Minimally Invasive Therapy & Allied Technologies

ISSN: 1364-5706 (Print) 1365-2931 (Online) Journal homepage: https://www.tandfonline.com/loi/imit20

Validation of virtual reality simulators: Key to the successful integration of a novel teaching technology into minimal access surgery

Marlies P. Schijven & Jack J. Jakimowicz

Minimally Invasive Therapy. 2005; 14:4-5; 244–246

Taylor & Francis
Taylor & Francis Group

Validation of virtual reality simulators: Key to the successful integration of a novel teaching technology into minimal access surgery

MARLIES P. SCHIJVEN[1] & JACK J. JAKIMOWICZ[2]

[1]*Department of Surgery, IJsselland Hospital, Capelle a/d IJssel, The Netherlands, and* [2]*Department of Surgery, Catharina Hospital, Eindhoven, The Netherlands*

Abstract

Minimal access surgery (MAS) requires additional training in the surgical curriculum, as skills needed to perform MAS are quite different from those used in open surgery. Moreover, residents do not seem to experience ample opportunity to gain such skills in the current surgical curriculum. Virtual reality (VR) simulation offers an interesting opportunity to train such skills in a safe, supporting environment. As with any new development, one should be careful about integrating costly technology into practice before it has been properly validated.

This article outlines the requirements for a valid and integrated approach towards the integration of novel VR simulation systems in minimal access surgery.

Key words: *Virtual reality simulation, laparoscopy, surgery, education, validation*

Introduction

Numerous surgical procedures across a broad spectrum of clinical specialties have become adapted to minimal access surgery (MAS). Probably the best example is laparoscopic cholecystectomy, the procedure of choice over its open counterpart. In the early phase of a surgeon performing MAS, there is little transfer of skills that builds on techniques learned earlier on in performing open surgery. Skills needed to perform MAS tend to be quite different in nature from those needed for open surgery, which are neither appropriate nor adequate for use in performing MAS (1). Acquiring laparoscopic skills thus involves initial learning and further refinement of both cognitive and psychomotor skills different in character from those needed for conventional, open surgery (2).

Specific MAS skills training is, therefore, a necessity when learning to perform MAS procedures adequately. However, studies have shown training in MAS often to be inadequate (3,4). Not surprisingly, multiple, nation-wide surveys report that surgical residents estimate themselves to be incapable of performing advanced surgical laparoscopic procedures upon completion of formal training (5–9). More specifically, there is a reported lack of volume in advanced laparoscopic procedures, and also a lack of opportunity for being the first operating surgeon. Therefore, in the current surgical traineeship there are multiple obstacles evidently preventing residents from acquiring proficiency in MAS.

Virtual reality training in minimal access surgery, will it work?

Usually, MAS skills training programs feature inanimate training models, e.g. box trainers. Although suited for training psychomotor abilities, they do not offer opportunity for procedural training, nor for objective feedback. Animate training models, e.g. porcine models, provide a genuine tissue model, but are costly, require a specific infrastructure and are usually not regularly available to the trainee.

Virtual reality (VR) simulation is a relatively new development in the MAS surgical skills training department. These simulators provide a promising asset in constructing a validated skills training program. VR MAS simulation provides not only real-time graphics, repetitive scenery, multiple anatomically different patient scenarios and optional force-feedback in tissue handling, but also offers the possibility of objective assessment and the construction of individual learning curves.

First reports concerning the use of VR simulation settings in MAS training have been published in literature, and outcomes of both basic psychomotor

Correspondence: M. P. Schijven, IJsselland Hospital, Prins Constantijnweg 2, NL-2900 AR Capelle a/d Ijssel, The Netherlands. Fax: +31 10 2130561. E-mail: mschijv@zonnet.nl

ISSN 1364-5706 print/ISSN 1365-2931 online
DOI: 10.1080/13645700500221881

skills training as well as procedural skills training are promising (10–14).

Nevertheless, as with any new technology applied to health care, VR simulators should be properly validated before they can legitimately stake credi bility from the profession, and even more so, before they are used to train and/or select residents. Derossis, Taffinder and authors were among the first to highlight the importance of validation research in this new area of surgical training (14–16).

Now what is considered to be a *valid* VR simulator? A valid VR simulator must be able to mimic visual-spatial ability and real-time characteristics of the procedure simulated, and preferably provide realistic haptic feedback.Moreover, it must be able to evaluate the performance of the procedure objectively, based on a sound scoring system. Such a scoring system can only be proper when it is constructed, approved and revised by renowned performers of the surgical procedure in question.

