ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ:
‘‘ΕΛΑΧΙΣΤΑ ΕΠΕΜΒΑΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ, ΡΟΜΠΟΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ ΚΑΙ ΤΗΛΕΧΕΙΡΟΥΡΓΙΚΗ’’

ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ΙΑΤΡΙΚΗ ΣΧΟΛΗ

ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

DIFFERENT FORMS OF LAPAROSCOPIC TRAINING: REVIEW AND COMPARISON

ΒΑΛΛΑΣ ΧΡΥΣΟΣΤΟΜΟΣ

ΑΘΗΝΑ 2014

ΠΡΑΚΤΙΚΟ ΚΡΙΣΕΩΣ
ΤΗΣ ΣΥΝΕΔΡΙΑΣΗΣ ΤΗΣ ΤΡΙΜΕΛΟΥΣ ΕΞΕΤΑΣΤΙΚΗΣ ΕΠΙΤΡΟΠΗΣ ΓΙΑ ΤΗΝ ΑΞΙΟΛΟΓΗΣΗ ΤΗΣ ΔΙΠΛΩΜΑΤΙΚΗΣ ΕΡΓΑΣΙΑΣ
Του Μεταπτυχιακού Φοιτητή Χρυσόστομου Βαλλά

Εξεταστική Επιτροπή

- Ανδρέας Αλεξάνδρου, Επιβλέπων
- Χρήστος Π. Τσιγκρής
- Θεόδωρος Διαμαντής

Η Τριμελής Εξεταστική Επιτροπή η οποία ορίσθηκε από την ΓΣΕΣ της Ιατρικής Σχολής του Παν. Αθηνών Συνεδρίαση της .....ης .... 20.... για την αξιολόγηση και εξέταση του υποψηφίου κ. Χρυσόστομου Βαλλά, συνεδρίασε σήμερα .../.../....

Η Επιτροπή **διαπίστωσε** ότι η Διπλωματική Εργασία του Κ. Χρυσόστομου Βαλλά
με τίτλο: DIFFERENT FORMS OF LAPAROSCOPIC TRAINING: REVIEW AND COMPARISON ,
είναι πρωτότυπη, επιστημονικά και τεχνικά άρτια και η βιβλιογραφική πληροφορία ολοκληρωμένη και εμπεριστατωμένη.

Η εξεταστική επιτροπή αφού έλαβε υπ' όψιν το περιεχόμενο της εργασίας και τη συμβολή της στην επιστήμη, με ψήφους .... προτείνει την απονομή του Μεταπτυχιακού Διπλώματος Ειδίκευσης (Master's Degree), στον παραπάνω Μεταπτυχιακό Φοιτητή.

Στην ψηφοφορία για την βαθμολογία ο υποψήφιος έλαβε για τον βαθμό «ΑΡΙΣΤΑ» ψήφους ...., για τον βαθμό «ΛΙΑΝ ΚΑΛΩΣ» ψήφους ...., και για τον βαθμό «ΚΑΛΩΣ» ψήφους .... Κατά συνέπεια, απονέμεται ο βαθμός «......................».

Τα Μέλη της Εξεταστικής Επιτροπής

- Ανδρέας Αλεξάνδρου, Επιβλέπων (Υπογραφή) ________________
- Χρήστος Π. Τσιγκρής, (Υπογραφή) ________________
- Θεόδωρος Διαμαντής, (Υπογραφή) ________________

Στη γυναίκα μου Χάιδω

ΕΥΧΑΡΙΣΤΙΕΣ

Με την εργασία αυτή ολοκληρώνεται η φοίτηση μου στο Μεταπτυχιακό Πρόγραμμα Σπουδών στην Ελάχιστα Επεμβατική Χειρουργική, Ρομποτική Χειρουργική και Τηλεχειρουργική της Ιατρικής Σχολής του Εθνικού και Καποδιστριακού Πανεπιστημίου Αθηνών. Στην πραγματοποίησή της συνέβαλαν καθηγητές, συνάδελφοι και φίλοι, τους οποίους ευχαριστώ.

Αρχικά οφείλω ένα μεγάλο ευχαριστώ στον Λέκτορα Χειρουργικής κ. Ανδρέα Αλεξάνδρου για την παραχώρηση του θέματος, για τις πολύτιμες συμβουλές και την προσωπική του συμβολή στην εκπόνηση αυτής της εργασίας.

Ιδιαίτερες ευχαριστίες οφείλω στον Καθηγητή Χειρουργικής, Διευθυντή της Α' Χειρουργικής Κλινικής της Ιατρικής Σχολής του Πανεπιστημίου Αθηνών και Επιστημονικό Υπεύθυνο του Μεταπτυχιακού Προγράμματος Σπουδών κ. Χρήστο Τσιγκρή και τον Καθηγητή Χειρουργικής της Ιατρικής Σχολής του Πανεπιστημίου Αθηνών κ. Θεόδωρο Διαμαντή για την παροχή γνώσεων και την καθοδήγησή τους καθόλη τη διάρκεια της φοίτησής μου.

Επιπλέον θα ήθελα να ευχαριστήσω τη Γραμματέα του Μεταπτυχιακού Προγράμματος Σπουδών κα. Λαμπρινή Κώνσταντου για την υλικοτεχνική υποδομή και τη βοήθεια που πάντα πρόθυμα προσέφερε.

Περισσότερο από όλους ευχαριστώ τη γυναίκα μου, τους γονείς μου και την αδελφή μου για τη συνεχή υποστήριξή τους, την αγάπη τους και την ατέλειωτη υπομονή τους.

CONTENTS

Chapter 1

1. Introduction

Laparoscopic surgery has been accepted as the main treatment approach for many various pathologies, because of its known advantages over open procedures. However, performing laparoscopic procedures demands very specific capabilities of the surgeon, which can only be gained through extensive training.[1,2]

1. 1 Surgical simulation

Surgical training consists of developing cognitive, clinical and technical skills, with the latter traditionally acquired through mentoring in the operating room (OR).[3] Surgical simulation offers the opportunity for surgical trainees to practice surgical skills before entering the OR and allows for detailed feedback and objective assessment of performance. The trainees actions can be analyzed, errors identified and corrected and performance scored under standardized conditions. To establish whether there is benefit in using simulated environments to teach surgical skills, it must be shown that the skills acquired through simulation-based training can positively transfer to clinical practice.

