Advances in Medical Education and Practice

Dovepress

open access to scientific and medical research

Open Access Full Text Article

COMMENTARY

Distance Education in Anesthesia Using Screen-Based Simulation – A Brief Integrative Review

This article was published in the following Dove Press journal:
Advances in Medical Education and Practice

Barry Swerdlow[1,2]
Julie Soelberg[1,3]
Lisa Osborne-Smith[1,3]

[1]Nurse Anesthesia Program, Oregon Health & Science University, Portland, OR, USA; [2]Department of Anesthesiology, Perioperative and Pain Medicine, Stanford University School of Medicine, Stanford, CA, USA; [3]Department of Anesthesiology and Perioperative Medicine, Oregon Health & Science University, Portland, OR, USA

Video Abstract

Point your SmartPhone at the code above. If you have a QR code reader the video abstract will appear. Or use: https://youtu.be/MxGWL-0_Cpw

Abstract: Screen-based simulation (SBS) using digital technology has been demonstrated to improve the cognitive and psychomotor skills of anesthesia trainees. As a method of education and evaluation, this form of simulation offers multiple advantages related to cost, availability, simplicity, repeatability, and scorability. Online use of SBS with software employing standard cloud-based peer-to-peer platforms allows for instruction at a distance of important anesthesia-related critical thinking skills including crisis management. Despite the fact that there are no studies concerning the application of SBS in anesthesia distance education, this form of instruction has increased as a result of quarantine measures associated with the coronavirus-2 pandemic that have disrupted traditional in-person mannequin-based simulation, and its usage likely will continue through the post-pandemic era for multiple reasons. Several options exist for asynchronous and synchronous teaching of anesthesia skills at a distance with SBS, and there are useful techniques that can assist in achieving these educational goals with this process.

Keywords: simulation, anesthesia, distance education, screen-based, virtual, computer

Introduction

Simulation is employed in anesthesia both for educational and assessment purposes.[1] Part or partial task trainers (eg airway trainers), "in-situ simulation" utilizing actual operating rooms, and computer-driven electromechanical mannequins in mock operating rooms (mannequin-based simulation (MBS)) have become integral parts of anesthesia training programs, and it has been shown that high-fidelity MBS training improves second-time simulated crisis management skills.[2,3] In recent years, screen-based simulation (SBS) using digital technology – also termed "virtual simulation" – has played an increasing role in anesthesia education, and even relatively low-fidelity SBS has proven effective in teaching skills related to appropriate responses to intraoperative adverse events.[2,4] In order to address specific issues related to SBS in anesthesia pedagogy, a review of the pertinent literature was performed. Data bases associated with the Stanford Lane Medical Library were searched using phrases including "anesthesia education," "anaesthesia education," "anesthesia training," "anaesthesia training," "screen-based simulation," "virtual simulation," "computer simulation," "computer-based simulation," "web-based simulation," "simulated crises," and "distance education," and approximately 150 articles were considered with dates of publication ranging from 1980 to 2020.

Correspondence: Barry Swerdlow
Oregon Health & Science University, SON 521 3455 SW US Veterans Hospital Road, Portland, OR 97239, USA
Tel +1 503 494 6468
Fax +1 503 346 8296
Email swerdlow@ohsu.edu

submit your manuscript | www.dovepress.com
DovePress
http://doi.org/10.2147/AMEP.S266469

What is SBS, and How Do We Classify Screen-Based Simulators Used in Anesthesia Education?

With designs similar to popular computer games, SBS in anesthesia education presents hypothetical patient scenarios in the form of dynamic graphical images and supplemental text. Users interact with these scenarios via keyboards, joysticks, touchpads, or mouse controls and choose actions from pre-determined selection menus.[5] This process differs from virtual reality learning that involves a head-mounted display with immersion into an adaptive and fully interactive environment.[6] SBS in this context can be classified in terms of its simulated physiology and its goal.[7,8]

Physiologic responses by such SBS programs are either script-controlled – wherein commands (scripts) are associated with specific physiologic responses – or model-controlled, with responses generated by mathematical models within the software. Screen-based simulators in anesthesia can be classified further by their purpose. The primary goal of most such SBS is the development of cognitive skills, but a few screen-based simulators are designed to foster psychomotor skills (see iLarynx® below).[7,8] For example, Anesoft Anesthesia Simulator® is a screen-based simulator with a model-controlled physiologic response to improve cognitive performance.[7,9]

What are the Benefits of SBS in Anesthesia Education?

