Training to proficiency in surgery using simulation: is there a moral obligation?

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ABSTRACT

A deontological approach to surgical ethics advocates that patients have the right to receive the best care that can be provided. The 'learning curve' in surgical skill is an observable and measurable phenomenon. Surgical training may therefore carry risk to patients. This can occur directly, through inadvertent harm, or indirectly through theatre inefficiency and associated costs.

Trainee surgeon operating, however, is necessary from a utilitarian perspective, with potential risk balanced by the greater societal need to train future independent surgeons.

New technology means that the surgical learning curve could take place, at least in part, outside of the operating theatre. Simulation-based deliberate practice could be used to obtain a predetermined level of proficiency in a safe environment, followed by simulation-based assessment of operative competence. Such an approach would require an overhaul of the current training paradigm and significant investment in simulator technology. This may increasingly be viewed as necessary in light of well-discussed pressures on surgical trainees and trainers.

This article discusses the obligations to trainees, trainers and training bodies raised by simulation technology, and outlines the current arguments both against and in favour of a simulation-based training-to-proficiency model in surgery. The significant changes to the current training paradigm that would be required to implement such a model are also discussed.

INTRODUCTION

The Halstedian apprenticeship training model in surgery has undergone significant revolution in recent decades.[1] Evolving patient expectations regarding the role of surgical trainees in their care,[2] an emphasis on theatre efficiency,[3] increased demands on the surgical workforce[4] and concerns regarding perceived operative competence and confidence of graduating trainees,[5–7] have led to a re-evaluation of the training paradigm. The implementation of work-hour restrictions,[8 9] and the requirement to train and retain a diverse workforce[10] present opportunities to rethink the way in which surgeons are trained. 'Competency-based' approaches to outcome-driven training and assessment are established across jurisdictions,[11 12] leading to the development of nominally time-independent postgraduate programmes.[13] The surgical specialties pose a unique challenge in this regard, due to the requirement for reliable methods of teaching and assessing competence in operative skill.[14] The role of simulation in surgery has evolved in tandem with competency-based education,[15] and represents just one way in which trainees can be trained and assessed against predefined standards.

The concept of a surgical 'learning curve' is demonstrable across procedures.[16–20] Studies have demonstrated the safe transfer of simulator-acquired operative skill to the operating theatre; a recent systematic review and meta-analysis of twelve randomised controlled trials demonstrated that simulation-led proficiency-based progression resulted in a 60% reduction in operative performance errors and a 15% reduction in procedural time.[21] In spite of this, simulation remains underused outside of simulation centres of excellence[22]; this is likely due to the significant cost, practicality and access issues associated with available simulator technology.[23]

The growth of simulation in surgical training raises questions as to its role in the entrustment, credentialing and certification of surgical trainees. Training to predefined objective performance metrics using simulation, followed by simulation-based assessment of competence, could mitigate against a fundamental conflict at the heart of surgical training; the rights of the individual patient seeking the best care available, and the interests of society at large in the training and assessment of competent surgeons.

The ethics of surgical training: balancing the patient's right to the best standard of care and the societal need to train independent surgeons

An ethical tension inherent in surgical training has been previously well explored,[24 25] and relates to the competing interests of the individual patient, to whom the best available care should be offered, and broader societal need. A deontological approach would emphasise the morality of each individual decision regarding whom should perform the operation, implying that the most qualified surgeon available should act as the primary operator in all cases. Proponents of in-theatre training appeal to the greater good; potential risks posed by less-than-competent trainees in practice are outweighed by the greater utilitarian societal need to train future surgeons.[25] It is likely that given the choice, patients would choose to have their procedure performed by a fully trained surgeon.[26] A social contract, it is argued, exists between the public and surgeons in training; patients forego some of their individual rights to receive care from whom they may perceive to be the best surgeon available, and accept the potential risk of supervised trainee operating. By allowing trainees to perform procedures either wholly or in part, these trainees gain experience towards becoming a future competent surgeon practising on behalf of the public at large.[24]

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The extent to which this ethical tension exists depends on the risk, or lack of, related to trainee operating. A large body of evidence demonstrates no association between the involvement of trainees in operative cases and negative patient outcomes.[27–34] The deontological argument, as outlined by Brenna and Das, recognises this and proposes two alternative underlying assumptions. Either there is no benefit in patient outcome resulting from training junior surgeons to the level expected for independent practice, or being operated on by a less than competent trainee does confer real risk which is mitigated, however successfully, by a series of checks and balances which prevent patient harm.[24] This would include consultant trainers 'stepping in' to prevent or recover from technical failings. A further 'safety mechanism' is readily apparent: surgical training (either formally or informally) operates on the basis of 'graduated autonomy', where trainees are granted opportunities to perform increasingly complex tasks and procedures as they progress through training years.[35] These checks and balances may provide both clinical and moral equivalence, though key decisions still have to be made by trainers at different stages of training; autonomy granting for discrete procedural steps, allowing the trainee to act as the primary operator and final certification. While aforementioned studies have not recorded associations between surgeon experience and outcome, other studies have recorded correlations between surgeon seniority or stage of training and longer operative times, and in some studies adverse patient outcomes.[36–38]

