NEW!

LapSim
Haptic System

Validation Studies
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Updated April 2013.
# 1. NEW PUBLICATIONS IN THIS EDITION

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2. VALIDATION OF LAPSIM

Surgical Skills Assessment of Applicants to General Surgery Residency

BACKGROUND: Manual skill proficiency is not currently employed in selecting residents for general surgery training programs. The study objective was to assess whether the technical skill levels of applicants to a general surgery residency program are higher than those of internal medicine residents. MATERIAL AND METHODS: Forty-two applicants to a community general surgery program underwent manual skill testing on interview day. Four laparoscopic tasks on a virtual reality (VR) simulator (LapSim, Goteborg, Sweden) were tested. Performance scores were computer-generated. Participants’ previous experience with other manual dexterity activities was assessed via a questionnaire. Applicants’ self-perception of their surgical skills was correlated with their skill dexterity scores on the simulator. Candidates’ simulator scores were also compared with those of a group of internal medicine interns (n=9) and a group of mid-level surgical residents, PGY 2-3 (n=7). RESULTS: Simulator scores of the applicants were significantly lower than those of mid-level surgical residents in all VR tasks (P<0.05). The internal medicine interns scored higher than the surgery candidates in three of four simulator tasks. Participation in other manual dexterity activities was not associated with increased dexterity scores. CONCLUSION: This study suggests that surgical dexterity levels do not correlate with the self-assessed skill levels or with previous experience with other manual dexterity activities. Moreover, there appears to be no self-selection of applicants for surgery residency based on actual surgical skills. Selection criteria for surgical training, which incorporate technical proficiency skills, may potentially better discriminate those applicants with an aptitude for a surgical specialty.

Warm-up in a Virtual Reality Environment Improves Performance in the Operating Room.
Dan Calatayud, MD,* Sonal Arora, MBBS,† Rajesh Aggarwal, PhD,† Irina Kruglikova, MD,‡ Svend Schulze, DSc,* Peter Funch-Jensen, DSc,‡ and Teodor Grantcharov, PhD§ (Ann Surg 2010;251: 1181–1185)

OBJECTIVE: To assess the impact of warm-up on laparoscopic performance in the operating room (OR). Background: Implementation of simulation-based training into clinical practice remains limited despite evidence to show that the improvement in skills is transferred to the OR. The aim of this study was to evaluate the impact of a short virtual reality warm-up training program on laparoscopic performance in the OP. Methods: Sixteen Laparoscopic Cholecystectomies were performed by 8 surgeons in the OR. Participants were randomized to a group which received a preprocedure warm-up using a virtual reality simulator and no warm-up group. After the initial laparoscopic cholecystectomy all surgeons served as their own controls by performing another procedure with or without preoperative warm-up. All OR procedures were videotaped and assessed by 2 independent observers using the generic OSATS global rating scale (from 7 to 35). RESULTS: There was significantly better surgical performance on the laparoscopic Cholecystectomy following preoperative warm-up, median 28.5 (range _ 18.5–32.0) versus median 19.25 (range _ 15–31.5), P _ 0.042. The results demonstrated excellent reliability of the assessment tool used (Cronbach’s _ _ 0.92). CONCLUSION: This study showed a significant beneficial impact of warm-up on laparoscopic performance in the OP. The suggested program is short, easy to perform, and therefore realistic to implement in the daily life in a busy surgical department. This will potentially improve the procedural outcome and contribute to improved patient safety and better utilization of OR resources.

Telemoriting versus on-site mentoring in virtual reality-based surgical training.

BACKGROUND: Telemoriting can be an adjunct to surgical training using virtual reality surgical simulation. Telemoriting is hypothesized to be as effective as a local mentor for surgical skills training.
METHODS: In this study, 20 Romanian medical students trained using a virtual reality surgical simulator (LapSim) with a telementor or local mentor. All the students watched an instructional module at the beginning of the exercise. The telementor, in the United States, interacted by videoconferencing. Before and after training sessions, tool path length and time for task completion were measured.

RESULTS: Instructional media and training with mentoring resulted in similar levels of performance between locally mentored and telementored groups. Right- and left-hand path length and time decreased significantly within each group from the initial to the final evaluation (p < 0.05) for most tasks (grasping, cutting, suturing). No significant difference was achieved for clip-applying.

CONCLUSIONS: Integration of instructional media with telementoring can be as effective for the development of surgical skills as local mentoring.

**Face and construct validity of virtual reality simulation of laparoscopic gynecologic surgery.**
Schreuder HW, van Dongen KW, Roeleveld SJ, Schijven MP, Broeders IA.

OBJECTIVE: The objective of the study was to validate virtual reality simulation in assessing laparoscopic skills in gynecology by establishing the extent of realism of the simulation to the actual task (face validity) and the degree to which the results of the test one uses reflects the subject tested (construct validity). STUDY DESIGN: Subjects (n = 56) were divided into 3 groups: novices (n = 15), intermediates (n = 20), and experts (n = 21). Participants completed 3 repetitions of a training program consisting of 4 basic skills and 3 gynecologic procedural simulations. The performance was compared between groups using a post hoc Student t test with the Bonferroni technique. Face validity was determined by using a questionnaire of 27 statements. RESULTS: Resulting from the questionnaire, the opinion about the realism and training capacities of the tasks was favorable among all groups. The degree of prior laparoscopic experience was reflected in the outcome performance parameters of the tasks. Experts achieved significant better scores on specific parameters. CONCLUSION: The results of this study indicate acceptance and thus face validity of the system among both reference (novice, intermediate) and expert group. There is a significant difference between subjects with different laparoscopic experience and thereby construct validity for the laparoscopic simulator could be established.

**The impact of self-belief on laparoscopic performance of novices and experienced surgeons.**

BACKGROUND: In many professions, nontechnical aspects such as motivation or coping with stress are known to influence performance, success, and outcome. These qualities are assessed and trained in novices for quality and safety reasons. This study explored the impact of self-belief of surgeons on laparoscopic performance using a virtual reality simulator (LapSim). METHODS: Eighteen inexperienced surgical residents (with less than ten laparoscopic procedures performed) and 22 advanced residents (with more than 50 laparoscopic procedures performed) filled out a ten-item questionnaire used for the assessment of the individual sense of general self-efficacy (GSE). Afterward the participants were asked to perform three defined tasks on the LapSim, each at two different levels of difficulty. The tasks consisted of coordination, dissection, and application of clips. To assess laparoscopic performance, the total time to complete the tasks, economy of motion, and damage parameters were analyzed and correlated with the GSE score by means of Bravis-Pearson correlation analysis. RESULTS: In novices, high GSE scores correlated with more errors and poor economy of motion, while in advanced residents, laparoscopic performance was independent of the level of assessed self-efficacy. CONCLUSION: In a small sample, high self-belief does not predict success. In novices it negatively correlates with laparoscopic skills, while in advanced residents it is independent of laparoscopic performance. Thus, training aspects seem to be of greater importance for laparoscopic skills. Nevertheless, nontechnical aspects like self-belief, motivation, stress-coping strategies, judgment, decision-making, and leadership should be included in the surgical curriculum.
Does box model training improve surgical dexterity and economy of movement during virtual reality laparoscopy? A randomised trial.
Clevin L, Grantcharov TP

OBJECTIVE: Laparoscopic box model trainers have been used in training curricula for a long time, however data on their impact on skills acquisition is still limited. Our aim was to validate a low cost box model trainer as a tool for the training of skills relevant to laparoscopic surgery. DESIGN: Randomised, controlled trial (Canadian Task Force Classification I). SETTING: University Hospital. MEASUREMENTS AND MAIN RESULTS: Sixteen gynaecologic residents with limited laparoscopic experience were randomised to a group that received a structured box model training curriculum, and a control group. Performance before and after the training was assessed in a virtual reality laparoscopic trainer (LapSim) based on objective parameters, registered by the computer system (time, error, and economy of motion scores). Group A showed significantly greater improvement in all performance parameters compared with the control group: economy of movement (p=0.001), time (p=0.001) and tissue damage (p=0.036), confirming the positive impact of box-trainer curriculum on laparoscopic skills acquisition. CONCLUSIONS: Structured laparoscopic skill training on a low cost box model trainer improves performance as assessed using the VR system. Trainees who used the box model trainer showed significant improvement compared to the control group. Box model trainers are valid tools for laparoscopic skills training and should be implemented in the comprehensive training curricula in gynaecology.

Is virtual reality simulation an effective training method in surgery?
Grantcharov TP.
No abstract available

Training opportunities and the role of virtual reality simulation in acquisition of basic laparoscopic skills.
Aggarwal R, Balasundaram I, Darzi A.

BACKGROUND: Within the past decade, there has been increasing interest in simulation-based devices for training and assessment of technical skills, especially for minimally invasive techniques such as laparoscopy. The aim of this study was to investigate the perceptions of senior and junior surgeons to virtual reality simulation within the context of current training opportunities for basic laparoscopic procedures. METHODS: A postal questionnaire was sent to 245 consultants and their corresponding specialist registrar (SpR), detailing laparoscopic surgical practice and their knowledge and use of virtual reality (VR) surgical simulators. RESULTS: One hundred ninety-one (78%) consultants and 103(42%) SpRs returned questionnaires; 16%(10/61) of junior SpRs (year 1-4) had performed more than 50 laparoscopic cholecystectomies to date compared with 76% (32/42) of senior SpRs (year 5-6) (P < 0.001); 90% (55/61) of junior SpRs and 67% (28/42) of senior SpRs were keen to augment their training with VR (P = 0.007); 81% (238/294) of all surgeons agreed that VR has a useful role in the laparoscopic surgical training curriculum. CONCLUSIONS: There is a lack of experience in index laparoscopic cases of junior SpRs, and laparoscopic VR simulation is recognized as a useful mode of practice to acquire technical skills. This should encourage surgical program directors to drive the integration of simulation-based training into the surgical curriculum.
Correlating virtual reality and box trainer tasks in the assessment of laparoscopic surgical skills.