SBS offers a number of advantages for anesthesia education when compared with MBS.[9] It is cost-effective – especially when the associated technology is scaled – and considerably less resource and personnel dependent, although instructors remain a crucial part of many formalized distance education options in anesthesia involving SBS (see below).[10] Mannequin simulators and mock operating rooms are expensive to purchase and house, and MBS sessions require multiple individuals for the management of teaching scenarios. These considerations, and the overlapping demands of a multitude of trainees with complex time schedules competing for identical resources, complicate and limit the use of MBS in many training programs – especially during periods of high demand, as undoubtedly will occur in the post-coronavirus disease of 2019 (COVID-19) era. Also, even before the current viral pandemic ends – when simulation centers reopen with initial relaxation of quarantine restrictions – mandated physical distancing between learners will restrict the full reinstitution of MBS. On the other hand, once appropriate software platforms are acquired in sufficient quantity (often a significant and potentially limiting up-front cost), SBS requires only a personal computer, and therefore is portable, allowing the user to practice in any location and at any time.[5] Scenarios are easily repeatable and promote deliberate practice for maximum educational value. Furthermore, these programs are standardized and include automated scoring (with instantaneous scalable evaluation) that allows the learners' decision-making processes to be captured and tracked to provide effective feedback.[5,9,11] This built-in scoring feature of SBS systems also may be beneficial for training programs with competency-based educational curricula.

Multiple studies have shown that SBS improves both cognitive and psychomotor skills in anesthesia trainees. Specifically, this phenomenon has been demonstrated with performing fiberoptic intubation (iLarynx®[12]), understanding anesthetic pharmacokinetics (Gas Man®[13]), utilizing Advanced Cardiac Life Support algorithms (Anesoft ACLS®[14]), managing intraoperative malignant hyperthermia (Leiden Anaesthesia Simulator[3]), and identifying anesthesia machine errors (Transparent Virtual Anesthesia Machine®[15]). Furthermore, several studies suggest that SBS may be comparable to MBS for fostering anesthesia-related cognitive skill sets. For example, almost two decades ago, relatively low fidelity SBS involving an early model-controlled screen-based simulator (Anesthesia Simulator Consultant developed by Schwid and O'Donnell[16,17]) was demonstrated to be as effective as high-fidelity MBS in teaching anesthesia residents competence in crisis management.[2] Likewise, a study of nurse anesthesia students showed no significant difference between times to recognition of anaphylaxis after training with MBS versus SBS (Anesoft Anesthesia®).[11] Somewhat unexpectedly, SBS also has been shown to be effective in improving teamwork skills.[10,18] This latter finding is particularly important in anesthesia since behavioral abilities – such as effective communication and leadership – are critical for successful management of intraoperative adverse events.[2,19-22]

What is the Educational Value of Fidelity in SBS?

The importance of fidelity in anesthesia simulation teaching is less than intuitive. Studies involving SBS in aviation show that training with higher fidelity simulation does not necessarily translate as better pilot performance.[2,23–27] As

noted above, a randomized controlled study demonstrated that low fidelity SBS was comparable to higher fidelity MBS in teaching anesthesia residents to manage anaphylaxis.[2] On the other hand, if an anesthesia simulator does not accurately recreate perioperative experiences, trainees may develop a false notion of what to expect during real-life circumstances.[7] In addition, to the extent that SBS does not reproduce a real-world scenario, trainees' attitudes and approaches to clinical problems do not mirror their normal behavior.[3] Possibly for these latter reasons, no studies have compared educational outcomes following use of different anesthesia SBS platforms with different levels of fidelity.

