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Simulation-based training in the paediatric surgery population: A review of current trends and future direction

Areej Saleem

Zorays Moazzam

Sohail Asghar Dogar

Saqib Hamid Qazi

NARRATIVE REVIEW

Simulation-based training in the Paediatric Surgery population: A review of current trends and future direction

Areej Salim,[1] Zorays Moazzam,[2] Sohail Asghar Dogar,[3] Saqib Hamid Qazi[4]

Abstract

In recent years, simulation-based training in surgery has emerged as a viable accompaniment to traditional teaching methods. Multiple studies have highlighted the benefits of simulation-based training in both learning and teaching aspects of surgical training, with a particular emphasis on the honing of technical skills. However, multiple issues still exist in widespread implementation of simulation-based training, especially in the developing countries. Furthermore, the existing literature needs to be expanded upon in both quantity and quality domains to ensure a more evidence-based transition to simulation-based training in surgery. The current review article was planned to take a look at the existing literature on the current state of simulation-based training in paediatric surgery, its potential to revolutionise paediatric surgical training, and to propose solutions to the issues that are delaying wider implementation.

Keywords: Simulation, Paediatric surgery, Medical education.

Introduction

Surgical training has traditionally aimed at exposing fellows, residents and students to various pathologies and their relevant procedures in a stepladder fashion, transitioning simply from observation to assistance and finally to independent expertise. Although this method has been successful to a large extent in producing competent and reliable surgeons, it does not cater to the needs of a modern surgical world where the highest levels of patient-safety, competency and transparency are demanded. Simulation-based training (SBT) has emerged as a suitable accompaniment to the traditional method of training, with a growing body of evidence attesting to its efficacy.

The current review article was planned to highlight the current state of SBT globally, as well as its prospects in an increasingly technology-driven world.

[1,3,4]Department of Surgery, [2]MBBS Student, Medical College, Aga Khan University Hospital, Karachi, Pakistan.

Correspondence: Saqib Hamid Qazi. Email: saqib.qazi@aku.edu

The Fitts-Posner and Kirkpatrick Models

Fitts and Posner developed a model for motor skill acquisition and expertise development, which can also be applied to the surgical field.[1] This three-stage model consists of cognition, integration and automation. During the cognition stage, the learner understands the task at hand and performs it in erratic, distinct steps. At the integration stage, with practice and feedback, the learner begins to perform the task more fluidly and with fewer interruptions. Finally, at the automation stage, the learner begins to perform the task continuously and fluidly with little cognitive input, thus allowing adaptation to any unforeseen circumstances without compromising the core task. As a result, the first stage should occur outside the operating room (OR). SBT is especially helpful in this case, as it allows earlier high-quality exposure to learners without compromising patient-safety.

The Kirkpatrick model is a four-stage approach to evaluate training, comprising reaction, learning, behaviour and results. Level I evaluates the degree to which the learners found the training enjoyable, while level II assesses the effectiveness with which learners were able to acquire the skills. Level III evaluates the degree to which participants were able to apply what they had learnt in a professional setting, and level IV evaluates the extent to which outcomes were changed as a result of the learning modality employed.[2] As a result, the Kirkpatrick model serves as a holistic model to evaluate training-based interventions, especially in a healthcare setting.

The Global Scene

The need for innovation in surgical training is especially required in paediatric surgery. Peri-operative mortality is higher amongst neonates and infants,[3] thus paediatric surgeons are held to the highest standards possible. On the other hand, there has been a decline in the number of paediatric surgery cases for general surgery residents.[4,5] Although the case load and exposure for paediatric surgery fellows has remained stable, variability between training programmes has been gradually increasing.[6] Moving towards a shorter workweek for residents and enhancing OR efficiency have further contributed to decreased case exposure for residents. This has, in turn, led to limited exposure of junior surgical attendings, especially to rare conditions and procedures.[7] As a result, the evolution of paediatric surgical training programmes from the "see one, do one, teach one" philosophy has become essential.

SBT has shown promise in improving the learning and teaching experience in paediatric surgery. It aims at employing technology to simulate real-life surgical dilemmas, enhancing the acquisition of surgical skills. It can broadly be divided into low-fidelity and high-fidelity simulations. Low-fidelity simulation consists of physical, inanimate objects that mimic the required task, an example of which is the Paediatric Laparoscopic Surgical Simulator (PLS).[8] Various studies have demonstrated that such simulations can improve skill-acquisition.[9] This can be translated into improved OR performance. Dawe et al. demonstrated that simulator-trained participants had significantly better global performance in laparoscopic procedures compared to participants who had not received such training.[10] However, the study was conducted in an adult setting, and it is not clear whether the results[10] can be generalised to a paediatric population which poses specific challenges, such as a smaller operating space. Furthermore, low-fidelity simulators are only capable of managing tasks of limited complexity, and thus may be beneficial for novices, with limited utility in trainees with more experience.

High-fidelity simulation consists primarily of computer-based simulation and virtual reality (VR). Computer-based simulation has been a mainstay in the aviation sector for decades, but has only recently been employed in surgery. Minimally Invasive Surgery (MIS) Trainer Virtual Reality (MIST VR®, VRsolutions, UK), LapSim® (Surgical Science, Sweden) and SmartSim® (SmartSurgiSol, Pakistan) are some examples in this regard among several others. Its effectiveness in improving technical skill-acquisition and OR performance has also been demonstrated in two prospective trials.[11,12] It holds significant advantages over low-fidelity simulation, which include the ability to perform tasks of greater complexity as well as progression monitoring. However, prohibitive costs have prevented this modality from being employed more widely, especially in the developing world.