The process of validation

Basically, the concept of validity addresses the question: Do we measure what we intend to measure (17)? Thus, valid innovations are innovations with low non-random (systematic) errors. The establishment of validity concerning an innovation, such as a virtual reality surgical simulator, reflects a process that is characterized by multiple steps – as there are multiple aspects to the concept of validity. A simulator should successfully pass all these steps in order to become both a reliable skills trainer and predictor of performance (18,19).

The assessment of any MAS VR system should therefore be able to demonstrate validity on different levels, and have the results in public press to account for it.

First, the level of **content validity** should be examined. Content validity refers to the degree of empirical foundation of the VR system, based on a theoretical construct. In practice: To what extent does the system cover the subject matter of a real activity? Does a VR simulator designed to develop true psychomotor abilities in fact also *measure* true psychomotor abilities, and is its assessment not blurred by a trainees anatomical knowledge, for instance? Proper evaluation of both the VR setting and underlying scoring system by the surgical community is, therefore, indispensable. Consensus in peer-reviewed literature concerning the system's outcome parameters, combined with consensus using focus-group meetings is crucial in this phase.

The concept of content validity should therefore be scrutinized early on in the development of VR simulators.

The most basic empirical level is of validity is that of **face validity**. Face validity refers to the degree of resemblance between a concept (VR simulation) and the actual construct (surgical procedure). This type of validity should not be assessed without attention to the opinion of both experts (the ones who buy it, e.g. surgeons, medical educators) and referents (the ones who use it, e.g. surgical trainees). Both groups should have a positive opinion of the innovation in order for a simulator to become a marketable concept.

Construct validity refers to the degree to which a simulator can distinguish between different levels of experience with the procedure of study. In practise, it is often based on the presence of a logical difference in outcome of experts and novices of the procedure on the simulator (e.g. expert surgeons scores are higher on a certain task than novices scores are). Although construct validity is often regarded as the central theme in validation studies, it only shows a contrast among levels of expertise with the procedure (20). Unlike content validity, it does not fully explain the underlying theoretical construct. Therefore, one should not focus solely on this parameter.

The most powerful evidence is gained through the test of **concurrent** or **predictive** validity, which refers to the degree of concordance of independent - paired- test outcomes between study results, using a concept instrument (VR simulator) and the study results on an established instrument, that is believed to measure the same theoretical construct. When referring to the degree of concordance of a concept instruments outcome and operation room performance, the term ***predictive*** validity is regularly used

VR simulation systems have recently proven to be a valuable asset in the surgical training curriculum (12,13,21). They are able to enhance MAS proficiency even above the level that is achieved regular surgical (non-VR) training (22). It must be stressed, however, that skills derived by VR training will only sustain when regularly applied in the clinical profession. As with any form of training, extinction is bound to occur when newly achieved skills are not used.

A surgical curriculum designed to incorporate VR training in the early phase of residents engagement in clinical MAS surgery is probably most efficient.

Discussion

Now what is important when choosing a VR surgical simulator? At the moment, there are multiple systems on the market, each featuring its own particular simulation and assessment. It is to be expected that an ever larger variety of systems and simulations will become rapidly available, as developments in VR simulation are evolving faster resulting form exponential growth in VR technology (23). Authors feel VR simulators should ideally be incorporated in a skills laboratory and/or training course in order to achieve maximal benefits both for the trainee and the training institute. In such a context, maximum opportunities for curriculum integration and evaluation are available.

Ideally, in a skills laboratory there is a place for (less expensive) VR systems focussing on training psychomotor skill and part-task surgical practice, as well as for the more advanced full procedural (force feedback enabled) VR systems. Authors favour such an integrated, step-wise approach. Indeed, by starting VR training within a more abstract (e.g. non-anatomical) environment, the trainees focus will be more on the psychomotor skills acquiring proficiency in movements. Later on, an integration of surgical knowledge and psychomotor skill can be further developed and refined using full procedural simulation tasks. An open VR platform, featuring multiple VR software simulations, with the possibility to have force-feedback in the system, is probably most versatile. Also, one is less likely to get stuck due to hard- and software ware limitations in the future.

The recently established EAES Work Group for evaluation and implementation of simulators and skills training programmes has taken up the task of evaluating studies concerning the application of VR surgical simulation systems, and to provide transparent consensus guidelines for both VR developers and the surgical community.

The guidelines of this workgroup are available through the EAES secretary (Veldhoven, the Netherlands) and will soon appear in the society's journal 'Surgical Endoscopy'.