Is Anesthesia Distance Education Using SBS Efficacious?

In general, online distance learning – asynchronous and synchronous – has become increasingly popular due to its ability to reach large groups of individuals seamlessly, flexible scheduling, and its lack of need for institutional buildings and infrastructure (and corresponding lower costs).[28] Within the field of anesthesia education, clinical competence of providers in remote or difficult-terrain locations has been upgraded using online learning programs.[29] In addition, distance education has become an integral component of many nurse anesthesia programs and often involves a synchronous, collaborative learning process.[30]

To date, however, there has been no published information concerning use of SBS in anesthesia distance education. Until recently, SBS in this setting has largely involved self-directed, asynchronous activities without instructor involvement that allows for maximum flexibility of location and timing of learning, and captures the benefits of scenario repeatability and automated feedback.[31] In contrast, instructor-facilitated, distance learning with SBS in anesthesia has not been widely employed. This state of affairs has changed with COVID-19. Mandatory social isolation precipitated in response to the viral pandemic radically altered the dynamics of anesthesia education – much as it has altered the options for all traditional educational forums – and online distance teaching has assumed a major role in substituting for former in-person curricular activities. This same social pressure has motivated the use of anesthesia distance education using SBS to fill gaps in educational programs formerly employing solely MBS.

Essentially three options exist for instructor-facilitated distance anesthesia education involving SBS: (1) students can perform simulations asynchronously, and then review their experiences – either asynchronously or synchronously – with an instructor using standard cloud-based peer-to-peer software platforms such as Zoom®, WebEx®, Slack®, and Microsoft® Teams; (2) using the same cloud-based platforms, students can synchronously view (and potentially verbally direct either individually or in small groups) the actions of an instructor as the latter individual performs the SBS; or (3) instruction may employ a hybrid of (1) and (2). The apparent advantages of option 2 include cost (only the instructor's version of the SBS software must be purchased) and the fact that students do not need to devote time and energy to master the precise workings of increasingly complex software platforms (eg SimSTAT®, a high fidelity, avatar-based VS system developed by the American Society of Anesthesiologists, has a substantial learning curve). Despite these considerations, however, this latter option does not allow for significant student interactivity and thereby markedly compromises the experiential aspects of learning. Alternatively, option 3 (a hybrid option) offers both an opportunity for instructor-guided teaching and for "hands-on" student engagement in the SBS exercise, and students with a background in gaming may have enhanced cognitive performance that facilitates their grasp of complex software.[32]

During all of these options for teaching anesthesia with online SBS exercises, several techniques may assist in achieving educational goals. Because many of the applicable SBS software scenarios run in real time, use of a "pause" option is often essential to allow for instructor-led teaching opportunities. During these pauses, key issues related to pathophysiology, cognitive algorithms used in clinical diagnosis, and patient management techniques can be outlined and discussed. Paused instruction also may employ multiple audiovisual documents including computer screenshots taken from the SBS, and standard PowerPoint displays. Repeated pausing, however, may be problematic insofar as these actions interrupt the overall flow of the screen-based scenario, and jeopardize losing the "big picture" to achieve specific teaching objectives. Ideally, the scenario can be run repeatedly – once with multiple pauses, and other times with fewer (or no) interruptions.

Despite these techniques, given its relative novelty, it is unclear if student satisfaction and/or achievement of educational goals (eg successful simulated crisis management) with training using SBS at a distance are comparable to the student acceptance and pedagogic value that characterizes either face-to-face SBS or MBS. In addition, many anesthesia SBS platforms have integrated