OBJECTIVE: The purpose of this study was to examine the correlation in the assessment of laparoscopic surgical skills in medical students with the use of a virtual reality laparoscopic trainer and a low-fidelity video box trainer with comparative tasks. STUDY DESIGN: Third-year medical students were asked to perform 3 basic skills set modules on LapSim (Surgical Science, Gothenburg, Sweden): coordination, grasping and lifting, and handling the intestines. Each task was set at the easiest level, and each student was allowed a maximum of 10 attempts to complete each task. Similar-appearing tasks were chosen for comparison with the use of a standard video box trainer: pegboard, cup drop and rope pass, respectively. Laparoscopic skills were evaluated with the use of both trainers during 1 session. Pearson's correlation coefficients were used to compare paired data on each student using statistical software. RESULTS: Forty-seven of 65 medical students were assigned to clinical clerkships on-campus at Temple University School of Medicine participated in the study. All 47 students participated in the video box trainer tasks; 34 students completed both the video box trainer and LapSim skills set. Observations that were obtained on the LapSim virtual reality system and video box trainer simulator demonstrated several correlations. The time to completion for the LapSim coordination task and the pegboard task were correlated (r = 0.507; P = .006), as were the grasping and lifting task completion time on LapSim and the comparative box trainer cup drop task completion time (r = 0.404; P = .022). When accounting for errors, the LapSim coordination task tissue damage score was correlated with the sum of all box trainer errors (r = 0.353; P = .040); the average grasping and lifting tissue damage was correlated with the total number of errors during all box trainer tasks (r = 0.374; P = .035). CONCLUSION: Overall, in evaluating laparoscopic skills, the LapSim and video box trainer were correlated positively with one another. The scoring of laparoscopic skills by both systems appears to be equivalent for the measurement of time to task completion and number of errors.

Construct validity of the LapSim: can the LapSim virtual reality simulator distinguish between novices and experts?

BACKGROUND: Virtual reality simulators may be invaluable in training and assessing future endoscopic surgeons. The purpose of this study was to investigate if the results of a training session reflect the actual skill of the trainee who is being assessed and thereby establish construct validity for the LapSim virtual reality simulator (Surgical Science Ltd., Gothenburg, Sweden). METHODS: Forty-eight subjects were assigned to one of three groups: 16 novices (0 endoscopic procedures), 16 surgical residents in training (>10 but <100 endoscopic procedures), and 16 experienced endoscopic surgeons (>100 endoscopic procedures). Performance was measured by a relative scoring system that combines single parameters measured by the computer. RESULTS: The higher the level of endoscopic experience of a participant, the higher the score. Experienced surgeons and surgical residents in training showed statistically significant higher scores than novices for both overall score and efficiency, speed, and precision parameters. CONCLUSIONS: Our results show that performance of the various tasks on the simulator corresponds to the respective level of endoscopic experience in our research population. This study demonstrates construct validity for the LapSim virtual reality simulator. It thus measures relevant skills and can be integrated in an endoscopic training and assessment program.

Virtual reality laparoscopic skill assessment in microgravity.

BACKGROUND: The objective of the study was to assess if performance of basic laparoscopic skills on a virtual reality (VR) simulator is impaired in microgravity relative to normal gravitational influences. MATERIALS AND METHODS: Fourteen subjects with various educational backgrounds underwent basic laparoscopy skill training for five consecutive days on the ground before flying aboard NASA's KC-135 zero-gravity laboratory. The participants performed basic laparoscopic exercises (clip applying, grasping, cutting, and
suturing) on a VR laparoscopy simulator, both on the ground and during 25-s microgravity windows in parabolic flight. Skill levels after ground training were compared with skill levels in performing the same tasks in microgravity. Blinded reviewers measured the number of tasks successfully completed, tissue damage number, left and right hand path lengths during task execution, and percentage of task attempts that resulted in successful completion. RESULTS: A significant increase in tissue injury (t test, P < 0.05) and task erosion were seen in clip applying, cutting, and grasping in microgravity (45%, 20% and 57% decrease in task attempts that resulted in a successful completion, respectively). However, there was no significant difference in the left and right hand path lengths, and the total number of tasks successfully completed on the ground versus in microgravity, for any of the four laparoscopic exercises (t test, P > 0.05). CONCLUSION: This study demonstrates decreased efficiency and increased injury to the simulated tissues in performing laparoscopic skills during microgravity as compared to performing these skills in standard gravitational influence. Additional experiments are indicated to further develop and validate VR microgravity surgical simulation.

**Objective assessment of gynecologic laparoscopic skills using the LapSimGyn virtual reality simulator.**
Larsen CR, Grantcharov T, Aggarwal R, Tully A, Sørensen JL, Dalsgaard T, Ottesen B.

BACKGROUND: Safe realistic training and unbiased quantitative assessment of technical skills are required for laparoscopy. Virtual reality (VR) simulators may be useful tools for training and assessing basic and advanced surgical skills and procedures. This study aimed to investigate the construct validity of the LapSimGyn VR simulator, and to determine the learning curves of gynecologists with different levels of experience. METHODS: For this study, 32 gynecologic trainees and consultants (juniors or seniors) were allocated into three groups: novices (0 advanced laparoscopic procedures), intermediate level (>20 and <60 procedures), and experts (>100 procedures). All performed 10 sets of simulations consisting of three basic skill tasks and an ectopic pregnancy program. The simulations were carried out on 3 days within a maximum period of 2 weeks. Assessment of skills was based on time, economy of movement, and error parameters measured by the simulator. RESULTS: The data showed that expert gynecologists performed significantly and consistently better than intermediate and novice gynecologists. The learning curves differed significantly between the groups, showing that experts start at a higher level and more rapidly reach the plateau of their learning curve than do intermediate and novice groups of surgeons. CONCLUSION: The LapSimGyn VR simulator package demonstrates construct validity on both the basic skills module and the procedural gynecologic module for ectopic pregnancy. Learning curves can be obtained, but to reach the maximum performance for the more complex tasks, 10 repetitions do not seem sufficient at the given task level and settings. LapSimGyn also seems to be flexible and widely accepted by the users.

**Improvement of surgical skills after a three-day practical course for laparoscopic surgery.**
Hassan I, Koller M, Zielke A, Lehmann K, Rothmund M, Gerdes B.

OBJECTIVES: Currently, skills labs are becoming increasingly important in the field of medical education. This study aims to objectively assess psychomotor skills acquisition of residents attending a three-day laparoscopic course. MATERIALS AND METHODS: 44 participants (test group) of the sixth practical course for Visceral Surgery of German surgical societies (Deutsche Gesellschaft für Chirurgie; DGCH and Berufsverband Deutscher Chirurgen; BDC) in Warnemuende with various degree of experience in laparoscopic surgery (18 advanced residents performing more than 50 laparoscopic operations and 26 novices performing less than 10 laparoscopic operations) and 6 consultants attending as tutors of the course (gold standard) were recruited as subjects. 20 medical students in their final year (camera holder) were chosen as a second control group (naive). Both control groups had no training during the practical course. The virtual reality simulator LapSim was used to assess laparoscopic skills of participants before and after the course. Time to complete the tasks, error score, and economy of motion parameters (path length and angular path) were analysed. RESULTS: After the practical course the advanced participants of the test group completed the task significantly faster (p = 0.019), with smaller error score (p = 0.023), and more economy of motion [path length (p = 0.014) and angular path (p =
than before the course. The novices of the test group and both control groups showed no significant improvement of their performance parameters (p >0.05). CONCLUSION: A three-day practical course for laparoscopic surgery improved laparoscopic skills of residents. However, advanced residents benefit most from the course.

**Virtual reality simulation can improve technical skills during laparoscopic salpingectomy for ectopic pregnancy.**

OBJECTIVES: To assess the first commercially available virtual reality (VR) simulator to incorporate procedural modules for training of inexperienced gynaecological surgeons to perform laparoscopic salpingectomy for ectopic pregnancy. DESIGN: Prospective cohort study. SETTING: Departments of surgery and gynaecology in central London teaching hospitals. SAMPLE: Thirty gynaecological surgeons were recruited to the study, and were divided into novice (<10 laparoscopic procedures), intermediate (20-50) and experienced (>100) groups. METHODS: All subjects were orientated to the VR simulator with a basic skills task, followed by performing ten repetitions of the virtual ectopic pregnancy module, in a distributed manner. MAIN OUTCOME MEASURES: Operative performance was assessed by the time taken to perform surgery, blood loss and total instrument path length. RESULTS: There were significant differences between the groups at the second repetition of the ectopic module for time taken (median 551.1 versus 401.2 versus 249.2 seconds, P = 0.001), total blood loss (median 304.2 versus 187.4 versus 123.3 ml, P = 0.031) and total instrument path length (median 17.8 versus 8.3 versus 6.8 m, P = 0.023). The learning curves of the experienced operators plateaued at the second session, although greater numbers of sessions were necessary for intermediate (seven) and novice (nine) surgeons to achieve similar levels of skill. CONCLUSIONS: Gynaecological surgeons with minimal laparoscopic experience can improve their skills during short-phase training on a VR procedural module. In contrast, experienced operators showed nonsignificant improvements. Thus, VR simulation may be useful for the early part of the learning curve for surgeons who wish to learn to perform laparoscopic salpingectomy for ectopic pregnancy.

**The value of virtual reality-simulator training in the development of laparoscopic surgical skills.**

OBJECTIVE: To determine the effectiveness of virtual reality (VR) training in improving the surgical skills of medical students and gynecologic trainees. DESIGN: A prospective observational study to assess the changes observed in objectively measured surgical performance after VR training. SETTING AND POPULATION: University teaching hospital and the laboratories of the University of Western Australia. PARTICIPANTS: Fifteen 5th-year medical students, six junior-doctor trainees (years 1-3), and eight senior trainees (years 4-6). INTERVENTIONS: Standard gynecologic procedures before and after VR training were undertaken on sheep. The procedures were video-recorded and edited to blind the scorer as to identity and seniority of the operator. The procedures were scored using a combination of operative time and penalties for surgical errors. The surgical scores were correlated with the VR scores. MEASUREMENTS AND MAIN RESULTS: Operative skills were assessed using a combination score compiled from scores obtained while undertaking salpingectomy, salpingotomy, and tubal clipping. Virtual reality scores were also a combination score derived from summation of various computer-calculated measures of time and accuracy in undertaking two standardized exercises. RESULTS: The baseline VR scores were significantly related to the overall pre-training scores (salpingectomy p = .032). A better initial VR score was also predictive of better surgical performance. The initial VR score was also predictive of improvement observed between baseline and post-training (p = .004). CONCLUSION: Virtual reality training is of value in improving surgical skills in the clinical environment. It appears to be of most value in the earliest stages of training. These data suggest that serious consideration should be given to incorporating VR training into the training program of obstetricians and gynecologists at an early stage.
Construct validity of the LapSim laparoscopic surgical simulator.
Woodrum DT, Andreatta PB, Yellamanchilli RK, Feryus L, Gauger PG, Minter RM.