Using simulation to reconcile the competing interests of individual patients and broader society in surgical training

Training to proficiency on simulators could mitigate against this real or potential risk. Simulation could be used to bridge the gap from novice to practitioner to competent surgeon, allowing the 'learning curve' to take place outside of the operating theatre.[39] The ideal simulation-based training and assessment model would allow trainees to use deliberate practice to obtain measured and objective proficiency in surgical procedures or discrete tasks before operating on a patient, with potential positive impacts on patient safety. Numerous studies have identified a reduction in 'real-world' intraoperative error in trainees who have been trained to predefined proficiency standards using simulation.[40–44] For example, in an early study by Seymour *et al*, trainees who had undergone simulation-based training to proficiency made six times fewer live intraoperative errors than their counterparts who had no such training.[40]

The subsequent impact on theatre efficiency could also have positive cost and time implications for resource allocation, to the utilitarian benefit of patients and society broadly. Trainee involvement in operative cases leads to longer operating time.[45–47] This has a direct impact on theatre costs.[45] Simulation-based training to proficiency leads to shorter operating times for trainees.[21] This has beneficial effects not only from a financial or resource allocation perspective, but may also improve the quality and efficiency of training. If trainees could first train to proficiency using simulation, in-theatre training time could then be used more productively. Less valuable theatre time could be spent on teaching basic surgical skills, and more spent observing autonomous trainees undertaking more complex tasks under trainer supervision.

A primarily simulation-based approach to surgical training would require not only simulator-based training but also assessment. Trainees are distrustful regarding the use of simulators in high-stakes assessment, including for the purposes of trainee entrustment or autonomy granting.[48] The full range of subtle and complex competencies required to be a competent independent surgeon may not be measurable using current simulator models.[48] Concerns exist regarding the impact of such an assessment programme on trainee operative exposure.[48] Simulators could, however, be used to assess a wider range of competencies than in-theatre assessments. While it would be deeply unethical to deliberately induce an emergency scenario or intraoperative complication in a patient's case in order to assess as trainee's response, judgement or technical ability, such a scenario could in theory be simulated with models of sufficient complexity.[49] Furthermore, using crisis scenarios when they arise in practice as an opportunity for trainee assessment may result in unnecessary risk to the patient, particularly when more experienced or competent practitioners are available. While error represents a powerful opportunity for learning,[50] such errors could be simulated outside of the operating theatre.[51] Rarely encountered and 'high-stakes' surgical scenarios could also be simulated for assessment,[52 53] though there remains a significant 'theory-reality' gap. While simulation has been demonstrated to improve quality of care during emergency scenarios such as cardiac arrest management,[54] it is unlikely that current simulation centres can replicate a wide range of complex intraoperative emergencies without significant investment, coupled with improvements in simulator complexity and fidelity. In future, simulation may be used both to teach and to assess surgeons on a series of predefined tasks and scenarios that may only be encountered infrequently and irregularly in practice.

Current simulator models and tools are perceived to be unable to fully replicate the intraoperative environment, preventing the assessment of the full complement of complex technical and non-technical skills required to be an independent operator.[33] The development of increasingly complex virtual reality and high-fidelity simulators,[55] along with the use of 'in-situ' simulation in functioning or previously functioning operating theatres, means that arguments focusing on the sophistication or complexity of simulators may have decreasing relevance over time as technology improves. Furthermore, the question is not whether simulators can fully replicate the theatre environment, but rather whether they can do so to a sufficient degree that there is value in using them for deliberate practice. If it is accepted that surgery carries risk, that deliberate practice reduces risk, and that deliberate practice can take place on a simulator, then such simulated practice should be undertaken by trainees. Similarly, whether or not simulator models can be used to assess the full range of technical and non-technical competencies required for independent practice does not preclude its use if, as evidence suggests, it can detect serious technical failings not identified by other methods of assessment. It is likely that simulators do, or can, replicate operative procedures to a significant degree of fidelity that serious underperformance in technique, procedural knowledge or communication could be identified and corrected.[56] As simulators increase in complexity, so too will their ability to assess subtleties in a trainee's performance.