scoring systems, and the validity of these and other evaluative functions of SBS in this setting has yet to be determined. Also, although SBS in both traditional and distance education may possess visual and audio fidelity, its lack of haptic realism involving both tactile and kinesthetic feedback remains an inherent technological limitation compared with MBS or virtual reality learning.[33] It is clear, however, that anesthesia education at a distance has multiple advantages that make it attractive in some instances, and that asynchronous and synchronous SBS as part of such distance education may diminish the need for and associated cost of extensive in-person MBS. As a result, and especially with the likelihood of repeat pandemics in the future, distance education involving SBS software platforms of increasingly high fidelity is likely to become integral part of future anesthesia training programs. As a result, and especially with the likelihood of repeat pandemics in the future, distance education involving SBS software platforms of increasingly high fidelity is likely to become an integral part of future anesthesia training programs.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Boulet JR, Murray DJ. Simulation-based assessment in anesthesiology: requirements for practical implementation. *Anesthesiology*. 2010;112(4):1041–1052. doi:10.1097/ALN.0b013e3181cea265
2. Nyseen A, Larbuisson R, Janssens M, Pendeville P, Mayne A. A comparison of the training value of two types of anesthesia simulators: computer screen-based and mannequin-based simulators. *Anesth Analg*. 2002;94:1560–1565. doi:10.1213/00000539-200206000-00035
3. Chopra V, Gesink BJ, De Jong J, Bovill JG, Spierdijk J, Brand R. Does training on an anesthesia simulator lead to improvement in performance? *Br J Anaesth*. 1994;73:293–297. doi:10.1093/bja/73.3.293
4. Schwid HA, Rooke GA, Michalowski P, Ross BK. Screen-based anesthesia simulation with debriefing improves performance in a mannequin-based anesthesia simulator. *Teach Learn Med*. 2001;13(2):92–96. doi:10.1207/S15328015TLM1302_4
5. Ventre KM, Schwid HA. Computer and web based simulators. In: Levine AI, DeMaria J, Schwartz AD, Sim AJ, editors. *The Comprehensive Textbook of Healthcare Simulation*. New York: Springer; 2013:191–208.
6. Pottle J. Virtual reality and the transformation of medical education. *Future Healthc J*. 2019;6(3):181–185. doi:10.7861/fhj.2019-0036
7. Singh PM, Kaur M, Trikha A. Virtual reality in anesthesia "simulation.". *Anesth Essays Res*. 2012;6(2):134–139. doi:10.4103/0259-1162.108289
8. Cumin D, Merry AF. Simulators for use in anaesthesia. *Anaesthesia*. 2007;62:151–162. doi:10.1111/j.1365-2044.2006.04902.x
9. Edwards DA, Lampotang S. Computer- and web-based simulators and virtual environments. In: Mahoney B, Minehart RD, Pian-Smith MCM, editors. *Comprehensive Healthcare Simulation: Anesthesiology*. Switzerland: Springer; 2020:117–125.
10. Liaw S, Chan SW, Chen FG, Hooi SC, Siau C. Comparison of virtual patient simulation with mannequin-based simulation for improving clinical performances in assessing and managing clinical deterioration: randomized controlled trial. *J Med Internet Res*. 2014;16(9):e214. doi:10.2196/jmir.3322
11. Erlinger LR, Bartlett A, Perez A. High-fidelity mannequin simulation versus virtual simulation for recognition of critical events by student registered nurse anesthetists. *AANA J*. 2019;87(2):105–110.
12. Oliveira GS, Glassenberg R, Chang R, Fitzgerald P, McCarthy RJ. Virtual airway simulation to improve dexterity among novices performing fiberoptic intubation. *Anaesthesia*. 2013;68:1053–1058. doi:10.1111/anae.12379
13. Garfield JM, Paskin S, Philip JH. An evaluation of the effectiveness of a computer simulation of anaesthetic uptake and distribution as a teaching tool. *Med Educ*. 1989;23:457–462. doi:10.1111/j.1365-2923.1989.tb00902.x
14. Schwid HA, Rooke GA, Ross BK, Sivarajan M. Use of a computerized advanced cardiac life support simulator improves retention of advanced cardiac life support guidelines better than a textbook review. *Crit Care Med*. 1999;27:821–824. doi:10.1097/00003246-199904000-00045
15. Fischler IS, Kaschub CE, Lizdas DE, Lampotang S. Understanding of anesthesia machine function is enhanced with a transparent reality simulation. *Simul Healthc*. 2014;9:56–64. doi:10.1097/SIH.0b013e31829b3fb3
16. Schwid HA, O'Donnell D. The anesthesia simulator-recorder: a device to train and evaluate anesthesiologists' responses to critical incidents. *Anesthesiology*. 1990;72(1):191–197. doi:10.1097/00000542-199001000-00028
17. Schwid HA, O'Donnell D. The anesthesia simulator-recorder: simulation plus expert system. *Anesthesiol Rev*. 1993;20(5):185–189.
18. Youngblood P, Hartr PM, Srivastava S, Moffett S, Heinrichs WL, Dev P. Design, development, and evaluation of an online virtual emergency department for training trauma teams. *Simul Healthc*. 2008;3(3):146–153. doi:10.1097/SIH.0b013e31817bedf7
19. Gaba DM, Howard SK, Flanagan B, Smith BE, Fish KJ, Botney R. Assessment of clinical performance during simulated crises using both technical and behavioral ratings. *Anesthesiology*. 1998;89(1):8–18. doi:10.1097/00000542-199807000-00005
20. Cooper JB. Toward prevention of anesthetic mishaps. *Int Anesthesiol Clin*. 1984;22:167–183. doi:10.1097/00004311-198408000-00013
21. Schaefer HG, Helmreich RL. The importance of human factors in the operating room. *Anesthesiology*. 1994;80(2):479. doi:10.1097/00000542-199402000-00035
22. Helmreich RL, Schaefer HG. Team performance in the operating room. In: Bogner MS, editor. *Human Error in Medicine*. Hillsdale, NJ: Lawrence Erlbaum Associates; 1994:225–253.
23. Lintern G, Thomley-Yates KE, Nelson BE, Roscoe SN. Content, variety and augmentation of simulated visual scenes for teaching air-to-ground attack. *Hum Factors*. 1987;29(1):45–59. doi:10.1177/001872088702900105
24. Lintern G, Shepard DJ, Parker DL, Yates KE, Nolan MD. Simulator design and instructional features for air-to-ground attack: a transfer study. *Hum Factors*. 1989;31(1):87–99. doi:10.1177/001872088903100107
25. Jentsch F, Bowers CA. Evidence for the validity of PC-based simulations in studying aircrew coordination. *Int J Aviat Psychol*. 1998;8:243–260. doi:10.1207/s15327108ijap0803_5
26. Salas E, Bowers CA, Rhodenizer L. It is not how much you have but how you use it: towards a rational use of simulation to support aviation training. *Int J Aviat Psychol*. 1998;8(3):197–208. doi:10.1207/s15327108ijap0803_2