BACKGROUND: Computer-aided simulators may increase the safety and efficiency of training in laparoscopic surgery. Before implementation of the Immersion LapSim (Gaithersburg, MD) simulator in our training curriculum, we wished to determine its construct validity (ie, whether the simulator could differentiate laparoscopic novices from trainees with greater experience). METHODS: Subjects were medical students (MS), residents (RES), and laparoscopic faculty (FAC). Subjects performed 10 repetitions of 6 LapSim tasks. The LapSim measured performance in 6 to 10 parameters per task, and performance was compared between groups. Post hoc t tests were used to make pair-wise comparisons among the 3 groups using the Bonferroni technique. Statistical significance was set at P < .05. RESULTS: The degree of prior laparoscopic experience was reflected in performance on at least 1 parameter for each task. Several patterns of performance between MS, RES, and FAC were observed. CONCLUSIONS: The LapSim has performance parameters that reliably differentiate between subjects with varying laparoscopic experience. However, some performance parameters do not differentiate between groups. To accurately measure a trainee’s skill level, only parameters that sensitively measure the true level of performance should be used.

LapSim virtual reality laparoscopic simulator reflects clinical experience in German surgeons.
Langelotz C, Kilian M, Paul C, Schwenk W.

BACKGROUND AND AIMS: The aim of this study was to analyze the ability of a training module on a virtual laparoscopic simulator to assess surgical experience in laparoscopy. METHODS: One hundred and fifteen participants at the 120th annual convent of the German surgical society took part in this study. All participants were stratified into two groups, one with laparoscopic experience of less than 50 operations (group 1, n=61) and one with laparoscopic experience of more than 50 laparoscopic operations (group 2, n=54). All subjects completed a laparoscopic training module consisting of five different exercises for navigation, coordination, grasping, cutting and clipping. The time to perform each task was measured, as were the path lengths of the instruments and their respective angles representing the economy of the movements. Results between groups were compared using chi(2) or Mann-Whitney U-test. RESULTS: Group 1 needed more time for completion of the exercises (median 424 s, range 99-1,376 s) than group 2 (median 315 s, range 168-625 s) (P<0.01). Instrument movements were less economic in group 1 with larger angular pathways, e.g. in the cutting exercise (median 352 degrees , range 104-1,628 degrees vs median 204 degrees , range 107-444 degrees , P<0.01), and longer path lengths (each instrument P<0.05). CONCLUSION: As time for completion of exercises, instrument path lengths and angular paths are indicators of clinical experience, it can be concluded that laparoscopic skills acquired in the operating room transfer into virtual reality. A laparoscopic simulator can serve as an instrument for the assessment of experience in laparoscopic surgery.

Objective assessment of laparoscopic skills using a virtual reality stimulator.
Eriksen JR, Grantcharov T.

BACKGROUND: Virtual reality simulation has a great potential as a training and assessment tool of laparoscopic skills. The study was carried out to investigate whether the LapSim system (Surgical Science Ltd., Gothenburg, Sweden) was able to differentiate between subjects with different laparoscopic experience and thus to demonstrate its construct validity. METHODS: Subjects 24 were divided into two groups: experienced (performed > 100 laparoscopic procedures, n = 10) and beginners (performed <10 laparoscopic procedures, n = 14). Assessment of laparoscopic skills was based on parameters measured by the computer system. RESULTS: Experienced surgeons performed consistently better than the residents. Significant differences in the parameters time and economy of motion existed between the two groups in seven of seven tasks. Regarding error parameters, differences existed in most but not all tasks. CONCLUSION: LapSim was able to differentiate
between subjects with different laparoscopic experience. This indicates that the system measures skills relevant for laparoscopic surgery and can be used in training programs as a valid assessment tool.

Assessing the learning curve for the acquisition of laparoscopic skills on a virtual reality simulator.
Sherman V, Feldman LS, Stanbridge D, Kazmi R, Fried GM.

BACKGROUND: The aim of this study was to develop summary metrics and assess the construct validity for a virtual reality laparoscopic simulator (LapSim) by comparing the learning curves of three groups with different levels of laparoscopic expertise. METHODS: Three groups of subjects ('expert', 'junior', and 'naïve') underwent repeated trials on three LapSim tasks. Formulas were developed to calculate scores for efficiency ('time-error') and economy of 'motion' ('motion') using metrics generated by the software after each drill. Data (mean +/- SD) were evaluated by analysis of variance (ANOVA). Significance was set at p < 0.05. RESULTS: All three groups improved significantly from baseline to final for both 'time-error' and 'motion' scores. There were significant differences between groups in time error performances at baseline and final, due to higher scores in the 'expert' group. A significant difference in 'motion' scores was seen only at baseline. CONCLUSION: We have developed summary metrics for the LapSim that differentiate among levels of laparoscopic experience. This study also provides evidence of construct validity for the LapSim.

Construct validity for the LAPSIm laparoscopic surgical simulator.

BACKGROUND: The skills required for laparoscopic surgery are amenable to simulator-based training. Several computerized devices are now available. We hypothesized that the LAPSIm simulator can be shown to distinguish novice from experienced laparoscopic surgeons, thus establishing construct validity. METHODS: We tested residents of all levels and attending laparoscopic surgeons. The subjects were tested on eight software modules. Pass/fail (P/F), time (T), maximum level achieved (MLA), tissue damage (TD), motion, and error scores were compared using the t-test and analysis of variance. RESULTS: A total of 54 subjects were tested. The most significant difference was found when we compared the most (seven attending surgeons) and least experienced (10 interns) subjects. Grasping showed significance at P/F and MLA (p < 0.03). Clip applying was significant for P/F, MLA, motion, and errors (p < 0.02). Laparoscopic suturing was significant for P/F, MLA, T, TD, as was knot error (p < 0.05). This finding held for novice, intermediate, and expert subjects (p < 0.05) and for suturing time between attending surgeons and residents (postgraduate year [PGY] 1-4) (p < 0.05). CONCLUSIONS: LAPSIm has construct validity to distinguish between expert and novice laparoscopists. Suture simulation can be used to discriminate between individuals at different levels of residency and expert surgeons.

A virtual reality simulator for objective assessment of surgeons' laparoscopic skill.
Hassan I, Sitter H, Schlosser K, Zielke A, Rothmund M, Gerdes B.

BACKGROUND: The aim of this study was to validate computed virtual reality simulation as a tool to assess laparoscopic skills and to establish whether the simulator allows differentiating between surgeons with different laparoscopic experience. METHODS: 27 physicians at the surgical department of the University of Marburg, Germany, with different experience in laparoscopic surgery were divided into three groups: experienced (group I), intermediate (group II), and novices (group III). Following a brief introduction to the virtual reality simulator (LapSim), each participant performed twice a training program consisting of seven tasks (examinations I and II). RESULTS: Comparison of experienced surgeons with less experienced laparoscopic physicians showed a significant (P<0.05) superiority of group I at examinations I and II in most exercises. The groups' difference was more obvious in examination II, since the technique was new for all participants during examination I. Tasks of low complexity in virtual reality such as camera navigation, which are performed by young, not yet responsible
surgeons in real surgery, did not show significantly different results between the three groups. CONCLUSION: Differences in laparoscopic experience can be visualised with a virtual reality simulator, and thus a simulator is helpful for assessing surgeons' laparoscopic skills.

**Laparoscopic skills training and assessment.**

Aggarwal R, Moorthy K, Darzi A.


BACKGROUND: The introduction of laparoscopic techniques to general surgery was associated with many unnecessary complications, which led to the development of skills laboratories to train novice laparoscopic surgeons. This article reviews the tools currently available for training and assessment in laparoscopic surgery.

METHODS: Medline searches were performed to identify articles with combinations of the following key words: laparoscopy, training, curriculum, virtual reality and assessment. Further articles were obtained by manually searching the reference lists of identified papers.

RESULTS: Current training involves the use of box trainers with either innate models or animal tissues; it lacks objective assessment of skill acquisition. Virtual reality simulators have the ability to teach laparoscopic psychomotor skills, and objective assessment is now possible using dexterity-based and video analysis systems.

CONCLUSION: The tools are now available for the development of a structured, competency-based, laparoscopic surgical training programme. Copyright 2004 British Journal of Surgery Society Ltd.

**Surgical Skills Assessment of Applicants to General Surgery Residency**

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BACKGROUND. Manual skill proficiency is not currently employed in selecting residents for general surgery training programs. The study objective was to assess whether the technical skill levels of applicants to a general surgery residency program are higher than those of internal medicine residents. Material and Methods. Forty-two applicants to a community general surgery program underwent manual skill testing on interview day. Four laparoscopic tasks on a virtual reality (VR) simulator (LapSim, Goteborg, Sweden) were tested. Performance scores were computer-generated. Participants’ previous experience with other manual dexterity activities was assessed via a questionnaire. Applicants’ selfperception of their surgical skills was correlated with their skill dexterity scores on the simulator. Candidates’ simulator scores were also compared with those of a group of internal medicine interns (n = 9) and a group of mid-level surgical residents, PGY 2-3 (n=7). Results. Simulator scores of the applicants were significantly lower than those of mid-level surgical residents in all VR tasks (P<0.05). The internal medicine interns scored higher that the surgery candidates in three of four simulator tasks.

Participation in other manual dexterity activities was not associated with increased dexterity scores. Conclusion. This study suggests that surgical dexterity levels do not correlate with the self-assessed skill levels or with previous experience with other manual dexterity activities. Moreover, there appears to be no self-selection of applicants for surgery residency based on actual surgical skills. Selection criteria for surgical training, which incorporate technical proficiency skills, may potentially better discriminate those applicants with an aptitude for a surgical specialty.
3. VR TO OR

**Development and Validation of a Comprehensive Curriculum to Teach an Advanced Minimally Invasive Procedure - A Randomized Controlled Trial.**
Palter VN and Grantcharov TP.