There is enormous potential to address patient safety, risk management concerns, OR management and work hours requirements with more efficient and effective training methods.

Over the last few decades laparoscopic procedures have evolved from diagnostic laparoscopy[4] to advanced, more complex procedures. These more advanced procedures require highly developed psychomotor skills. The surgeon's anatomic awareness must be developed in concert with the ability to safely achieve, exposure and identify and control important structures. To assist with the critical components of many advanced operations, specialized equipment is available and commonly used. These instruments require a great deal of expertise in order to be used effectively and safely.[5]

1. 2 Types of surgical simulation

Surgical simulation involves the use of objects, devises, electronic and/or mechanical surgical simulators, cadavers, animals and animal organs to reproduce or rapresent, under test conditions, situations that are likely to occur in the actual operative setting. The different forms of simulation are summarized below :

Synthetic models and box trainers

Physical simulators, such as box trainers, do not directly measure movements or skills, and require a trained observer to determine performance. Their relatively low acquisition cost, high availability and easy portability make this type of simulator the most widely available and validated surgical training system.

Live animal models

Anaesthetized, live animals provide a high-fidelity, non-patient environment that allows trainees to develop the psychomotor and cognitive skills required for the operative setting. The numbers of animals needed as well as cultural, financial and ethical issues limit their use.

Cadaveric models

The limited supply of cadavers, coupled with concerns regarding disease transmission from human tissues and fluids, and ethical and cultural issues, limit this mode of training.

Ex vivo animal tissue models

Using anatomic sections or tissues from euthanased animals (ex vivo) is another form of simulation in surgical skills training. Dedicated ‘wet rooms’ within skills centres are mandatory if this training model is to be employed.

Virtual reality (computer-based) models

Virtual reality (VR) surgical simulators use computer-generated instruments through specially designed interfaces to manipulate computer-generated objects. An attractive feature of VR surgical simulators is that they can provide objective and repeated measurements, such as the time taken to complete a task, the errors made in the process and also the efficiency with which the movements were made in the accomplishment of the task. These metrics present the opportunity for the assessment of competency without the need for an observer to be present.

Most surgical VR systems function as part-task trainers that aim to increase surgeon skill by shaping behaviours required for performing surgery. Realistic tactile sensations (i.e. haptics) in the use of surgical instruments is imperfect in some VR simulators. Although work is progressing to improve realistic haptics in VR trainers, this development is expensive.

VR technology has developed software that attempts to replicate skills required for entire minimally invasive surgery procedures, but this provides limited practice in decision-making and relatively poor haptic feedback.

Augmented reality simulators

Augmented reality (AR) combines physical reality (such as a box trainer) and VR into one system. Haptic feedback is maintained, using original laparoscopic instruments and tactile tasks, and objective measures of performance are generated.[6]

Chapter 2

Objectives

The objectives of this review are to synthesise the current literature on the effectiveness of different forms in laparoscopic training and evaluate the impact on the development of technical competence.

Methods

This research project was conducted as a literature review, therefore formal ethical approval was not required. The following databases were searched, chosen to provide the broadest range of research within the fields of healthcare and educational research: Pubmed, Medline and the Cochrane Library.

These databases were searched using the following keywords combinations: surgical AND training, “virtual reality”, “augmented reality” and “surgical simulation”, along with publication types (systematic review, meta-analysis) to identify systematic reviews published in English from 2003 to 2013 that synthesized research involving any health profession trainees preparing to treat adult human patients.

Were excluded:

- Narrative reviews.
- Reviews focused on technical development of simulation systems.
- Simulation training aimed at pediatric clinicians.
- Systematic reviews focused on uses of simulation other than training.
- Articles already included in systematic reviews.
- Primary studies where simulation was not the intervention or independent variable.

All studies meeting the final inclusion criteria were initially classified by the type of surgical simulation technique used, in order to categorise the available types of surgical simulation.

The included studies were categorized initially by the non-simulation-based training method. Studies were then categorized by intervention and then by the level of evidence. Once grouped, studies were then further analyzed following a system based on guidelines for educational studies involving simulators produced by the BEME Collaboration and the TAP.[7,8]

Results

Seven independent systematic reviews and one review, with one hundred twenty RCTs and two hundred fifty studies, were qualified for full analysis and are outlined in Figure 1.

These studies fell across five main categories of surgical simulation technique (cadaver, model, computer, video and augmented reality) and compared with no training and standard training, as well as with each other.

Figure 1: Summary of systematic reviews for simulation training

Citation	Publication years covered/ number of RCTs / studies included	Content
Systematic reviews		
Gurusamy (Cochrane; 2009a)	to 2008: 23 RCTs	Virtual reality training for surgical trainees in laparoscopic surgery
Schout (2008)	to 2008: 3 RCTs 45 studies	Simulation training models in urology
ASERNIP-S (2012)	to 2012: 20 RCTs	Transfer of simulation-based skills to the operating room
Sutherland (2006)	to 2005: 30 RCTs	Effectiveness of surgical simulation compared to other methods of surgical training
Lynagh (2007)	to 2006: 44 RCTs	Effectiveness of medical skills laboratories or simulators
Marinopoulos (2007)	to 2006: 9 systematic reviews	Effectiveness of continuing medical education (CME)
Matthew P. Thomas (2013)	to 2013: 32 studies	Effectiveness of surgical simulation on the development of technical competence during surgical training
Review		
Sanne M. B. I. Botden(2008)	to 2008: 4 studies	Developments in augmented reality laparoscopic simulation
	Total 120 RCTs and 250 included studies	**7 fully systematic reviews**

The objective of the systematic review by Gurusamy[9], was to determine whether VR training can supplement and/or replace conventional laparoscopic surgical training. Twenty-three trials (mostly with a high risk of bias) involving six hundred twenty two participants were included in this review.