It is important to emphasise that training to proficiency using simulation does not entirely resolve the deontological vs utilitarian conflict explored above. It is unlikely that simulation over an 8-year postgraduate surgical training programme can fully replicate the technical and non-technical experience gained by a career of in-theatre operating. Therefore, the more experienced, qualified surgeon will likely remain superior in performing a given procedure than a junior trainee with simulator experience. The logical extension of the argument that a procedure should be performed by the best surgeon available is that all patients requiring a specific procedure should be operated on by a single surgeon or surgical team who can demonstrate the

best outcomes; this is not feasible from a resource allocation or training perspective. Again, however, the approach should be to minimise risk where possible. Using simulation represents an imperfect means of doing so, though this approach is not without its significant challenges.

Reimagining the surgical training paradigm

A move towards a simulation-based approach to entrustment, credentialing and certification would require a major reconfiguration of the current surgical training model. Trainees currently balance dual roles; that of the learner and that of service provision.[57] This extends to the operating theatre, where trainees perform necessary roles in preoperative preparation, intraoperative assistance and immediate postoperative care. Simulation-based training to proficiency would require a rethink of the trainee role to include dedicated time for simulation-based teaching, practice and assessment. Alternatively, trainees would be required to commit significant 'out of office' hours towards simulation-based deliberate practice. It is unlikely that such an approach would produce enough hours of deliberate practice to replace the lost in-theatre experience.

Furthermore, an essential component of deliberate practice is structured, targeted feedback[58]; while this may be easily provided in real time in the theatre environment, trainers would be required to observe a trainee's simulated operative performance on a frequent and regular feedback to ensure progression. Under a simulation-based training to proficiency model, there would be obligations not only on trainees, but also on trainer and training bodies. Trainers would be obligated to train and assess trainees in simulation, to inform key decisions such as autonomy granting, credentialing or certification. Training bodies be required to provide accreditation and funding for any used simulators, curricula and assessment tools. In future, automated procedural assessment could reduce the associated time requirement for trainers,[59 60] allowing trainees to practice to proficiency safely with minimal trainer involvement. Such an approach to simulator-measured metrics used to inform entrustment and credentialing decisions is already in use by some robotic surgery platforms.[61] It is conceivable that similar programmes could be developed using laparoscopic, endovascular or endoscopic simulators. Whether trainees, trainers or the wider public trust decisions on a surgeons competency based on simulated operative performance alone remains to be seen, but has precedence in other high-stakes fields such as the aviation industry.

There remain significant resource considerations related to the use of simulation training and assessment. Training bodies and hospital training sites would face significant challenges. There would be indirect costs associated with providing protected time for trainees and trainers to participate in simulation training.[23] The direct costs related to the implementation of a simulation-based training and assessment model are significant[23]; one centre from the USA calculated the costs of their simulation centre to be upwards of US$360 000 per year.[62] These costs raise ethical implications from a resource allocation perspective, and information regarding the cost-effectiveness of simulation training in healthcare is scarce.[63]

A simulation-based training and assessment model would need to be viewed as an enhancement to trainee learning, rather than an impediment. Without access to simulator technology and dedicated training time, trainees working under such a model would not reach proficiency. If this then prevented trainees from being granted autonomy in the operating theatre, or prevented trainees from progressing through training, the negative impact on the individual trainee's operative skill would be exacerbated. Trainees most in need of further training, feedback and assessment would be denied a further opportunity to develop their skills, leading to a future of undertrained and underconfident surgeons. This would likely disproportionately affect trainees in resource-poor settings. Protective measures would need to implemented to ensure that what has been lost through reduced in-theatre operating is matched, and perhaps exceeded, by simulation.

CONCLUSION

A traditional deontological approach to surgical ethics advocates that patients have the right to receive the best care that can be provided. Surgical training may carry risk to patients. This can occur directly, through inadvertent harm, or indirectly through increasing theatre costs and reduced output due to inefficiency. The 'learning curve' in surgical skill is an observable and measurable phenomenon and could take place, at least in part, outside of the operating theatre. While simulation's use in training is well established, the introduction of a simulation-based training to proficiency model would also require simulator models to be used in trainee assessment. As technology improves, it is likely that simulator models and automated simulator-measured metrics will be able to reliably identify a trainee's competence, perhaps even prior to trainees performing their first operation on a patient.

Trainee operating is necessary from a utilitarian perspective, with any potential risk balanced by the greater societal need to train independent surgeons. However, simulation training and assessment may mitigate against this risk. Trainees in future could move a substantial proportion of the learning curve outside of the theatre using simulation-based deliberate practice to obtain a predetermined level of proficiency in a safe environment. Such an approach would require an overhaul of the current training paradigm and significant investment in simulator technology, which may be increasingly viewed as necessary in the same way that simulation-based credentialing in training surgeons on robotic platforms. Future technology such as video-analysis and machine learning may provide the solution to simulation-based self-learning and assessment. The cost, time and human resource implications of a simulation-based training to proficiency model are significant and require further exploration.

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