OBJECTIVE: This study allocated 25 surgical residents to receive either conventional residency training or a comprehensive training curriculum for laparoscopic colorectal surgery. All participants performed a laparoscopic right colectomy, which was video recorded and assessed using 2 previously validated assessment tools. Secondary outcome measures were knowledge relating to the execution of the procedure, assessed with a multiple-choice test, and technical performance on the simulator. RESULT: Curricular-trained residents demonstrated superior performance in the operating room compared with conventionally trained residents. Curricular-trained residents scored higher on the multiple-choice test and outperformed conventionally trained residents in 7 of 8 tasks on the simulator. CONCLUSION: Participation in a comprehensive ex vivo training curriculum for laparoscopic colorectal surgery results in improved technical knowledge and improved performance in the operating room compared with conventional residency training.

**Warm-up in a Virtual Reality Environment Improves Performance in the Operating Room.**
Dan Calatayud, MD,* Sonal Arora, MBBS,† Rajesh Aggarwal, PhD,† Irina Kruglikova, MD,‡ Svend Schulze, DSc,* Peter Funch-Jensen, DSc,‡ and Teodor Grantcharov, PhD§

OBJECTIVE: To assess the impact of warm-up on laparoscopic performance in the operating room (OR). Background: Implementation of simulation-based training into clinical practice remains limited despite evidence to show that the improvement in skills is transferred to the OR. The aim of this study was to evaluate the impact of a short virtual reality warm-up training program on laparoscopic performance in the OP. Methods: Sixteen Laparoscopic Cholecystectomies were performed by 8 surgeons in the OR. Participants were randomized to a group which received a preprocedure warm-up using a virtual reality simulator and no warm-up group. After the initial laparoscopic cholecystectomy all surgeons served as their own controls by performing another procedure with or without preoperative warm-up. All OR procedures were videotaped and assessed by 2 independent observers using the generic OSATS global rating scale (from 7 to 35). RESULTS: There was significantly better surgical performance on the laparoscopic Cholecystectomy following preoperative warm-up, median 28.5 (range _ 18.5–32.0) versus median 19.25 (range _ 15–31.5), P _ 0.042. The results demonstrated excellent reliability of the assessment tool used (Cronbach’s _ _ 0.92). CONCLUSION: This study showed a significant beneficial impact of warm-up on laparoscopic performance in the OP. The suggested program is short, easy to perform, and therefore realistic to implement in the daily life in a busy surgical department. This will potentially improve the procedural outcome and contribute to improved patient safety and better utilization of OR resources.

**Effect of virtual reality training on laparoscopic surgery: randomised controlled trial.**
Larsen CR, Soerensen JL, Grantcharov TP, Dalsgaard T, Schouenborg L, Ottosen C, Schroeder TV, Ottesen BS.
BMJ. 2009 May 14;338:b1802. doi: 10.1136/bmj.b1802.

OBJECTIVE: To assess the effect of virtual reality training on an actual laparoscopic operation. DESIGN: Prospective randomised controlled and blinded trial. SETTING: Seven gynaecological departments in the Zealand region of Denmark. PARTICIPANTS: 24 first and second year registrars specialising in gynaecology and obstetrics. INTERVENTIONS: Proficiency based virtual reality simulator training in laparoscopic salpingectomy and standard clinical education (controls). MAIN OUTCOME MEASURE: The main outcome measure was technical performance assessed by two independent observers blinded to trainee and training status using a previously validated general and task specific rating scale. The secondary outcome measure was operation time in minutes. RESULTS: The simulator trained group (n=11) reached a median total score of 33
points (interquartile range 32-36 points), equivalent to the experience gained after 20-50 laparoscopic procedures, whereas the control group (n=10) reached a median total score of 23 (22-27) points, equivalent to the experience gained from fewer than five procedures (P<0.001). The median total operation time in the simulator trained group was 12 minutes (interquartile range 10-14 minutes) and in the control group was 24 (20-29) minutes (P<0.001). The observers’ inter-rater agreement was 0.79. CONCLUSION: Skills in laparoscopic surgery can be increased in a clinically relevant manner using proficiency based virtual reality simulator training. The performance level of novices was increased to that of intermediately experienced laparoscopists and operation time was halved. Simulator training should be considered before trainees carry out laparoscopic procedures. TRIAL REGISTRATION: ClinicalTrials.gov NCT00311792.

Proficiency-based virtual reality training significantly reduces the error rate for residents during their first 10 laparoscopic cholecystectomies.

BACKGROUND: Virtual reality (VR) training has been shown previously to improve intraoperative performance during part of a laparoscopic cholecystectomy. The aim of this study was to assess the effect of proficiency-based VR training on the outcome of the first 10 entire cholecystectomies performed by novices.
METHODS: Thirteen laparoscopically inexperienced residents were randomized to either (1) VR training until a predefined expert level of performance was reached, or (2) the control group. Videotapes of each resident's first 10 procedures were reviewed independently in a blinded fashion and scored for predefined errors.
RESULTS: The VR-trained group consistently made significantly fewer errors (P = .0037). On the other hand, residents in the control group made, on average, 3 times as many errors and used 58% longer surgical time.
CONCLUSIONS: The results of this study show that training on the VR simulator to a level of proficiency significantly improves intraoperative performance during a resident's first 10 laparoscopic cholecystectomies.

Psychomotor performance measured in a virtual environment correlates with technical skills in the operating room.
Kundhal PS, Grantcharov TP.

BACKGROUND: This study was conducted to validate the role of virtual reality computer simulation as an objective method for assessing laparoscopic technical skills. The authors aimed to investigate whether performance in the operating room, assessed using a modified Objective Structured Assessment of Technical Skill (OSATS), correlated with the performance parameters registered by a virtual reality laparoscopic trainer (LapSim). METHODS: The study enrolled 10 surgical residents (3 females) with a median of 5.5 years (range, 2-6 years) since graduation who had similar limited experience in laparoscopic surgery (median, 5; range, 1-16 laparoscopic cholecystectomies). All the participants performed three repetitions of seven basic skills tasks on the LapSim laparoscopic trainer and one laparoscopic cholecystectomy in the operating room. The operating room procedure was video recorded and blindly assessed by two independent observers using a modified OSATS rating scale. Assessment in the operating room was based on three parameters: time used, error score, and economy of motion score. During the tasks on the LapSim, time, error (tissue damage and millimeters of tissue damage [tasks 2-6], error score [incomplete target areas, badly placed clips, and dropped clips [task 7]), and economy of movement parameters (path length and angular path) were registered. The correlation between time, economy, and error parameters during the simulated tasks and the operating room procedure was statistically assessed using Spearman's test. RESULTS: Significant correlations were demonstrated between the time used to complete the operating room procedure and time used for task 7 (r (s) = 0.74; p = 0.015). The error score demonstrated during the laparoscopic cholecystectomy correlated well with the tissue damage in three of the seven tasks (p < 0.05), the millimeters of tissue damage during two of the tasks, and the error score in task 7 (r (s) = 0.67; p = 0.034). Furthermore, statistically significant correlations were observed between the economy of motion score from the operative procedure and LapSim's economy parameters (path length and angular path in six of the tasks) (p < 0.05). CONCLUSIONS: The current study demonstrated significant correlations between operative performance in the operating room (assessed using a well-validated rating scale) and psychomotor
performance in virtual environment assessed by a computer simulator. This provides strong evidence for the validity of the simulator system as an objective tool for assessing laparoscopic skills. Virtual reality simulation can be used in practice to assess technical skills relevant for minimally invasive surgery.

**VR to OR: a review of the evidence that virtual reality simulation improves operating room performance.**

Seymour NE.

The use of virtual reality (VR) simulation to train surgeons has been supported by a body of experimental data derived from randomized trials of VR simulation training versus no such training. These investigations have focused on the use of VR devices to train surgeons in laparoscopic and flexible endoscopic skills, and the studies have generally demonstrated that skills acquired through courses of training in VR transfer to the clinical or animal laboratory setting, where assessments of various types have been used to measure performance. These studies, as well as the study model that describes them, and the future of randomized trials of this type are reviewed.

**Curriculum-based solo virtual reality training for laparoscopic intracorporeal knot tying: objective assessment of the transfer of skill from virtual reality to reality.**

Munz Y, Almoudaris AM, Moorthy K, Dosis A, Liddle AD, Darzi AW.

**BACKGROUND:** Very few studies have addressed the transferability of skills from virtual reality (VR) to real life. The aim of this study was to assess the feasibility and effectiveness of teaching intracorporeal knot tying (ICKT) by VR simulation only. **METHODS:** Twenty novices underwent structured training of basic skills training on the Minimally Invasive Surgical Trainer simulator (Mentice AB, Gothenburg, Sweden) followed by knot tying training on the LapSim simulator (Surgical Science, Gothenburg, Sweden). They were assessed pre- and post-training on a video trainer. Assessment of performance included motion tracking and video-based checklist. Nonparametric statistical analysis was used, and P < .05 was deemed significant. **RESULTS:** All participants completed a correct knot as compared with only 25% before VR training. Time to completion was 66% faster and knot quality 45% better after VR training. Significant reduction in number of movements (P = .006) and distance traveled (P < .000) by both hands after VR training. **CONCLUSIONS:** Teaching ICKT by VR simulators only is feasible and effective. Furthermore, this study highlights the complementary use of different VR simulators within a structured curriculum.

**Skills acquired on virtual reality laparoscopic simulators transfer into the operating room in a blinded, randomised, controlled trial.**

Cosman, PH, Hugh TJ, Shearer CJ, Merrett ND, Biankin AV, Cartmill JA.

Virtual reality surgical simulators have proven value in the acquisition and assessment of laparoscopic skills. In this study, we investigated skill transfer from a virtual reality laparoscopic simulator into the operating room, using a blinded, randomised, controlled trial design. Surgical trainees using the LapSim System performed significantly better at their first real-world attempt at a laparoscopic task than their colleagues who had not received similar training, as measured independently by a number of expert surgical observers using four criteria.

**Comparison of training on two laparoscopic simulators and assessment of skills transfer to surgical performance.**

Youngblood PL, Srivastava S, Curet M, Heinrichs WL, Dev P, Wren SM.