Four trials compared VR training with video training (VT), twelve trials compared VR training with no training, four trials compared VR training with VT, no training and standard training, and three trials compared different forms of VR each other. Participants were divided in those without prior laparoscopic experience and those with limited laparoscopic experience. In the first group VR decreased time to complete a task, increased accuracy and decreased errors compared with no training, also VR group was more accurate than video trained. In the second group VR reduced operating time and error better than standard training.

The objective of the systematic review by Schout[10], was to obtain an overview of training models and their validity in endourology. Three RCTs and forty five studies, compared thirty training models in uretero-endoscopy.

The objective of the systematic review by the update report of the Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP-S)[6], was to determine whether skills acquired through simulation-based training transfer to the operative setting. A total of twenty RCTs and six hundred twenty nine participants, were included in this review.

Nine RCTs examined performance during laparoscopic procedures in participants who had trained using simulation with those who had not received simulation-based training. These included laparoscopic cholecystectomy[11,12,13,14], bilateral tubal ligation[15], salpingectomy[16], Nissen fundoplication[17], diagnostic arthroscopy of the knee[18] and totally extraperitoneal inguinal hernia repair.[19]

One RCT compared laparoscopic camera navigation in participants who had trained using simulation with those who had received patient-based training.[20]

Six RCTs examined performance during endoscopic procedures in participants who had trained using simulation with those who had not received simulation-based training. These included colonoscopy[21], cystourethroscopy[22], oesophagogastroduodenoscopy[23], nasolaryngoscopy[24], endoscopic sinus surgery[25], and transurethral resection of the prostate.[26]

One RCT compared colonoscopy procedures in participants who had trained using simulation with those who had received patient-based training.[27]

Two RCTs examined performance of other surgical procedures in participants who had trained using simulation with those who had not received simulation-based training. The RCTs included abdominal fascial closure[28], and knowledge, attitude and skills in the operating room.[29]

One RCT compared performance during cardiac surgery weaning patients from cardiopulmonary bypass in participants who had trained using high-fidelity simulation with those who had received interactive seminar-based education.[30]

The objective of systematic review by Sutherland[31], was to evaluate the effectiveness of surgical simulation compared with other methods of surgical training. Thirty RCTs with seven hundred sixty participants were able to be included.

Nine studies compared computer simulation versus no training.[32,33,34,35,36,37,38,39,40] Those trained on computer simulators performed better than those who received no training at all.

Five studies compared computer simulation versus standard training.[41,42,36,43,44] The computer simulation versus standard training comparisons varied.

Seven studies compared computer simulation versus video simulation.[45,35,46,47,48,38,41] Computer simulation showed mixed results.

One study compared computer simulation versus physical trainer or model.[39] Computer simulation training showed to be superior to training on a physical trainer.

Two studies compared two or more types of computer simulation: MIST-VR.[49,50] These studies showed mixed results.

Six studies compared video simulation versus no training.[51,38,52,53,54,35] Video simulation groups did not show consistently better results than groups who did not receive training.

Five studies compared video simulation versus other forms of training.[55,56,57,58,59] No differences were seen between video box training and other forms of training such as bench models or standard training.

Four studies compared physical or model simulation versus other forms of training, including no training.[60,39,61,55] Model training showed better results than standard training.
One study compared cadaver training versus standard training.[61] The cadaver trained group received better results than the standard training group, which learned independently from the manuals.

The objective of systematic review by Lynagh[62], was to evaluate the effectiveness of medical skills laboratories or simulators. In particular, to determine if performance in medical skills laboratories is transferable to actual clinical performance and maintained over time. Forty four RCTs were included in this review.
Thirteen studies compared simulation versus no training. Twelve studies compared simulation versus standard training. Nine studies compared simulation versus video box. Three studies evaluated two simulators. Two studies compared model simulator versus no training. One study compared model versus cadaver and five studies compared model versus standard training.

The objective of systematic review by Marinopoulos[63], was to comprehensively and systematically synthesize evidence regarding the effectiveness of CME and differing instructional designs in terms of knowledge, attitudes, skills, practice behavior, and clinical practice outcomes. Nine systematic reviews and one hundred thirty six articles were included in this review.
CME was effective, at least to some degree, in achieving and maintaining the objectives studied, including knowledge (22 of 28 studies), attitudes (22 of 26), skills (12 of 15), practice behavior (61 of 105), and clinical practice outcomes (14 of 33).

The objective of systematic review by Matthew P. Thomas[64], was to establish the current state of knowledge on the effect of surgical simulation on the development of technical competence during surgical training. Thirty two studies were analyzed, across five main categories of surgical simulation technique.
Nine studies were included that detail the use of bench models and box-trainers; 8 studies were RCTs[65,52,60,59,54,66,15,67], with one cohort study.[68]
Fourteen studies analyzed VR training were found. Eleven of these were RCTs[45,42,34,69,70,71,11,12,72,16,73], with three cohort studies.[74,75,72]

Two studies met the inclusion criteria that described the use of an animal model in surgical simulation, with one RCT[51] and one cohort study.[76]
The use of human cadavers (the donation of the human body after death) was described in a total of four studies that met the final inclusion criteria. Only one of these was a RCT[61], the remainder were cohort studies.[77,78,79]

The objective of the review by Sanne M. B. I. Botden[80], was to present the current developments in augmented reality (AR) laparoscopic simulation. Four simulators were analyzed in this review.
ProMIS combines the virtual and real worlds in the same system: users learn, practise and measure their proficiency with real instruments on physical and virtual models. It comprises a number of modules designed to develop and evaluate surgical proficiency. Real instruments, trocars and port placement are used on physical tissue.
The computer-enhanced laparoscopic training system (CELTS) is a prototype laparoscopic surgery simulator that uses real instruments, real video display and laparoscopic light sources with synthetic skin and task trays to permit highly realistic practice of basic surgical skills. Since instruments and displays are real, actual suturing can be performed without the need to create software models of suture or needle behaviour, for instance.
The LTS3-e (LTS) is a relatively low-cost augmented reality simulator capable of training and assessment of technical laparoscopic skills of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) Fundamentals of Laparoscopy (FLS) program.
The Blue DRAGON (University of Washington, Seattle, WA, USA) is a system for acquiring the kinematics and the dynamics of two endoscopic tools along with the visual view of the surgical scene. The assessment of the performance is based on the placement of the instrument and the tool–tissue interaction during the task.

