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Review

Simulators and the simulation environment: Getting the balance right in simulation-based surgical education

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ABSTRACT

Introduction: Simulation occupies a central position in surgical education. It offers a safe environment for trainees to develop and improve their skills through sustained deliberate self-practice and appropriate feedback. This review explores the role of simulators and the simulation environment in light of educational theory to promote effective learning.
Data sources: Information was obtained from peer-reviewed publications, books and online material.
Conclusion: A simplistic perspective frames simulation as a means of gaining technical skills on basic models by offering a safe alternative to carrying out procedures on real patients. Although necessary, that aspect of simulation requires greater depth to satisfy the growing demand for alternatives to traditional clinical learning. A more realistic view should frame simulation as a means to gaining mastery within a complex clinical world. In order to strike the balance on simulating an ideal clinical scenario, alignment of the simulator and the simulation environment in the appropriate context appears crucial.

1. Introduction

A shorter working week for junior doctors in the UK[1] and USA[2] may contribute to missed educational opportunities. In surgery, the increased complexity of caseloads and the greater awareness of medico-legal implications (in that it is ethically unacceptable to "learn on" patients) may further minimise trainee exposure. Rather than specifically designed curricula, the hallmark of current surgical training appears to be total volume of exposure.[3] Simulation has proven to be an excellent adjunct to surgical education, offering a safe environment where learners can repeatedly practise a range of clinical skills without endangering patients.[4] In fact, the UK's Chief Medical Officer explicitly stated that simulation will be of central importance in healthcare education, especially for surgery and related craft specialities.[5]

On one hand, simulation can be very "high-tech" utilising state of the art technology in a specialist simulation laboratory. On the other hand, it can consist of very basic instruments in any available space. It can be agreed that as long as a simulation modality is used to augment surgical education and ultimately patient care, it can prove successful. In order to strike the balance in simulating an ideal clinical scenario, alignment of the simulator and the simulation environment in the appropriate context appears crucial. This review article proposes the notion that in order for simulation to be effective, it should be a "mirror for care".

2. Search strategy

Twenty key papers by surgical education authorities and experts in the literature formed our starting point for review; this was supplemented by a Google search to include books and online material on surgical education. In order to augment the search strategy and refine the review further, four key terms were used on Pubmed: "simulation", "medical education", "surgical education" and "learning" (date range January 2001 and December 2011). Two hundred ninety five articles in English were retrieved and screened. Speciality-specific and task-specific papers were excluded if these did not add to the already established argument within the scope of this paper as a review. The most appropriate ten papers that added

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to our argument were examined in further detail and included given the world limit available for this article. Particular care was taken to limit potential bias. Only papers written in English were included. A formal systematic review may have included further articles, identifying alternate areas for discussion; this was not a systematic review, but rather a detailed exploration and critical appraisal of key concepts underpinning effective simulation.

3. Simulation

Simulation is the process of "reproducing" one or more aspects of the working environment.[6] In surgical education, effectively this is an instructional process that substitutes clinical or surgical encounters with artificial models, live actors or virtual reality patients.[7] These "models" (physical or computer-based) are the simulators. Simulation is thus regarded as the wider universe within which simulators can be used for training or assessment purposes. The simulation environment consists of both the physical space and its contents (such as the equipment and participants, including the simulators) where the simulation process takes place.

Simulation can replicate clinical scenarios in a realistic environment. For many trainees, simulation equates safety with absence of risk.[8] This reflects a growing climate within healthcare of "aversion to risk generally, and a philosophy of risk-free training".[9] The reality is, however, that clinical care does in fact entail risk, and its effective management is requisite to becoming a mature clinician. Developing an understanding of the impact of risk on clinical skill and judgement is a crucial element of expertise.[10]

There is ample evidence to support the use of simulation in the acquisition of technical skills.[11,12] A recent systematic review and meta-analysis in laparoscopic colorectal surgery highlighted that surgical trainees could obtain similar results to expert surgeons if supervised by experienced trainers.[13]

The Best Evidence Medical Education Collaboration (an international group of individuals, Universities and organisations committed to the promotion of best evidence medical education) formed a topic group addressing the aspects of simulators that led to effective learning. A landmark meta-analysis[14] consequently highlighted enhanced surgical performance in simulator training when the training procedure incorporated characteristics of deliberate practice such as goal-directed training, repetition, reflection and feedback, where feedback appeared to be the most important factor.