**BACKGROUND:** Several studies have investigated the transfer of surgical trainees’ skills acquired on surgical simulators to the operating room setting. The purpose of this study was to compare the effectiveness of two laparoscopic surgery simulators by assessing the transfer of skills learned on simulators to closely matched
surgical tasks in the animal laboratory. STUDY DESIGN: In this post-test-only Control group study design, 46 surgically naive medical student volunteers were randomly assigned to one of three groups: Tower Trainer group (n = 16), LapSim group (n = 17), and Control group (n = 13). Outcomes measures included both time and accuracy scores on three laparoscopic tasks (Task 1: Grasp and Place; Task 2: Run the Bowel; Task 3: Clip and Cut) performed on live anesthetized pigs, and a global rating of overall performance as judged by four experienced surgeons. RESULTS: The Tower Trainer group performed significantly better than the Control group on 1 of 7 outcomes measures - Task 3: Time (p < 0.032), although the LapSim group performed significantly better than the Control group on 2 of 7 measures - Task 3: Time (p < 0.008) and Global score (p < 0.005). In comparing the two simulators, the LapSim group performed significantly better than the Tower Trainer group on 3 of 7 outcomes measures - Task 2: Time (p < 0.032), Task 2: Accuracy (p < 0.030) and Global score (p < 0.005), although the Tower Trainer group did not perform significantly better than the LapSim group on any measure. CONCLUSIONS: This study demonstrated that naive subjects trained on a virtual-reality part-task trainer performed better on live surgical tasks in a porcine model as compared with those trained with a traditional box trainer. These findings could aid in selection of appropriate training methodologies.

The transfer of basic skills learned in a laparoscopic simulator to the operating room.
Hyltander A, Liljegren E, Rhodin PH, Lönroth H.

BACKGROUND: The aim of the study was to evaluate whether basic surgical skills achieved by training in LapSim, a computer-based laparoscopic simulator, could be transferred to the operating room. METHODS: For this study, 24 medical students undergoing courses in surgery were randomly assigned to train with LapSim or to serve as control subjects. After they had undergone simulator training 2 h per week for 5 weeks, their basic skills in laparoscopic surgery were assessed in a porcine model. The time to perform each task was measured, and four senior surgeons independently graded the overall performance on a 9-step differential rating scale. RESULTS: The participants randomized to train with LapSim showed significantly better results for all tasks in both parts of the study than the untrained participants, according to the expert evaluation. Time consumption was accordingly lower in the training group in the control group. CONCLUSIONS: The results show that basic skills achieved by systematic training with a laparoscopic simulator such as LapSim can be transferred to the operating room.
4. CURRICULA

**New**: A Comparison of 2 Ex Vivo Training Curricula for Advanced Laparoscopic Skills: A Randomized Controlled Trial
Orzech N, Palter VN, Reznick RK, Aggarwal R, Grantcharov TP

OBJECTIVE: To compare the effectiveness and cost of 2 ex vivo training curricula for laparoscopic suturing. BACKGROUND: Although simulators have been developed to teach laparoscopic suturing, a barrier to their wide implementation in training programs is a lack of knowledge regarding their relative training benefit and their associated cost. METHOD: This prospective single-blinded randomized trial allocated 24 surgical residents to train to proficiency using either a virtual reality (VR) simulator or box trainer. All residents then placed intracorporeal laparoscopic stitches during a Nissen fundoplication on a patient. The operating room (OR) cases were video-recorded and technical proficiency was assessed using 2 validated tools. OR performance of both groups was compared to that of conventionally trained residents and to fellowship-trained surgeons. A cost analysis of box training, VR training, and conventional residency training across Canadian surgical programs was performed. RESULTS: After ex vivo training, no significant differences in laparoscopic suturing in the OR were found between the 2 groups with respect to time (P = 0.74)—global rating score (P = 0.65) or checklist score (P = 0.97). It took conventionally trained residents 6 practice attempts in the OR to achieve the technical proficiency of the ex vivo trained groups (P = 0.83). VR training was more efficient than box training (transfer effectiveness ratio of 2.31 vs 1.13). The annual cost of training 5 residents on the FLS trainer box was $11,975.00, on the VR simulator was $77,500.00, and conventional residency training was $17,380.00. Over 5 years, box training was the most cost-effective option for all programs, and VR training was more cost-effective for programs with more 10 residents. CONCLUSIONS: Training on either a VR simulator or on a box trainer significantly decreased the learning curve necessary to learn laparoscopic suturing. VR training, however, is the more efficient training modality, whereas box training the more cost-effective option.

**New**: Designing a proficiency-based, content validated virtual reality curriculum for laparoscopic colorectal surgery: A Delphi approach
Palter VN, Graafland M, Schijven MP, Grantcharov TP
Surgery 2012 vol 151, p391-7

BACKGROUND: Although task training on virtual reality (VR) simulators has been shown to transfer to the operating room, to date no VR curricula have been described for advanced laparoscopic procedures. The purpose of this study was to develop a proficiency-based VR technical skills curriculum for laparoscopic colorectal surgery. METHODS: The Delphi method was used to determine expert consensus on which VR tasks (on the LapSim simulator) are relevant to teaching laparoscopic colorectal surgery. To accomplish this task, 19 international experts rated all the LapSim tasks on a Likert scale (1–5) with respect to the degree to which they thought that a particular task should be included in a final technical skills curriculum. Results of the survey were sent back to participants until consensus (Cronbach’s α >0.8) was reached. A cross-sectional design was utilized to define the benchmark scores for the identified tasks. Nine expert surgeons completed all identified tasks on the “easy”, “medium,” and “hard” settings of the simulator. RESULTS: In the first round of the survey, Cronbach’s α was 0.715; after the second round, consensus was reached at 0.865. Consensus was reached for 7 basic tasks and 1 advanced suturing task. Median expert time and economy of movement scores were defined as benchmarks for all curricular tasks. CONCLUSION: This study used Delphi consensus methodology to create a curriculum for an advanced laparoscopic procedure that is reflective of current clinical practice on an international level and conforms to current educational standards of proficiency-based training.

**New**: Development and Validation of a Comprehensive Curriculum to Teach an Advanced Minimally Invasive Procedure - A Randomized Controlled Trial.
Palter VN and Grantcharov TP
OBJECTIVE: This study allocated 25 surgical residents to receive either conventional residency training or a comprehensive training curriculum for laparoscopic colorectal surgery. All participants performed a laparoscopic right colectomy, which was video recorded and assessed using 2 previously validated assessment tools. Secondary outcome measures were knowledge relating to the execution of the procedure, assessed with a multiple-choice test, and technical performance on the simulator. RESULT: Curricular-trained residents demonstrated superior performance in the operating room compared with conventionally trained residents. Curricular-trained residents scored higher on the multiple-choice test and outperformed conventionally trained residents in 7 of 8 tasks on the simulator. CONCLUSION: Participation in a comprehensive ex vivo training curriculum for laparoscopic colorectal surgery results in improved technical knowledge and improved performance in the operating room compared with conventional residency training.

New: Validation of a Structured Training and Assessment Curriculum for Technical Skill Acquisition in Minimally Invasive Surgery: A Randomized Controlled Trial
Palter VN, Orzech N, Reznick RK, Grantcharov T

OBJECTIVE: To develop and validate an ex vivo comprehensive curriculum for a basic laparoscopic procedure. BACKGROUND: Although simulators have been well validated as tools to teach technical skills, their integration into comprehensive curricula is lacking. Moreover, neither the effect of ex vivo training on learning curves in the operating room (OR), nor the effect on nontechnical proficiency has been investigated. METHODS: This randomized single-blinded prospective trial allocated 20 surgical trainees to a structured training and assessment curriculum (STAC) group or conventional residency training. The STAC consisted of case-based learning, proficiency-based virtual reality training, laparoscopic box training, and OR participation. After completion of the intervention, all participants performed 5 sequential laparoscopic cholecystectomies in the OR. The primary outcome measure was the difference in technical performance between the 2 groups during the first laparoscopic cholecystectomy. Secondary outcome measures included differences with respect to learning curves in the OR, technical proficiency of each sequential laparoscopic cholecystectomy, and nontechnical skills. RESULTS: Residents in the STAC group outperformed residents in the conventional group in the first ($P = 0.004$), second ($P = 0.036$), third ($P = 0.021$), and fourth ($P = 0.023$) laparoscopic cholecystectomies. The conventional group demonstrated a significant learning curve in the OR ($P = 0.015$) in contrast to the STAC group ($P = 0.032$). Residents in the STAC group also had significantly higher nontechnical skills ($P = 0.027$). CONCLUSIONS: Participating in the STAC shifted the learning curve for a basic laparoscopic procedure from the operating room into the simulation laboratory. STAC-trained residents had superior technical proficiency in the OR and nontechnical skills compared with conventionally trained residents. (The study registration ID is NCT01560494.)

New: Instructor Feedback Versus No Instructor Feedback on Performance in a Laparoscopic Virtual Reality Simulator: A Randomized Trial

OBJECTIVE: To investigate the impact of instructor feedback versus no instructor feedback when training a complex operational task on a laparoscopic virtual reality simulator. BACKGROUND: Simulators are now widely accepted as a training tool, but there is insufficient knowledge about how much feedback is necessary, which is useful for sustainable implementation. METHODS: A randomized trial complying with CONSORT Statement. All participants had to reach a predefined proficiency level for a complex operational task on a virtual reality simulator. The intervention group received standardized instructor feedback a maximum of 3 times. The control group did not receive instructor feedback. Participants were senior medical students without prior laparoscopic experience (n = 99). Outcome measures were time, repetitions, and performance score to reach a predefined proficiency level. Furthermore, influence of sex and perception of own surgical skills were examined. RESULTS: Time (in minutes) and repetitions were reduced in the intervention group (162 vs 342 minutes; $P < 0.005$) and (29 vs 65 repetitions; $P < 0.005$). The control group achieved a higher performance score than the intervention group (57% vs 49%; $P = 0.004$). Men used less time (in minutes) than women ($P = 0.037$), but no
sex difference was observed for repetitions ($P = 0.20$). Participants in the intervention group had higher self-perception regarding surgical skills after the trial ($P = 0.011$).

**CONCLUSIONS:** Instructor feedback increases the efficiency when training a complex operational task on a virtual reality simulator; time and repetitions used to achieve a predefined proficiency level were significantly reduced in the group that received instructor feedback compared with the control group.

**Simulation in surgical education**

Vanessa N. Palter MD, Teodor P. Grantcharov MD PhD.