Discussion

The systematic review by Gurusamy[9], suggests that VR training can supplement standard laparoscopic surgical training of apprenticeship and is at least as effective as video trainer training in supplementing standard laparoscopic training.

On the other hand the systematic review by Schout[10], contains few RCTs and though more validation studies must published to determine which of the training models are most valuable for postgraduate training.

The update report of the ASERNIP-S[6], demonstrates that simulation-based training, as part of a surgical skills training program and incorporating the achievement of reaching predetermined proficiency levels, results in skills transfer to the operating setting. This review was classified as average for its evidence, because the studies included were of variable qualify and did not have comparable simulation-based methods for the same indications.

The systematic review by Sutherland[31], suggests that computer simulation generally is better than no training, but not superior to standard training or to video simulation. Video simulation did not show consistently superior results to no training. There were not enough data to determine if video simulation is better than standard training or the use of models. Model simulation may be better than standard training and cadavers may be better than models.

The systematic review by Lynagh[62], suggests that simulator training significantly improved procedural skills versus no or standard training.

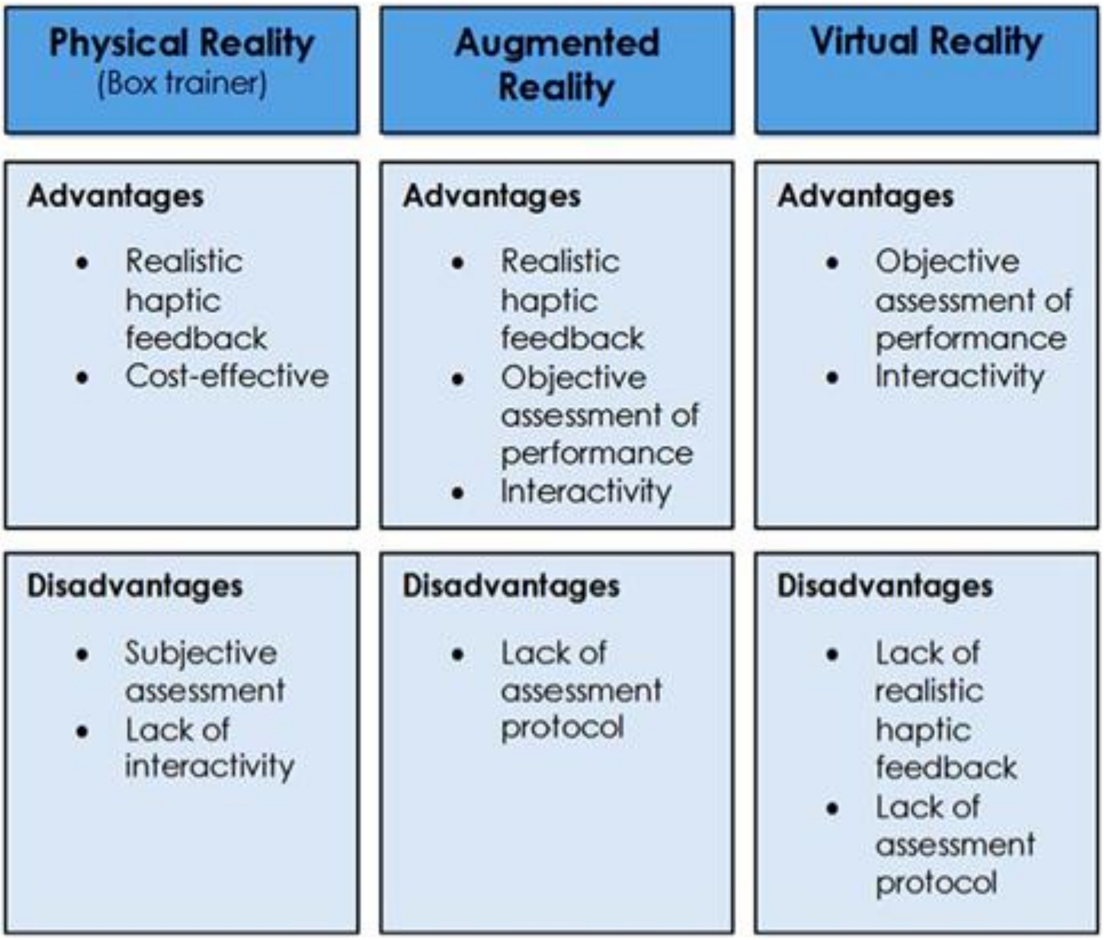
The systematic review by Marinopoulos[63], suggests VR for surgical skills, because obtains a significant decrease in time to perform tasks and trend to decrease error rate. Also concludes that video training is not superior to standard training or no training and that the evidence for computer versus video training, is insufficient.

The systematic review by Matthew P. Thomas[64], demonstrates the benefits of surgical simulation in the development of technical competence. Improvements in outcome measures are demonstrated in every study, across all five main simulation categories.
Where studies compared the use of different simulation techniques, the evidence suggests that the use of bench models and cadaveric simulation is equivalent[61], as is the use of bench models and live animals.[51] Skills learnt on VR and box trainers were also shown to be transferable between the two techniques, with VR simulation providing a greater improvement in the real operating room.[45]
The transfer of skills between different simulation tools is addressed by a small number of studies, suggesting that skills can be transferred from VR to the human cadaver[79], and from the box trainer to VR and vice versa.[45] In addition, in those studies that attempt to demonstrate transfer of skills from the simulated environment to the real patient (13 studies in total), all but one showed simulation to be effective on transfer.

The review by Sanne M. B. I. Botden[80], suggests that AR is the essential link connecting the virtual with the real world. Virtual information is added to the real world. AR simulation is the combination of physical (real) and virtual reality in one system (Figure 2). This enhancement of physical training in laparoscopic simulation can be accomplished with overlays of anatomical representations or by objective assessment at the end of the performance. A major advantage of the AR laparoscopic simulator over the VR simulator is that it allows the trainee to use the same instruments that are currently used in the operating room. The simulator provides realistic haptic feedback because of the hybrid mannequin environment in which the trainee is working, which is absent in VR systems. This simulator offers a physically realistic training environment that is based on real instruments interacting with real objects.
The physical task is combined with demonstration videos on the screen, and the performance of the trainee is recorded for subsequent replay. Because AR simulators are a learning system on their own, there is no need for an expert laparoscopic surgeon to be on the scene to guide the trainee. Therefore AR simulation is a good way for trainees to practise their laparoscopic skills in their free time.

