHS and Royal Surgical Colleges is essential to ensure the continued introduction and development of surgical simulation facilities.
8 ASiT would welcome further discussion with stakeholders regarding ways to facilitate the provision of affordable and accessible means of surgical simulation to individual hospitals and schools of surgery, which is vital to support timely introduction and uptake.
9 Funding for local simulation training facilities must not be drawn from existing study leave budgets. The financial burden of surgical training being passed onto trainees is already significant, and study leave budgets must be ring-fenced and protected.
10 Industry currently plays a leading role in developing commercially available simulation programmes. Their role in future simulation-based training needs to be considered as they may provide useful experience, resources and funding.
11 Careful consideration must be given to the specific simulation equipment purchased in order that it is of validated educational value, suitable for the needs of end-user trainees, and is an appropriate use of resources be those financial or otherwise. Although ASiT recognises the considerable ingenuity in many local solutions to-date, there may be a role for central guidance in order that resources are not wasted on inappropriate facilities or equipment.

10.3. Maximising the educational benefit of simulation

12 There must be improved accessibility, promotion, awareness and high standards of local facilities to permit trainees and trainers to fully utilise these valuable resources.
13 Although trainees should be prepared and encouraged to supplement formal training time with their own skills practice, it is vital that dedicated teaching time be made available within existing programmes for supervised simulation training in order that full benefit is attained.
14 Trainees must be involved in local and regional decisions regarding the appropriate placement of simulation facilities in order to ensure these are easily accessible for training.
15 There should be a greater focus on developing simulated operative models for all surgical disciplines and all grades of training. Simulation facilities frequently only cater to one speciality or technique (e.g. laparoscopic), or basic skills for junior trainees and it is imperative all grades and specialties have equitable access to appropriate resources.
16 Simulation fidelity should increase in line with seniority and surgical complexity. Given evidence of equivalence for low- and high-fidelity simulation in skills acquisition at a basic level, resource intensive high-fidelity (e.g. virtual reality) training should not be delivered at the expense of more cost-effective lower-fidelity training models where these may be more appropriate.
17 We look forward to an expansion in simulation training for non-technical skills given the complexities and risks encountered within the operating theatre environment. Integration of non-technical skills simulation into multidisciplinary training would be welcomed.

10.4. Ensuring the future quality of simulation

18 ASiT believes a unified national accreditation of approved simulation skills courses and facilities is essential to maintain national standards and welcomes initiatives by the JCST and Royal Surgical Colleges to lead on this issue.
19 A number of professional associations already exist (e.g. the Association of Simulated Practice in Healthcare [http://www.aspih.org.uk]) to promote multi-disciplinary involvement and research. These should be supported by surgical training organisations and the wider surgical community.
20 Assessment tools in surgical training already exist and continued development and uptake of these will assist in demonstrating progress with the use of such facilities.
21 It is recognised that on-going research is required to both refine existing simulation tools, and also to facilitate the development of the next generation of simulators. We urge training authorities to consider this prior to instituting curriculum changes which may not be achievable in many Deaneries/ Schools of Surgery.
22 The JCST, Surgical Royal Colleges, Specialty Associations and NHS must support and invest in research to evidence-base the use of simulation in surgical training, together with the development of advanced technologies to allow simulation of more complex and realistic surgical procedures.

11. Conclusion

The utility of simulation in surgical training is well-established, with proven validity and demonstrable transfer of skills to the clinical setting. Through a reduction in the technical learning curve, simulation can prepare surgeons for actual practice and in doing so it has the potential to improve both patient safety and service efficiency. More broadly, multi-disciplinary simulation of the theatre environment can aid development of non-technical skills and assist in preparing theatre teams for infrequently encountered scenarios such as surgical emergencies. The role of simulation in the formal training curriculum is less well-established, and availability of facilities for this varies widely between region, grade and specialty. The 22 action-points proposed in this paper address the future introduction, availability and role of simulation in surgical training. Adoption of these should guide trainers, trainees and training bodies alike to ensure equitable provision of appropriate equipment, time and resources to allow the full integration of simulation into the surgical curriculum.

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Author contribution
All authors contributed to the conception, critical revision and final approval of the paper submitted.

Conflict of interest statement
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