With recent concerns regarding patient safety, and legislation regarding resident work hours, it is accepted that a certain amount of surgical skills training will transition to the surgical skills laboratory. Virtual reality offers enormous potential to enhance technical and non-technical skills training outside the operating room. Virtual-reality systems range from basic low-fidelity devices to highly complex virtual environments. These systems can act as training and assessment tools, with the learned skills effectively transferring to an analogous clinical situation. Recent developments include expanding the role of virtual reality to allow for holistic, multidisciplinary team training in simulated operating rooms, and focusing on the role of virtual reality in evidence-based surgical curriculum design.

**What is the ideal interval between training sessions during proficiency-based laparoscopic simulator training?**

Stefanidis D., Walters C, Mostafavia A, B. Heniford T
The American Journal of Surgery Volume 197, Issue 1, January 2009, Pages 126-129

**BACKGROUND:** The aim of this study was to identify the ideal interval between training sessions in a proficiency-based laparoscopic suturing simulator curriculum. **METHODS:** We analyzed performance data from 3 randomized controlled trials of novices ($n = 66$) who followed a similar proficiency-based simulator curriculum in laparoscopic suturing on the Fundamentals of Laparoscopic Surgery model. The change in performance and intertraining interval were correlated. **RESULTS:** Overall participant performance improved from 530 +/- 58 seconds at baseline to 81 +/- 14 seconds at training completion ($P < .001$). Intertraining intervals ranged from 1 to 43 days and performance change between training sessions varied widely. There was no correlation of performance change with intertraining interval ($r = .05$, $P = .30$). Performance deterioration was similar at different intertraining intervals. Shorter intervals were associated, however, with shorter training duration ($r = .35$, $P = .005$). **CONCLUSIONS:** No association was found between intertraining interval and change in performance during proficiency-based laparoscopic simulator training but shorter intervals were associated with improved skill acquisition. Further study is needed to confirm these findings.

**Designing and validating a customized virtual reality-based laparoscopic skills curriculum.**

Panait L, Bell RL, Roberts KE, Duffy AJ.

**OBJECTIVE:** We developed and instituted a laparoscopic skills curriculum based on a virtual reality simulator, LapSim (Surgical Science, Göteborg, Sweden). Our goal was to improve basic skills in our residents. The hypothesis of this study is that performance in our course will differentiate levels of experience in the training program, establishing construct validity for our curriculum. **DESIGN:** We designed a novel curriculum that consisted of 17 practice modules and a 7-part examination. All residents who completed the curriculum successfully were included in this study. Performance to complete the examination was analyzed. Data were stratified by level of training. **SETTING:** University surgical skill training laboratory. **PARTICIPANTS:** In all, 29 residents of all levels of training and 3 attending surgeons completed the curriculum. **RESULTS:** The average number of practice repetitions required was 243. To complete the examination component, junior residents (R1-R3) required more repetitions than senior residents (R4, R5), 28.3 versus 13.9, respectively ($p < 0.002$). Tasks on camera and instrument navigation as well as coordination did not reveal significant differences. The complex
The future of patient safety: Surgical trainees accept virtual reality as a new training tool.


ABSTRACT: BACKGROUND: The use of virtual reality (VR) has gained increasing interest to acquire laparoscopic skills outside the operating theatre and thus increasing patients' safety. The aim of this study was to evaluate trainees' acceptance of VR for assessment and training during a skills course and at their institution.

METHODS: All 735 surgical trainees of the International Gastrointestinal Surgery Workshop 2006–2008, held in Davos, Switzerland, were given a minimum of 45 minutes for VR training during the course. Participants’ opinion on VR was analyzed with a standardized questionnaire.

RESULTS: Fivehundred-twenty-seven participants (72%) from 28 countries attended the VR sessions and answered the questionnaires. The possibility of using VR at the course was estimated as excellent or good in 68%, useful in 21%, reasonable in 9% and unsuitable or useless in 2%. If such VR simulators were available at their institution, most course participants would train at least one hour per week (46%), two or more hours (42%) and only 12% wouldn’t use VR.

Similarly, 63% of the participants would accept to operate on patients only after VR training and 55% to have VR as part of their assessment.

CONCLUSION: Residents accept and appreciate VR simulation for surgical assessment and training. The majority of the trainees are motivated to regularly spend time for VR training if accessible.

Documenting a learning curve and test-retest reliability of two tasks on a virtual reality training simulator in laparoscopic surgery.

Hogle NJ, Briggs WM, Fowler DL.


BACKGROUND: Virtual reality simulators are a component of the armamentarium for training surgical residents. No one knows exactly how to incorporate virtual reality simulators into a curriculum. The purpose of this study was to document and show the learning curve and test-retest reliability of 2 tasks on a virtual reality-training simulator (LapSim; Surgical Science, Göteborg, Sweden) in laparoscopic surgery.

METHODS: Twenty-nine medical students participated in 8 iterations of 7 virtual reality tasks (“camera navigation” (CN), “instrument navigation,” “coordination,” “grasping,” “lifting and grasping” (LG), “cutting,” and “clip applying”). Learning curves for each outcome variable of the CN and LG tasks were generated. Using ANOVA, we evaluated the differences between each score from attempt number 7 to attempt number 8 to document test-retest reliability.

RESULTS: A plateau in the learning curve occurred within 8 sessions for CN misses, CN tissue damage, and LG maximum damage. Over the course of 8 sessions, a plateau in the learning curve was nearly reached for CN time, CN drift, CN path, CN angular path, and LG left and right path. The following variables had a downward trend to the mean learning curve over 8 sessions, but they did not reach a plateau: LG time, LG left and right miss, LG left and right angular path, and LG tissue damage.

CONCLUSION: Using the LapSim virtual reality simulator, we documented a learning curve and test-retest reliability for each outcome variable for CN and LG for rank novices. The modeling of the general learning curve is useful in designing training program. These results may be important in developing standards for technical evaluation in a surgical training curriculum.
**Criterion-based training with surgical simulators: proficiency of experienced surgeons.**

OBJECTIVE: In our effort to establish criterion-based skills training for surgeons, we assessed the performance of 17 experienced laparoscopic surgeons on basic technical surgical skills recorded electronically in 26 modules selected in 5 commercially available, computer-based simulators. METHODS: Performance data were derived from selected surgeons randomly assigned to simulator stations, and practicing repetitively during one and one-half day sessions on 5 different simulators. We measured surgeon proficiency defined as efficient, error-free performance and developed proficiency score formulas for each module. Demographic and opinion data were also collected. RESULTS: Surgeons' performance demonstrated a sharp learning curve with the most performance improvement seen in early practice attempts. Median scores and performance levels at the 10th, 25th, 75th, and 90th percentiles are provided for each module. Construct validity was examined for 2 modules by comparing experienced surgeons' performance with that of a convenience sample of less-experienced surgeons. CONCLUSION: A simple mathematical method for scoring performance is applicable to these simulators. Proficiency levels for training courses can now be specified objectively by residency directors and by professional organizations for different levels of training or post-training assessment of technical performance. But data users should be cautious due to the small sample size in this study and the need for further study into the reliability and validity of the use of surgical simulators as assessment tools.

**An evidence-based virtual reality training program for novice laparoscopic surgeons.**
Aggarwal R, Grancharov TP, Eriksen JR, Blirup D, Kristiansen VB, Funch-Jensen P, Darzi A.

OBJECTIVE: To develop an evidence-based virtual reality laparoscopic training curriculum for novice laparoscopic surgeons to achieve a proficient level of skill prior to participating in live cases. SUMMARY BACKGROUND DATA: Technical skills for laparoscopic surgery must be acquired within a competency-based curriculum that begins in the surgical skills laboratory. Implementation of this program necessitates the definition of the validity, learning curves and proficiency criteria on the training tool. METHODS: The study recruited 40 surgeons, classified into experienced (performed >100 laparoscopic cholecystectomies) or novice groups (<10 laparoscopic cholecystectomies) or novice groups (<10 laparoscopic cholecystectomies). Ten novices and 10 experienced surgeons were tested on basic tasks, and 11 novices and 9 experienced surgeons on a procedural module for dissection of Calot triangle. Performance of the 2 groups was assessed using time, error, and economy of movement parameters. RESULTS: All basic tasks demonstrated construct validity (Mann-Whitney U test, P < 0.05), and learning curves for novices plateaued at a median of 7 repetitions (Friedman's test, P < 0.05). Expert surgeons demonstrated a learning rate at a median of 2 repetitions (P < 0.05). Performance on the dissection module demonstrated significant differences between experts and novices (P < 0.002); learning curves for novice subjects plateaued at the fourth repetition (P < 0.05). Expert benchmark criteria were defined for validated parameters on each task. CONCLUSION: A competency-based training curriculum for novice laparoscopic surgeons has been defined. This can serve to ensure that junior trainees have acquired prerequisite levels of skill prior to entering the operating room, and put them directly into practice.

**Development of a valid, cost-effective laparoscopic training program.**
Adrales GL, Chu UB, Hoskins JD, Witzke DB, Park AE

BACKGROUND: Practical programs for training and evaluating surgeons in laparoscopy are needed to keep pace with demand for minimally invasive surgery. METHODS: At the University of Kentucky five inexpensive simulations have been developed to train and assess surgical residents. Residents are videotaped performing laparoscopic procedures on models. Five surgeons assess the taped performances on 4 global skills. RESULTS: Creating mechanical models reduces training costs. Trainees agreed procedures were well represented by the simulations. Blinded assessment of performances showed high interrater agreement and correlated with the trainees' level of experience. Nonclinician evaluations on checklists correlated with evaluations by surgeons.
CONCLUSIONS: Inexpensive simulations of laparoscopic appendectomy, cholecystectomy, inguinal herniorrhaphy, bowel enterotomy, and splenectomy enable surgical residents to practice laparoscopic skills safely. Obtaining masked, objective, and independent evaluations of basic skills in laparoscopic surgery can assist in reliable assessment of surgical trainees. The simulations described can anchor an innovative educational program during residency for training and assessment.

Completion of a novel, virtual-reality-based, advanced laparoscopic curriculum improves advanced laparoscopic skills in senior residents.


INTRODUCTION: Virtual reality simulators contribute to basic laparoscopic skill acquisition. These trainers have not yet been shown to contribute to the acquisition of more advanced laparoscopic skills as measured by the Fundamentals of Laparoscopic Surgery (FLS). We have customized novel basic and advanced curricula for the LapSim trainer (Surgical Science, Göteborg, Sweden). Successful completion of these programs is required of our residents. We hypothesize that the successful completion of our advanced curriculum will result in the significant improvement of our residents' advanced laparoscopic skills as measured by the FLS skills scores.