Both VR and AR systems provide objective measurements of performance, but lack meaningful assessment protocols. However, AR simulators additionally offer realistic haptic feedback. For laparoscopic suturing training, for example, AR is the best choice for a simulation system, as haptic feedback during practice is mandatory for good skills transfer to the trainee.

Figure 2: Properties of the different simulation techniques used in laparoscopic training



Conclusions

Five main categories of simulation technique currently used to develop technical competence in surgical training are identified here: cadaver, model, computer, video and augmented reality. On reviewing the available evidence, the benefits of all five of these techniques in improving technical skills can be seen within the simulated environment.

The use of cadaveric simulation is equivalent to the use of VR or box trainers. Due to the scarcity of cadaveric material, and the ethical and moral issues around its use, resources should be directed towards training on VR and box trainers.

Skills learnt on both box trainers and VR are transferable to the real patient, with the evidence suggesting the slight superiority of VR. However, VR equipment is more expensive. Surgical skills curricula should therefore incorporate simulation on box trainers, with VR being used in addition, where resources allow.

Several AR simulators have been developed over the recent years, and they are improving rapidly. The advantage of AR over VR is that they offer realistic haptic feedback, like traditional box trainers, while additionally providing objective assessment of performance. For basic skills, however, VR has previously been proven a valid training method. Augmented reality simulators are a potent new modality of laparoscopic simulator system that should be imple-mented in current laparoscopic training curricula.

The goal of implementing simulation-based training in surgery is to provide a complementary experience that accelerates the learning curve and enhances patient encounters. Although the literature supports both synthetic and virtual reality training in technical skills acquisition, there are some weaknesses in this body of literature. First, although a large variety of virtual-reality simulators is available on the market, many of the existing studies investigated the earlier virtual reality models. Second, many of the new procedural models lack evidence for validity, which raises concern that the field will be dominated by technology rather than educational principles. Finally, the studies describe disparate interventions, sometimes on the same simulator, making comparisons difficult.

Areas for future research in surgical simulation include the determination of how skills learnt during simulation exercises are retained, the frequency and intensity of simulation that provides the maximum benefit, and further work on the transfer of skills between different simulation techniques. The complex nature of educational interventions must also be recognised by those planning and evaluating surgical simulation research, particularly when designing a “skills curriculum”.

ΠΕΡΙΛΗΨΗ

Σκοπός : Να γίνει σύγκριση και εκτίμηση της αποτελεσματικότητας των διαφόρων μορφών λαπαροσκοπικής εκπαίδευσης.

Μέθοδοι : Πραγματοποιήθηκε ανάλυση εργασιών μέσω αναζητήσεων σε Pubmed, Medline και Cochrane Library, των τελευταίων δέκα ετών. Χρησιμοποιήθηκαν εργασίες οι οποίες τηρούσαν τις κατευθυντήριες οδηγίες του οργανισμού για την ιατρική εκπαίδευση που στηρίζεται στις καλύτερες ενδείξεις (BEME) και του προγράμματος αξιολόγησης τεχνολογιών (TAP).

Αποτελέσματα : Πραγματοποιήθηκε ανάλυση επτά ανεξάρτητων συστηματικών ανασκοπήσεων και μιας ανασκόπησης, που περιείχαν εκατόν είκοσι τυχαιοποιημένες ελεγχόμενες μελέτες (RCTs) και διακόσιες πενήντα εργασίες. Η εκπαίδευση με εξομοιωτές εικονικής πραγματικότητας (VR) φάνηκε να υπερτερεί σε σχέση με καμία εκπαίδευση. Οι εξομοιωτές επαυξημένης πραγματικότητας (AR) αποδείχθηκαν ως το πιο σύγχρονο και με πολλές δυνατότητες σύστημα λαπαροσκοπικών εξομοιωτών, το οποίο παρέχει περισσότερα οφέλη από τους παραδοσιακούς εξομοιωτές λαπαροσκοπικών επεμβάσεων και τους εξομοιωτές εικονικής πραγματικότητας.

Συμπεράσματα : Οι ιατρικοί εξομοιωτές υψηλής πιστότητας και ακρίβειας στην απόδοση, διευκολύνουν και προωθούν την διαδικασία της εκπαίδευσης και της μεταφοράς των ικανοτήτων που ανακτώνται, στην αίθουσα του χειρουργείου. Οι εξομοιωτές επαυξημένης πραγματικότητας θα πρέπει να ενταχθούν στα σύγχρονα προγράμματα λαπαροσκοπικής εκπαίδευσης.

Λέξεις κλειδιά : Σύγκριση · Λαπαροσκοπική εκπαίδευση · Επαυξημένη πραγματικότητα · Εξομοιωτής

ABSTRACT

Objectives : To compare and evaluate the effectiveness of different forms in laparoscopic training.

Methods : Studies were analyzed through searches of Pubmed, Medline and the Cochrane Library over the last ten years. Included studies were identified according to guidelines adapted from a Best Evidence in Medical Education (BEME) and a Technology Assessment Program (TAP) review.

Results : Seven independent systematic reviews and one review, with one hundred twenty randomized controlled trials (RCTs) and two hundred fifty studies, were able to be included. Virtual reality (VR) training for laparoscopic procedures is better than no training. Augmented reality (AR) simulators are a potent new modality laparoscopic simulator system, that have better benefits from the traditional box trainers and the VR simulators.

Conclusion : High – fidelity medical simulations are educationally effective and results in skills transfer to the operating setting. AR simulators should be implemented in current laparoscopic training.