Despite the rapid advances in simulation technology, widespread adoption is still limited. National standardised curricula which incorporate SBT are scarce, with literature search yielding only one study which proposed a national curriculum in France.[13] This study incorporated both technical (laparoscopic/suturing on low-fidelity models) as well as non-technical (teamwork and communication) skills. This model was very well received by both the residents as well as the trainers, thus serving as a reference for future programmes.[13] A review further emphasised the need for regular SBT and for national curricula to support and nurture such programmes.[14]

The Scene in Pakistan

In Pakistan, the adoption of SBT has been considerably slower compared to the developed countries. The first virtual trainer lab in Pakistan was introduced at the Holy Family Hospital, Rawalpindi, in collaboration with Virginia Commonwealth University, United States. This lab consisted of three modules, which included demonstrations on VR simulators. Currently, private institutions, such as the Aga Khan University Hospital (AKUH), Liaquat National Hospital (LNH), and the Sindh Institute of Urology and Transplantation (SIUT) in Karachi, and the Services Hospital in Lahore, also offer SBT with varying degrees.[15] Despite the vast advances in surgical training in Pakistan over the years, a lot is still left to be done. A survey was conducted comprising 3rd, 4th and 5th-year surgical training residents in seven institutions accredited with the College of Physicians and Surgeons of Pakistan (CPSP). Only 37.5% respondents noted that a dry lab was available at their institution, while none reported availability of wet-lab or VR simulators. Only 18.75% residents had ever attended a basic laparoscopy workshop. Regarding the residents' perception of their own surgical skills, 47.92% described it as poor; 14.58% good; 16.67% average; 18.75% below-average; and 2% did not respond to the query. It is important to note that none of the residents believed that their surgical skills were excellent, highlighting the lack of confidence in their own surgical skills, possibly owing to the lack of SBT in their medical curricula.[15]

Despite the majority of literature on SBT originating from developed countries, a few studies advocating its effectiveness have also been conducted in Pakistan. A randomised control trial (RCT) conducted in Lahore highlighted a significant increase in Global Assessment of Laparoscopic Surgery (GOALS) scores after six months of SBT compared to no-SBT in surgical residents (14.76 ± 1.67 vs 9.76 ± 0.79; $p<0.001$).[16] This improvement has also been highlighted in medical student training, with an experimental study showing better skill-acquisition in normal vaginal delivery in students who underwent SBT compared to traditional teaching methods (8.91 ± 3.20 vs 5.67 ± 1.84; $p<0.01$).[17]

What the Future Bodes for SBT

Despite substantial adoption in the wider surgical field, the use of SBT is currently limited in the realm of paediatric surgery. A recent systematic review highlighted only 43 studies evaluating SBT in paediatric surgery, with 20 of those studies using SBT as an assessment tool for technical skills, and 23 as a training tool. It identified that although there were many Kirkpatrick level I and II studies, no level III or IV studies were identified. As a result, it concluded that although the impact of SBT in improving paediatric surgical learning is well documented, its impact on clinical behaviour and performance has not been evaluated yet. Furthermore, only two level II studies were identified in advanced paediatric surgery, pointing towards an overwhelming focus on SBT in improving basic skills while ignoring advanced learning.[18]

SBT models proposed till now in paediatric surgery lag behind other surgical specialties in key areas. Firstly, majority of them have not been independently validated, and, as such, their effects are not generalisable. Secondly, models which have been validated, such as PLS, have not been implemented into a broader skills curriculum, thus mitigating their effectiveness. Furthermore, non-technical skills, such as situational awareness, decision-making capacity and teamwork and communication, which are essential components in any medical field, have not been given their due importance. Only two studies evaluating non-technical skills in paediatric surgery through SBT have been conducted thus far.[19] Greater emphasis should be placed on evaluating SBT holistically, giving equal importance to the technical and non-technical aspects. Emphasis should also be placed on Kirkpatrick levels III and IV studies to evaluate the translation of SBT into actual clinical practice.

Despite the accumulation of data which elucidates the benefits of SBT in paediatric surgery, a major question still remains: Is it financially worth it, especially in the developing countries? The answer remains elusive. The cost of high-fidelity simulation, such as computer-based technology and VR, mean that, although in the future it might become widely adopted as part of standard paediatric surgery curricula in high-income countries, it will mostly remain out of reach as far as the developing world, including Pakistan, is concerned. SmartSim® has been marketed as being 10% of the cost of other commercially available surgical simulators locally. However, for widespread adoption, a long-term solution, such as further investment in research and design of such indigenous innovations, is required. Public-private partnerships could help to fund such endeavours and to build a competitive marketplace so that the costs associated with such systems may benefit the consumers through surgical training programmes. In the short term, however, solutions such as TouchSurgery© (Touch Surgery Labs, UK) are available. This is an interactive, self-directed web-based platform that provides interactive surgical experiences for a variety of specialties. However, once again, paediatric surgery is not as well-represented as should have been the case. Thus, such platforms should aim at expanding the variety of simulations available, especially in highly-specialised fields, such as paediatric surgery.

Thus, the role of SBT in paediatric surgery is currently limited by the lack of validated models and the associated costs. To counter this, significant investment is required in the research, design and validation of such systems, as well as a national curriculum to ensure standardised implementation across the spectrum. The need for paediatric surgery to adopt innovation in training methods is essential for this specialty.

Conclusion

Despite the promise of SBT in paediatric surgery, work still needs to be done to reap maximum benefits. For further growth, there is a need to validate existing SBT models, to tailor models specific to paediatric surgery and to improve accessibility to such platforms, especially in the developing world. If implemented successfully, SBT may represent a paradigm shift in surgical training.

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