METHODS: In all, 23 surgical residents (PGY 1-4), who had already passed our basic skills curriculum, completed our advanced LapSim curriculum. All individuals underwent FLS skills testing before and after completing the training. Laparoscopic case experience during the training period was documented for all trainees. FLS scores were analyzed by t test and controlled for case experience.

RESULTS: Posttraining FLS scores demonstrate a significant increase for all residents from a mean of 57-66 (p < 0.02), especially for seniors (PGY 3-4): 56-68 (p < 0.01). The operative laparoscopic case volume ranged from 1-90 (mean, 30) for juniors (PGY 1-2) and 12-76 (mean 50) for seniors during the training period. Junior resident FLS improvement was dependent on case volume during the period of training; residents with less than 30 cases had a mean improvement of 0, whereas those with at least 30 cases had a 15 point improvement (p < 0.01). Senior resident FLS score improvement was independent of case numbers during the training period.

CONCLUSIONS: Completion of our advanced LapSim curriculum results in improved advanced laparoscopic skills in senior residents as measured by FLS scores. This skill improvement is independent of laparoscopic case experience. Continuing to mandate the use of this skills curriculum should improve our residents' performance in advanced laparoscopic surgical procedures.
5. REVIEWS

**New: Training in surgical oncology – The role of VR simulation**
Lewis TM, Aggarwal R, Rajaretnam N, Grantcharov TP, Darzi A
Surg Oncology 2011 vol 20, p134-139

There have been dramatic changes in surgical training over the past two decades which have resulted in a number of concerns for the development of future surgeons. Changes in the structure of cancer services, working hour restrictions and a commitment to patient safety has led to a reduction in training opportunities that are available to the surgeon in training. Simulation and in particular virtual reality (VR) simulation has been heralded as an effective adjunct to surgical training. Advances in VR simulation has allowed trainees to practice realistic full length procedures in a safe and controlled environment, where mistakes are permitted and can be used as learning points. There is considerable evidence to demonstrate that the VR simulation can be used to enhance technical skills and improve operating room performance. Future work should focus on the cost effectiveness and predictive validity of VR simulation, which in turn would increase the uptake of simulation and enhance surgical training.

**New: Surgical Skills Simulation: A Shift in the Conversation**
Selzer DJ and Dunnington GL

EXCERPT FROM EDITORIAL: With the publication of the article “State of the Evidence on Simulation-Based Training for Laparoscopic Surgery: A Systematic Review,” Zendejas et al have allowed the conversation regarding the skills laboratory and laparoscopic skill acquisition to shift from a discussion of “Is it effective?” to a discussion of “How can it be most effective?” Importantly, this shift in the conversation allows a vigorous focus on critical issues such as the timing to initiate simulation, how best to coordinate the skills laboratory with clinical experience, what type of simulators should be purchased, how to use the skills laboratory to assess proficiency, and how to avoid deterioration of laparoscopic skills. Before these questions are answered, it is necessary to understand why simulation-based training in laparoscopic surgery was inevitable.

**New: State of the evidence on simulation-based training for laparoscopic surgery: a systematic review.**
Zendejas B, Brydges R, Hamstra SJ, Cook DA.

OBJECTIVE: Summarize the outcomes and best practices of simulation training for laparoscopic surgery. Much new evidence has accrued since previous reviews were published. METHODS: We systematically searched the literature through May 2011 for studies evaluating simulation, in comparison with no intervention or an alternate training activity, for training health professionals in laparoscopic surgery. Outcomes were classified as satisfaction, skills (in a test setting) of time (to perform the task), process (eg, performance rating), product (eg, knot strength), and behaviors when caring for patients. We used random effects to pool effect sizes. RESULTS: From 10,903 articles screened, we identified 219 eligible studies enrolling 7138 trainees, including 91 (42%) randomized trials. For comparisons with no intervention (n = 151 studies), pooled effect size (ES) favored simulation for outcomes of knowledge (1.18; N = 9 studies), skills time (1.13; N = 89), skills process (1.23; N = 114), skills product (1.09; N = 7), behavior time (1.15; N = 7), behavior process (1.22; N = 15), and patient effects (1.28; N = 1), all P < 0.05. When compared with nonsimulation instruction (n = 3 studies), results significantly favored simulation for outcomes of skills time (ES, 0.75) and skills process (ES, 0.54). Comparisons between different simulation interventions (n = 79 studies) clarified best practices. For example, in comparison with virtual reality, box trainers have similar effects for process skills outcomes and seem to be superior for outcomes of satisfaction and skills time. CONCLUSIONS: Simulation-based laparoscopic surgery training of health professionals has large benefits when compared with no intervention and is moderately more effective than nonsimulation instruction.
Surgical Skills Training and Simulation
Tsuda S, Scott D, Doyle J, Jones DB
Current Problems in Surgery
Volume 46, Issue 4, April 2009, Pages 271-370
No abstract available

How far will simulators be involved into training?
Laguna MP, de Reijke TM, de la Rosette JJ.

The expansion of laparoscopy and endoscopic surgery has promoted a change in surgical skills acquisition. This review aims to identify problems that modulate surgical skills acquisition and the role of simulation in the current training programs. Social, medical, and working time constraints, together with patient safety issues, lead to a decreased availability of operating room (OR) training opportunities. Systematic reviews show that there is a positive “model to model” transfer of skills more evident for virtual reality (VR) simulation, although transfer from video tower exists for naïve trainees, both of which supplement standard laparoscopic training. VR to OR positive transfer is proven for laparoscopic cholecystectomy and colonoscopy/sigmoidoscopy, although not for all parameters analyzed. A mixed model integrating both types of trainers into surgical curricula may strengthen their respective possibilities. To what extent simulation will be included in the surgical training programs depends on development of objective and finer assessment tools and proficiency-based criteria.

Virtual reality training for surgical trainees in laparoscopic surgery.
Gurusamy KS, Aggarwal R, Palanivelu L, Davidson BR.
Cochrane Database Syst Rev. 2009 Jan 21,(1)

BACKGROUND: Surgical training has traditionally been one of apprenticeship, where the surgical trainee learns to perform surgery under the supervision of a trained surgeon. This is time consuming, costly, and of variable effectiveness. Training using a virtual reality simulator is an option to supplement standard training. OBJECTIVES: To determine whether virtual reality training can supplement or replace conventional laparoscopic surgical training (apprenticeship) in surgical trainees with limited or no prior laparoscopic experience. SEARCH STRATEGY: We searched The Cochrane Hepato-Biliary Group Controlled Trials Register, the Cochrane Central Register of Controlled Trials (CENTRAL) in The Cochrane Library, MEDLINE, EMBASE, Science Citation Index Expanded, and grey literature until March 2008. SELECTION CRITERIA: We included all randomised clinical trials comparing virtual reality training versus other forms of training including video trainer training, no training, or standard laparoscopic training in surgical trainees with little or no prior laparoscopic experience. We also included trials comparing different methods of virtual reality training. DATA COLLECTION AND ANALYSIS: We collected the data on the characteristics of the trial, methodological quality of the trials, mortality, morbidity, conversion rate, operating time, and hospital stay. We analysed the data with both the fixed-effect and the random-effects models using RevMan Analysis. For each outcome we calculated the standardised mean difference with 95% confidence intervals based on intention-to-treat analysis. MAIN RESULTS: We included 23 trials with 612 participants. Four trials compared virtual reality versus video trainer training. Twelve trials compared virtual reality versus no training or standard laparoscopic training. Four trials compared virtual reality, video trainer training and no training, or standard laparoscopic training. Three trials compared different methods of virtual reality training. Most of the trials were of high risk of bias. In trainees without prior surgical experience, virtual reality training decreased the time taken to complete a task, increased accuracy, and decreased errors compared with no training; virtual reality group was more accurate than video trainer training group. In the participants with limited laparoscopic experience, virtual reality training reduces operating time and error better than standard in the laparoscopic training group; composite operative performance score was better in the virtual reality group than in the video trainer group. AUTHORS’ CONCLUSIONS: Virtual reality training can supplement standard laparoscopic surgical training of apprenticeship and is at least as effective as video trainer training in supplementing standard laparoscopic training. Further research of better methodological quality and more patient-relevant outcomes are needed.
The formula for a successful laparoscopic skills curriculum.
Stefanidis D, Heniford BT.
Arch Surg. 2009 Jan;144(1):77-82; discussion 82.

Although multiple simulators have been validated as effective training tools, curriculum development is lagging, and considerable work is needed to determine the best methods for training. This article identifies the factors that influence the successful incorporation of simulator training into the resident curriculum, reviews the evidence regarding laparoscopic curriculum development in the surgical literature, and provides a formula for effective curriculum design. A successful laparoscopic skills curriculum depends on many factors including participant motivation, available resources and personnel, and trainee and faculty commitment. It should encompass goal-oriented training, sensitive and objective performance metrics, appropriate methods of instruction and feedback, deliberate, distributed, and variable practice, an amount of overtraining, maintenance training, and a cognitive component. A curriculum that follows these principles is likely to spark trainee interest, ensure their satisfaction and participation in training sessions, and lead to an effective and efficient way of acquiring new skills using simulators. A skills curriculum is a dynamic process that should be tailored to individual needs and be continuously optimized based on accumulated evidence and experience.

Systematic review of randomized controlled trials on the effectiveness of virtual reality training for laparoscopic surgery.
Gurusamy K, Aggarwal R, Palanivelu L, Davidson BR.
Br J Surg. 2008 Sep;95(9):1088-97. Comment in:

BACKGROUND: Surgical training has traditionally been one of apprenticeship. The aim of this review was to determine whether virtual reality (VR) training can supplement and/or replace conventional laparoscopic training in surgical trainees with limited or no laparoscopic experience. METHODS: Randomized clinical trials addressing this issue were identified from The Cochrane Library trials register, Medline, Embase, Science Citation Index Expanded, grey literature and reference lists. Standardized mean difference was calculated with 95 per cent confidence intervals based on available case analysis. RESULTS: Twenty-three trials (mostly with a high risk of bias) involving 622 participants were included in this review. In trainees without surgical experience, VR training decreased the time taken to complete a task, increased accuracy and decreased errors compared with no training. In the same participants, VR training was more accurate than video trainer (VT) training. In participants with limited laparoscopic experience, VR training resulted in a greater reduction in operating time, error and unnecessary movements than standard laparoscopic training. In these participants, the composite performance score was better in the VR group than the VT group. CONCLUSION: VR training can supplement standard laparoscopic surgical training. It is at least as effective as video training in supplementing standard laparoscopic training.