Keywords : Comparison · Laparoscopic training · Augmented reality · Simulator

REFERENCES

1. Darzi A, Smith S, Taffinder N Assessing operative skill needs to become more objective. Br Med J (1999) 318:887–888
2. Sanne M. B. I. Botden Z Jack J. Jakimowicz What is going on in augmented reality simulation in laparoscopic surgery? Surg Endosc (2009) 23:1693–1700
3. Satava RM, Gallagher AG, Pellegrini CA. Surgical competence and surgical proficiency: definitions, taxonomy, and metrics. JAm Coll Surg. 2003;196:933–937
4. Kelling G. Ueber oesophagoskopie, gastroskopie und kolioskopie. Munch Med Wochenschr 1902; 1: 21-24
5. Kurt E Roberts, Robert L Bell, Andrew J Duffy Evolution of surgical skills training. World J Gastroenterol 2006 May 28; 12(20): 3219-3224
6. Surgical simulation for training: skills transfer to the operating room (update) : Systematic review. ASERNIP-S report no. 80. Published November 2012
7. Issenberg SB, McGaghie WC, Petrusa ER, Gordon DL, Scalese RL. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teach. 2005;27:10-28
8. Brief Overview: Systematic Reviews Of Simulation Training. Published April 2009
9. Gurusamy K, Aggarwal R, Palanivelu L, Davidson BR. Systematic review of randomized controlled trials on the effectiveness of virtual reality training for laparoscopic surgery. Br J Surg. 2008 Sep;95(9):1088-97. doi: 10.1002/bjs.6344
10. Schout BM, Hendrikx AJ, Scherpbier AJ, Bemelmans BL. Update on training models in endourology: a qualitative systematic review of the literature between January 1980 and April 2008. Eur Urol. 2008 Dec;54(6):1247-61. doi: 10.1016/j.eururo.2008.06.036. Epub 2008 Jun 25
11. Ahlberg G, Enochsson L, Gallagher AG, Hedman L, Hogman C, McClusky DA, Ramel S, Smith CD, Arvidsson D 2007, 'Proficiency-based virtual reality training significantly reduces the error rate for residents during their first 10 laparoscopic cholecystectomies', The American Journal of Surgery, vol. 193, pp. 797–804
12. Cosman PH, High TJ, Shearer CJ, Merrett ND, Biankin AV, Cartmill JA 2007, 'Skills acquired on virtual reality laparoscopic simulators transfer into operating room in blinded, randomised controlled trial', Studies in Health Technology and Informatics, vol. 125, pp.76–81
13. Hogle NJ, Chang L, Strong VEM, Welcome AOU, Sinaan M, Bailey R, Fowler DL 2009, 'Validation of laparoscopic surgical skills training outside the operating room: a long road', Surgical Endoscopy, vol. 23, pp. 1476–82

14. Sroka G, Feldman LS, Vassiliou MC, Kaneva PA, Fayez R, Fried GM, 'Fundamentals of Laparoscopic Surgery simulator training to proficiency improves laparoscopic performance in the operating room-a randomized controlled trial', The American Journal of Surgery, vol. 199, pp. 115–20
15. Banks EH, Chudoff S, Karmin I, Wang C, Pardanani S 2007, 'Does a surgical simulator improve resident operative performance of laparoscopic tubal ligation?' The American Journal of Obstetrics and Gynecology, vol. 197, pp. 541 .e1–541 .e5
16. Larsen CR, Søerensen JL, Grantcharov TP, Dalsgaard T, Schouenborg L, Otto sen C, Schroeder TV, Ottesen BS 2009, 'Effect of virtual reality training on laparoscopic surgery: randomised controlled trial', British Medical Journal, vol. 338, pp. b1802
17. Van Sickle KR, Ritter EM, Baghai M, Goldenberg AE, Huang IP, Gallagher AG, Smith CD 2008, 'Prospective, randomized, double-blind trail of curriculum-based training for intracorporeal suturing and knot tying', Journal of American Colege of Surgeons, vol. 207, pp. 560–8
18. Howells NR, Gill HS, Carr AJ, Price AJ Rees JL 2008, 'Transferring simulated arthroscopic skills to the operating theatre: a randomised blinded study', Journal of Bone and Joint Surgery, vol. 90-B(4), pp. 494–9
19. Zendejas B, Cook DA, Bingener J, Huebner M, Dunn WF, Sarr MG, Farley DR 2011, 'Simulation-based mastery learning improves patient outcomes in laparoscopic inguinal hernia repair: A randomized controlled trial', Annals of Surgery, vol. 254(3), pp. 502-511
20. Franzeck FM, Rosenthal R, Muller MK, Nocito A, Wittich F, Maurus C, Dindo D, Clavien P, Hahnloser D 2012, 'Prospective randomized controlled trial of simulator-based versus traditional in-surgery laparoscopic camera navigation training' Surgical Endoscopy, vol. 26(1), pp. 235-41
21. Park J, MacRae H, Musselman LJ, Rossos P, Hamstra SJ, Wolman S, Reznick RK 2007, 'Randomized controlled trial of virtual reality simulator training: transfer to live patients', The American Journal of Surgery, vol. 194, pp. 205–11
22. Schout BMA, Ananias HJK, Bemelmans BLH, d'Ancona FCH, Muijtjens AMM, Dolamans VEMG, Scherpbier AJJA, Hendrikx AJM 2009, 'Transfer of cysto-urethroscopy skills from a virtual-reality simulator to the operating room: a randomized controlled trial', BJU International, vol. 106, pp. 226–31
23. Shirai Y, Yoshida T, Shiraishi R, Okamoto T, Nakamura H, Harada T, Nishikawa J, Sakaida I 2008, 'Prospective randomized study on the use of a computer-based endoscopic simulator for training in esophagogastroduodenoscopy', Journal of Gastroenterology and Hepatology, vol. 23, pp. 1046–50
24. Ossowski KL, Rhee DC, Rubenstein EN, Ferguson BJ 2008, 'Efficacy of sinonasal simulator in teaching endoscopic nasal skills', Laryngoscope, vol. 118, pp. 1482–5