4. The role of the trainer in simulation

It has been advocated that the earlier stages of teaching of surgical skills should take place outside the operating room; practice is the rule until automaticity in basic skills is achieved.[15] This mastery of basic skills allows trainees to focus on more complex issues both technical and nontechnical. However, oversimplifying a task (by fragmenting it into components) in order to teach trainees can have a major drawback, by taking perspective out of a task. This can be referred to as the "ha–ha effect"[16]; a metaphor to account for the differing perspective between expert and novice. An expert's perception may radically differ from a novice's, and a novice may struggle with difficulties that the expert can no longer see. Hence for simulation to be effective there needs to be alignment between the intended learning outcome and what the simulation strategy is designed to achieve, in addition to both the trainee and trainer perception of the modality. It is however difficult to establish when a trainee is competent in performing a technical or non-technical skill. Hence there must be a measurable outcome that can be assessed. In simulation literature, the concept of validity is integral to measurement and decision-making in surgical education.[17]

5. Simulators

The spectrum of simulators is vast.[7] This includes bench top models (e.g. foam for suturing), VR simulators (e.g. computer-programmes for laparoscopic skills), cadaveric tissue (e.g. for bowel anastomoses), box trainers (e.g. for laparoscopic skills), live porcine models (e.g. for arterial anastomoses) and simulated patients (e.g. for communication and interpersonal skills). In the UK, simulated patients represent an integral component of undergraduate medical education in order to help teach communication skill scenarios.

6. Simulation environment

Recreating the working environment where multidisciplinary teams interact, such as that of the simulated ward, has been shown to provide a powerful learning experience for trainees, allowing learners to examine their roles within a team.[18] The creation of a realistic environment can also increase the psychological fidelity of scenarios when using higher level simulators.[6] Poor validity is associated with lack of realism. However no single level of realism will meet all simulation and hence educational needs. If simulation is to engage with the richness of the clinical experience, it must somehow address aspects of the richness and complexity of a true clinical experience.

A feasible model of two common clinical situations for medical students (urinary catheterisation and wound closure) has been described.[19] Latex models were attached to simulated patients, allowing students to integrate procedural and communication skills in a safe environment with structured feedback. Although that was the original pilot study with small numbers, this idea of contextualised simulation was reported to be a powerful learning experience. It would be interesting to note the long-term outcomes on confidence and competence of such contextualised simulation, in both novices and experienced trainees. Such scenarios with high psychological fidelity may stimulate deep learning, allowing trainees to reach a level of expertise greater than that offered with non-contextualised simulation.

7. Developing competence and expertise in simulation

Miller[20] introduced his famous "hierarchical" triangle of four levels, where from base to pinnacle one "Knows", then "Knows how", then "Shows how", before reaching the final stage of "Does", delineating the components of developing competence. In each step towards competence, the trainee progresses through the necessary cognitive and behavioural steps that underlie the next step, building the knowledge that ultimately underpins the execution of a specific skill. This triangle appears to assume that competence predicts performance. It is well known that other workplace factors may also hinder task execution, representing challenges to every-day learning. Rethans and colleagues[21] have thus proposed a modification to Miller's triangle, "The Cambridge Model", taking such factors into consideration, distinguishing competence from performance. In order to relate this to contextualised simulation, the role of the simulated environment should be carefully orchestrated in order to allow trainees to gain competence applicable to every day clinical work.

Expert performance represents the highest level of technical skill acquisition. Through extended experience, it is the final result of a gradual improvement in performance. This concept is best elucidated by Ericsson[22] who believes most professionals reach a stable, average level of performance and maintain this status-quo for the rest of their careers. Surgical "experts" have consequently been defined as experienced surgeons with repeatedly better