27. Flexman RE, Stark EA. Training simulators. In: Salvendy G, editor. *Handbook of Human Factors*. New York: John Wiley & Sons; 1987:1012–1038.
28. Arkorful V, Abaidoo N. The role of e-learning, advantages and disadvantages of its adoption in higher education. *Int J Instruct Tech and Dist Learn*. 2015;12(1):29–42.
29. Shah S, Knoble S, Ross O, Pickering S. A distance blended learning program to upgrade the clinical competence of district non-doctor anesthesia providers in Nepal. *World J Surg*. 2017;41:3006–3011. doi:10.1007/s00268-017-4273-3
30. Pecka SL, Kotcherlakota S, Berger AM. Community of inquiry model: advancing distance learning in nurse anesthesia education. *AANA J*. 2014;82(3):212–218.
31. American Society of Anesthesiologists. Simulation training for physician anesthesiologists is now available anywhere, anytime. Available from: https://www.asahq.org/education-and-career/educational-and-cme- offerings/simulation-education/anesthesia-simstat. Accessed May 29, 2020.
32. Granic I, Lobel A, Engels RCME. The benefits of playing video games. *Am Psychologist*. 2014;69(1):66–78. doi:10.1037/a0034857
33. Owens R, Taekman JM. Virtual reality, haptic simulators, and virtual environments. In: Levine AI, DeMaria J, Schwartz AD, Sim AJ, editors. *The Comprehensive Textbook of Healthcare Simulation*. New York: Springer; 2013:191–208.