25. Fried MP, Sadoughi B, Gibber MJ, Jacobs JB, Lebowitz RA, Ross DA, Bent III JP, Parikh SR, Sasaki CT, Schaefer SD 2010, 'From virtual reality to the operating room: the endoscopic sinus surgery simulator experiment', Otolaryngology-Head and Neck Surgery, vol. 142, pp. 202–7
26. Kälström R, Hjertberg H, Svanvik J 2010, 'Impact of virtual reality-simulated training on urology residents' performance of transurethral resection of the prostate', Journal of Endourology, vol. 24(9), pp. 1521-28
27. Haycock A, Koch AD, Familiari P, van Delft F, Dekker E, Petruzziello L, Haringsma J, Thomas-Gibson S 2010, 'Training and transfer of colonoscopy skills: a multinational, randomized, blinded, controlled trial of simulator versus bedside training', Gastrointestinal Endoscopy, vol. 71(2), pp. 298–307
28. Palter VN, Grantcharov T, Harvey A, MacRae HM 2011, 'Ex vivo technical skills training transfers to the operating room and enhances cognitive learning: a randomized controlled trial'. Annals of Surgery, vol. 253(5), pp. 886-88
29. Patel V, Aggarwal R, Osinibi E, Taylor D, Arora S, Darzi A 2012, 'Operating room introduction for the novice' The American Journal of Surgery, vol. 203(2), pp. 266-75
30. Bruppacher HR, Alam SK, LeBlanc VR, Latter D, Naik, VN, Savoldelli GL, Mazer CD, Kurrek MM, Joo HS 2010, 'Simulation-based training improves physicians' performance in patient care in high-stakes clinical setting of cardiac surgery', Anesthesiology, vol. 112(4), pp. 985–992
31. Leanne M. Sutherland, Philippa F. Middleton, Adrian Anthony, Jeffrey Hamdorf, Patrick Cregan, David Scott, Guy J. Maddern. Surgical Simulation: A Systematic Review. Ann Surg 2006;243: 291–300
32. Ahlberg G, Heikkinen T, Iselius L, et al. Does training in a virtual reality simulator improve surgical performance? Surg Endosc. 2002;16:126–129
33. Gallagher AG, McClure N, McGuigan J, et al. Virtual reality training in laparoscopic surgery: a preliminary assessment of Minimally Invasive Surgical Trainer Virtual Reality (MIST VR). Endoscopy. 1999;31:310–313
34. Grantcharov TP, Kristiansen VB, Bendix J, et al. Randomized clinical trial of virtual reality simulation for laparoscopic skills training. Br JSurg. 2004;91:146–150
35. Jordan JA, Gallagher AG, McGuigan J, et al. Virtual reality training leads to faster adaptation to the novel psychomotor restrictions encountered by laparoscopic surgeons. Surg Endosc. 2001;15:1080– 1084
36. Torkington J, Smith SGT, Rees BI, et al. Skill transfer from virtual reality to a real laparoscopic task. Surg Endosc. 2001;15:1076–1079
37. Hyltander A, Liljegren E, Rhodin PH, et al. The transfer of basic skills learned in a laparoscopic simulator to the operating room. Surg Endosc. 2002;16:1324–1328

38. Munz Y, Kumar BD, Moorthy K, et al. Laparoscopic virtual reality and box trainers. Surg Endosc. 2004;18:485–494
39. Youngblood PL, Srivastava S, Curet M, et al. Comparison of training on two laparoscopic simulators and assessment of skills transfer to surgical performance. JAm Coll Surg. 2005;200:564–551
40. Eversbusch A, Grantcharov TP. Learning curves and impact of psy¬chomotor training on performance in simulated colonoscopy: a random¬ized trial using a virtual reality endoscopic trainer. Surg Endosc. 2004; 18:1514–1518
41. Pearson AM, Gallagher AG, Rosser JC, et al. Evaluation of structured and quantitative training methods for teaching intracorporeal knot tying. Surg Endosc. 2002;16:130–137
42. Seymour NE, Gallagher AG, Roman SA, et al. Virtual reality training improves operating room performance results of a randomized, double-blinded study. Ann Surg. 2002;236:458–464
43. Watterson JD, Beiko DT, Kuan JK, et al. Randomized prospective blinded study validating acquisition of ureteroscopy skills using com¬puter based virtual reality endourological simulator. J Urol. 2002;168: 1928–1932
44. Wilhelm DM, Ogan K, Roehrborn CG, et al. Assessment of basic endoscopic performance using a virtual reality simulator. J Am Coll Surg. 2002;195:675–681
45. Hamilton EC, Scott DJ, Fleming JB, et al. Comparison of video trainer and virtual reality training systems on acquisition of laparoscopic skills. Surg Endosc. 2002;16:406–411
46. Jordan JA, Gallagher AG, McGuigan J, et al. A comparison between randomly alternating imaging, normal laparoscopic imaging, and virtual reality training in laparoscopic psychomotor skill acquisition. Am JSurg. 2000;180:208–21 1
47. Kothari SN, Kaplan BJ, DeMaria EJ, et al. Training in laparoscopic suturing skills using a new computer-based virtual reality simulator (MIST-VR) provides results comparable to those with an established pelvic trainer system. JLaparoendosc Adv Surg Tech. 2002;12:167– 173
48. Lehmann KS, Ritz JP, Maass H, et al. A prospective randomized study to test the transfer of basic psychomotor skills from virtual reality to physical reality in a comparable training setting. Ann Surg. 2005;241: 442–449
49. Ali MR, Mowery Y, Kaplan B, et al. Training the novice in laparoscopy: more challenge is better. Surg Endosc. 2002;16:1732–1736
50. MackayS,MorganP,DattaV,etal. Practicedistributioninproceduralskills training: a randomized controlled trial. SurgEndosc. 2002;16:957–961
51. Fried GM, Derossis AM, Bothwell J, et al. Comparison of laparoscopic performance in vivo with performance measured in a laparoscopic simulator. Surg Endosc. 1999;13:1077–1081