Integrating simulation in surgery as a teaching tool and credentialing standard.
Rehrig ST, Powers K, Jones DB.

The time-honored training methods of surgery are rapidly being replaced with new teaching tools that are being integrated into residency and credentialing standards. Numerous factors including societal, professional, and legal have all forced surgical training programs to seek alternative methods of training residents. Learning theories that have provided the basis for open surgical skills training have been modified and culminated in the theory of automaticity and the "pretrained" laparoscopic novice. A vast array of simulators exists for training, ranging from inanimate video trainers, human patient simulators, to more recently virtual reality (VR) computer-based trainers. Currently, inanimate trainers are deployed widely throughout surgical training programs and serve as the primary platform for laparoscopic skills training. As technology evolves, VR systems have become available, allowing for more complex skills training with realistic computer-generated anatomic structures. Using the theories of crisis management and crew resource management, simulation is moving from simple skills training to whole-team training in mock operating room environments. Looking to the near future, medical training will continue to evolve to meet the changing demands of society and professional responsibility to
ensure patient safety. With the advent of accredited skills-training centers endorsed by the American College of Surgeons, simulation will be the catalyst for these continuing changes.

Simulation of laparoscopic surgery – four years’ experience at the Department of Surgery of the University Hospital Marburg.


It is well known that learning curves are longer for laparoscopic surgery compared to open surgery. Recently, virtual reality (VR) simulation was developed as alternative to conventional training. Such a new training system makes it possible to offer a wide range of repeatable surgical situations, and thus, enable assessments based on direct observation of performance. During the last four years we did several studies using a VR simulator (LapSim). After a constructive validity study - discrimination between novices and experienced laparoscopic surgeons, we were able to show that advanced residents benefit most from a three-day practical course for laparoscopic surgery, while - in a further investigation - we found contrary to training at the Pelvitrainer that novices in laparoscopic surgery have the most benefit from VR training. Minimally invasive surgery is significantly more sophisticated for the surgeon than open surgery. While Research on laparoscopic surgery has focused primarily on the development and assessment of technical skills, non technical skills such as visual-spatial perception and stress coping has received much less attention. We showed that spatial perception as well as stress coping positively correlates with virtual laparoscopic skills. A high degree of spatial perception led to faster adaption to a non-stereoview environment and correlated with high level of laparoscopic skills. Furthermore, Ineffective stress-coping strategies correlate with poor virtual laparoscopic performance. VR simulation seems to be a promising tool to improve laparoscopic skills in a modern apprenticeship model. According to patient safety, the development of this instrument for surgery should be advanced professionally just as a flight simulators in aviation.

Proving the effectiveness of virtual reality simulation for training in laparoscopic surgery.


OBJECTIVE: The aim of this study was to compare learning curves for laparoscopic cholecystectomy (LC) after training on a proficiency based virtual reality (VR) curriculum with that of a traditionally trained group. SUMMARY BACKGROUND DATA: Simulator-based training has been shown to improve technical performance during real laparoscopic procedures, although research to date has not proven the persistence of this effect over subsequent cases. MATERIAL AND METHODS: Twenty novice surgeons underwent baseline laparoscopic skills testing followed by a 1-day didactic training session. Control subjects (n = 10) performed 5 cadaveric porcine LCs each; VR-trained subjects (n = 10) completed a VR training curriculum followed by 3 porcine LCs each. A further 10 experienced laparoscopic surgeons (>100 LCs) performed 2 porcine LCs each to define benchmark levels. Technical skill assessment was by motion analysis and video-based global rating scores (out of 35). RESULTS: There were no intergroup differences in baseline skill. The first LC revealed significant differences between control and VR groups for time (median 4590 seconds vs. 2165 seconds, P = 0.038), path length (169.2 meters vs. 86.8 meters, P = 0.009), number of movements (2446 vs. 1029, P = 0.009), and video scores (17 vs. 25, P = 0.001). The VR group, although not a control, achieved video and dexterity scores equivalent to expert levels of performance. CONCLUSIONS: A proficiency based VR training curriculum shortens the learning curve on real laparoscopic procedures when compared with traditional training methods. This may be a more cost- and time-effective approach, and supports the need for simulator-based practice to be integrated into surgical training programs.
The benefits of virtual reality simulator training for laparoscopic surgery.
Hart R, Karthigasu K.

PURPOSE OF REVIEW: Virtual reality is a computer-generated system that provides a representation of an environment. This review will analyse the literature with regard to any benefit to be derived from training with virtual reality equipment and to describe the current equipment available. RECENT FINDINGS: Virtual reality systems are not currently realistic of the live operating environment because they lack tactile sensation, and do not represent a complete operation. The literature suggests that virtual reality training is a valuable learning tool for gynaecologists in training, particularly those in the early stages of their careers. Furthermore, it may be of benefit for the ongoing audit of surgical skills and for the early identification of a surgeon's deficiencies before operative incidents occur. It is only a matter of time before realistic virtual reality models of most complete gynaecological operations are available, with improved haptics as a result of improved computer technology. SUMMARY: It is inevitable that in the modern climate of litigation virtual reality training will become an essential part of clinical training, as evidence for its effectiveness as a training tool exists, and in many countries training by operating on live animals is not possible.

Computer-based surgical simulation is too expensive. Or is it?
Haluck RS.
Editorial. No abstract available.

The LapSim virtual reality simulator: promising but not yet proven
Katherine Fairhurst • Andrew Strickland •Guy Maddern
DOI 10.1007/s00464-010-1181-0
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_ Springer Science+Business Media, LLC 2010

ABSTRACT
Background The acquisition of technical skills using surgical simulators is an area of active research and rapidly evolving technology. The LapSim is a virtual reality simulator that currently allows practice of basic laparoscopic skills and some procedures. To date, no reviews have been published with reference to a single virtual reality simulator. Methods A PubMed search was performed using the keyword “LapSim,” with further papers identified from the citations of original search articles. Results Use of the LapSim to develop surgical skills has yielded overall results, although inconsistencies exist. Data regarding the transferability of learned skills to the operative environment are encouraging as is the validation work, particularly the use of a combination of measured parameters to produce an overall comparative performance score. Conclusion Although the LapSim currently does not have any proven significant advantages over video trainers in terms of basic skills instruction and although the results of validation studies are variable, the potential for such technology to have a huge impact on surgical training is apparent. Work to determine standardized learning curves and proficiency criteria for different levels of trainees is incomplete. Moreover, defining which performance parameters measured by the LapSim accurately determine laparoscopic skill is complex. Further technological advances will undoubtedly improve the efficacy of the LapSim, and the results of large multicenter trials are anticipated.
6. SIMPRAXIS

**New**: Assessing the value of the SimPraxis Laparoscopic™ Cholecystectomy Trainer
Gammarra A, Hogle NJ, Azab B, Bloom SW, Widmann WD
JSLS 2012 vol 16, p191-194

**BACKGROUND AND OBJECTIVES**: Our aim was to determine whether the SimPraxis™ Laparoscopic Cholecystectomy Trainer is an effective adjunct for training both junior and senior surgical residents.

**METHODS**: During the 2009-2010 academic year, 20 of 27 surgical residents at our institution completed training with the SimPraxis Laparoscopic Cholecystectomy Trainer. These 20 residents took an identical 25-question pre- and posttest prepared in-house by a senior laparoscopic surgeon, based on the SimPraxis Laparoscopic Cholecystectomy program content. Included within the SimPraxis program is a multiple data point scoring system. For our reporting purposes, we divided the residents into 2 groups, junior (PGY 1-2; n=11) and senior (PGY 3-5; n=9).

**RESULTS**: The junior residents demonstrated a statistically significant improvement in their post-test scores ($P=0.001$). On the contrary, the senior residents showed nonstatistically significant minor improvement in their examination scores ($P=.09$). While, the pretest scores were significantly higher for the senior residents compared with the junior residents ($P=.003$), the post-test scores were non-significantly different between the senior vs. the junior residents ($P=.07$). There was no significant difference between the time it took junior and senior residents to complete the SimPraxis program.

**CONCLUSION**: Our data demonstrates that junior residents benefitted the most from the SimPraxis training program. Requiring junior surgical residents to complete both skills and cognitive training programs may be an effective adjunct in preparation for participation in laparoscopic cholecystectomy procedures.

**New**: Validation study of a computer-based open surgical trainer: SimPraxis® simulation platform
Tran LN, Gupta P, Poniatowski LH, Alanee S, Dall’Era MA, Sweet RM
Advances in Medical Education and Practice 2013 Vol 4, p23-30

**BACKGROUND**: Technological advances have dramatically changed medical education, particularly in the era of work-hour restrictions, which increasingly highlights a need for novel methods to teach surgical skills. The purpose of this study was to evaluate the validity of a novel, computer-based, interactive, cognitive simulator for training surgeons to perform pelvic lymph node dissection (PLND).

**METHODS**: Eight prostate cancer experts evaluated the content of the simulator. Contextual aspects of the simulator were rated on a five-point Likert scale. The experts and nine first-year residents completed a simulated PLND. Time and deviations were logged, and the results were compared between experts and novices using the Mann-Whitney test.

**RESULTS**: Before training, 88% of the experts felt that a validated simulator would be useful for PLND training. After testing, 100% of the experts felt that it would be more useful than standard video training. Eighty-eight percent stated that they would like to see the simulator in the curriculum of residency programs and 56% thought it would be useful for accreditation purposes. The experts felt that the simulator aided in overall understanding, training indications, concepts and steps of the procedure, training how to use an assistant, and enhanced the knowledge of anatomy. Median performance times taken by experts and interns to complete a PLND procedure on the simulator were 12.62 and 23.97 minutes, respectively. Median deviation from the incorporated procedure pathway for experts was 24.5 and was 89 for novices.

**CONCLUSION**: We describe an interactive, computer-based simulator designed to assist in mastery of the cognitive steps of an open surgical procedure. This platform is intuitive and flexible, and could be applied to any stepwise medical procedure. Overall, experts outperformed novices in their performance on the trainer. Experts agreed that the content was acceptable, accurate, and representative.