References

1. Figert PL, Park AE, Witzke DB, Schwartz RW. Transfer of training in acquiring laparoscopic skills. J Am Coll Surg. 2001;193:533–7.
2. Chaudhry A, Sutton C, Wood J, Stone R, et al. Learning rate for laparoscopic surgical skills on MIST VR, a virtual reality simulator: quality of human-computer interface. Ann R Coll Surg Engl. 1999;81:281–6.
3. Liberman MA, Greason K. Residency training in advanced laparoscopic surgery: how are we doing?. Surg Laparosc Endosc Percutan Tech. 1999;9:87–90.
4. Park A, Witzke DB. Training and educational approaches to minimally invasive surgery: state of the art. Semin Laparosc Surg. 2002;9:198–205.
5. Chiasson PM, et al. Minimally invasive surgery training in Canada. A survey of general surgery. Surg Endosc. 2003: 371–7.
6. Schijven MP, Berlage JTM, Jakimowicz J. Minimal access surgery training in the Netherlands. A survey among residents-in-training for general surgery. Surg Endosc. 2004;18:1805–14.
7. Chung R, Pham Q, Wojtasik L, Chari V, et al. The laparoscopic experience of surgical graduates in the United States. Surg Endosc. 2003;17:1792–5.
8. Rattner DW, Apelgren KN, Eubanks WS. The need for training opportunities in advanced laparoscopic surgery. Surg Endosc. 2001;15:1066–70.
9. Nussbaum MS. Surgical endoscopy training is integral to general surgery residency and should be integrated into residency and fellowships abandoned. Semin Laparosc Surg. 2002;9:212–5.
10. Hyltander A, Rhodin P, Liljegren E. The transfer of basic skills learned in a laparoscopic simulator to the operating room. Surg Endosc. 2002;16:1324–8.
11. Gallagher AG, McClure N, McGuigan J, Crothers I, et al. Virtual Reality Training in Laparoscopic Surgery: A Preliminary Assessment of Minimally Invasive Surgical Trainer Virtual Reality (MIST VR). Endoscopy. 1999;31:310–3.
12. Grantcharov TP, Kristiansen VB, Bendix J, Bardram L, et al. Randomized clinical trail of virtual reality simulation for laparoscopic skills training. Br J Surg. 2004;91:146–50.
13. Seymour NE, Gallagher AG, Roman SA, O'Brian M, et al. Virtual reality improves operating room performance: results of a randomized, double-blind study. Ann.Surg. 2002;236:458–63.
14. Taffinder N, Sutton C, Fishwick RJ, McManus IC, et al. Validation Of Virtual Reality To Teach And Assess Psychomotor Skills In Laparoscopic Surgery: Results From Randomized Controlled Studies Using The MIST VR Laparoscopic Simulator. In: Westwood JD, et al., eds. Technology and informatics 50: proceedings of medicine meets virtual reality. San Diego: IOS Press and Ohmsha Amsterdam. 1988: 124–30.
15. Derossis AM, Gerald FM, Abrahamowicz M, Sigman HH, et al. Development of a model for training and evaluation of laparoscopic skills. Am J Surg. 1998;175:482–7.
16. Schijven M, Jakimowicz J. Face-, expert- and referent validity of the Xitact® LS500 Laparoscopy Simulator. Surg Endosc. 2002;16:1764–70.
17. Nelson AA. Research design: measurement, reliability and validity. Am J Hosp Pharm. 1980;37:851–7.
18. Schijven M, Jakimowicz J. Construct validity: experts and residents performing on the Xitact LS500 laparoscopy simulator. Surg Endosc. 2003;17:803–10.
19. Schijven MP. Virtual Reality Simulation for Laparoscopic Cholecystectomy: the process of validation and implementation in the surgical curriculum outlined., in Surgery. Leiden. 2005 ISBN 90-9019048-1. p. 180.
20. Smith CD, Stubbs J, Stubbs HD. Simulation technology in surgical education: can we assess manipulative skills and what does it mean to the learner. In: Westwood JD, et al., eds. Medicine meets virtual reality: art, science, technology: Healthcar (R)Evolution. San Diego: IOS Press and Ohmsa. 1998: 379–380.
21. Strom P, Kjellin A, Hedman L, Johnson E, et al. Validation and learning in the Procedicus KSA virtual reality surgical simulator. Implementing a new safety culture in medical school. Surg Endosc. 2003;17:227–31.
22. Schijven MP, Jakimowicz JJ, Broeders IAMJ, Tseng LNL. The Eindhoven laparoscopic cholecystectomy training course: Improving operating room performance using Virtual Reality Training. Surg Endos. 2005; in press.
23. Schijven M, Jakimowicz J. Virtual reality surgical laparoscopic simulators: how to choose. Surg Endosc. 2003;17:1943–50.