52. Scott DJ, Bergen PC, Rege RV, et al. Laparoscopic training on bench models: better and more cost effective than operating room experience? JAm Coll Surg. 2000;191:272–283
53. Taffinder N, Sutton C, Fishwick RJ, et al. Validation of virtual reality to teach and assess psychomotor skills in laparoscopic surgery: results from randomised controlled studies using the MIST VR laparoscopic simu¬lator. Stud Health Technol Inform. 1998;50:124–130
54. Traxer O, Gettman MT, Napper CA, et al. The impact of intense laparoscopic skills training on the operative performance of urology residents. J Urol. 2001;166:1658–1661
55. Matsumoto ED, Hamstra SJ, Radomski SB, et al. The effect of bench model fidelity on endourological skills: a randomized controlled study. J Urol. 2002;167:1243–1247
56. Keyser EJ, Derossis AM, Antoniuk M, et al. A simplified simulator for the training and evaluation of laparoscopic skills. Surg Endosc. 2000; 14:149–153
57. Jordan JA, Gallagher AG, McGuigan J, et al. Randomly alternating image presentation during laparoscopic training leads to faster automa¬tion to the 'fulcrum effect'. Endoscopy. 2000;32:317–321
58. Harold KL, Matthews BD, Backus CL, et al. Prospective randomized evaluation of surgical resident proficiency with laparoscopic suturing after course instruction. Surg Endosc. 2002;16:1729–1731
59. Risucci D, Cohen JA, Garbus JE, et al. The effects of practice and instruction on speed and accuracy during resident acquisition of simu¬lated laparoscopic skills. Curr Surg. 2001;58:230–235
60. Hamilton EC, Scott DJ, Kapoor A, et al. Improving operative performance using a laparoscopic hernia simulator. Am JSurg. 2001;182:725–728
61. Anastakis DJ, Regehr G, Reznick RK, et al. Assessment of technical skills transfer from the bench training model to the human model. Am JSurg. 1999;177:67–70
62. Lynagh M, Burton R, Sanson-Fisher R. A systematic review of medical skills laboratory training: where to from here? Med Educ. 2007 Sep;41(9):879-87. Epub 2007 Aug 13
63. Spyridon S. Marinopoulos, Todd Dorman, Neda Ratanawongsa, Lisa M. Wilson, Bimal H. Ashar, Jeffrey L. Magaziner, Redonda G. Miller, Patricia A. Thomas, Gregory P. Prokopowicz, Rehan Qayyum, Eric B. Bass. Effectiveness of Continuing Medical Education. AHRQ Publication No. 07-E006. January 2007
64. Matthew P. Thomas. The role of simulation in the development of technical competence during surgical training: a literature review. Int J Med Educ. 2013;4:48-58
65. Derossis AM, Bothwell J, Sigman HH, Fried GM. The effect of practice on performance in a laparoscopic simulator. Surg Endosc.1998;12:1117-1120

66. Korndorffer JR, Dunne JB, Sierra R, Stefanidis D, Touchard CL, Scott DJ. Simulator training for laparoscopic suturing using performance goals translates to the operating room. J Am Coll Surg. 2005;201:23-29
67. Price J, Naik V, Boodhwani M, Brandys T, Hendry P, Lam BK. A randomised evaluation of simulation training on performance of vascular anastomosis on a high-fidelity in vivo model: the role of deliberate practice. J Thorac Cardiovasc Surg. 2011;142:496-503
68. Joyce DL, Dhillon TS, Caffarelli AD, Joyce DD, Tsirigotis DN, Burdon TA et al. Simulation and skills training in mitral valve surgery. J Thorac Cardiovasc Surg. 2011;141:107-112
69. McClusky III DA, Gallagher AG, Ritter EM, Lederman AB, Van Sickle KR, Baghai M et al. Virtual reality training improves junior residents' operating room performance: results of a prospective, randomised, double-blinded study of the complete laparoscopic cholecystectomy. J Am Coll Surg. 2004;199:S73
70. Andreatta PB, Woodrum DT, Birkmeyer JD, Yellamanchilli RK, Doherty GM, Gauger PG et al. Laparoscopic skills are improved with LapMentorTM training – results of a randomised, double-blinded study. Ann Surg. 2006;243:854-863
71. Chaer RA, DeRubertis BG, Lin SC, Bush HL, Karwowski JK, Birk D et al. Simulation improves resident performance in catheter-based intervention – results of a randomised, controlled study. Ann Surg. 2006;244:343-352
72. Verdaasdonk EGG, Dankelman J, Lange JF, Stassen LPS. Transfer validity of laparoscopic knot-tying training on a VR simulator to a realistic environment: a randomised controlled trial. Surg Endosc. 2008;22:1636-1642
73. Maschuw K, Schlosser K, Kupietz E, Slater EP, Weyers P, Haasan I. Do soft skills predict surgical performance? A single-center randomised controlled trial evaluating predictors of skill acquisition in virtual reality laparoscopy. World J Surg. 2011;35:480-486
74. Dayal R, Faries PL, Lin SC, Bernheim J, Hollenbeck S, DeRubertis B et al. Computer simulation as a component of catheter-based training. J Vasc Surg. 2004;40:1112-1117
75. Dawson DL, Meyer J, Lee ES, Pevec WC. Training with simulation improves residents' endovascular procedure skills. J Vasc Surg. 2007;45: 149-154
76. Bijoy Thomas M, Dandolu V, Caputo P, Milner R, Hernandez E. Resident education in principles and technique of bowel surgery using an ex-vivo porcine model. Obstet Gynecol Int. 2010; 20 10:852647
77. Martin M, Vashist B, Frezza E, Ferone T, Lopez B, Pahuja M et al. Competency-based instruction in critical invasive skills improves both resident performance and patient safety. Surgery. 1998;124:313-317

78. Bergeson RK, Schwend RM, DeLucia T, Silva SR, Smith JE, Avilucea FR. How accurately do novice surgeons place thoracic pedicle screws with the free hand technique? Spine. 2008;33:E510-E507
79. Martin KD, Belmont PJ, Schoenfeld AJ, Todd M, Cameron KL, Owens BD. Arthroscopic basic task performance in shoulder simulator model correlates with similar task performance in cadavers. J Bone Joint Surg. 2011;93:e127(1-5)
80. Sanne M. B. I. Botden Z Jack J. Jakimowicz. What is going on in augmented reality simulation in laparoscopic surgery? Surg Endosc (2009) 23:1693–1700