Systematic Review of Laparoscopic Surgery and Simulation-based Training

Juan U González-Tova, Pallikonda S Madhulika

ABSTRACT

Introduction: We performed a systematic review to analyze the effect and to describe all available simulation-based training as well as the securing of laparoscopic surgery aptitudes during residency programs.

Materials and methods: This systematic review aimed to examine the effectiveness of simulation-based training to develop laparoscopic surgery skills using the published randomized controlled trials (RCTs) searching in PubMed from 2014 till now. This review of the literature tends to the subject of whether laparoscopic recreation deciphers the gain of surgical abilities to the operation room (OR).

Results: According to this review, we found that specific learned skills could be reproduced in the OR. Reenactment-based preparing and laparoscopic surgery found that particular abilities could be translatable to the OR. Twenty-one investigations revealed learning results measured in five behavioral classifications: Economy of development (8 ponders); suturing (3 examines); execution time (13 considers); mistake rates (7 thinks about); and worldwide rating (7 contemplates).

Conclusion: Simulation-based training can help to obtain obvious advantages of surgical aptitudes in the OR. This review proposes that simulation-based training is a successful approach to instruct laparoscopic surgery abilities, increasing reproduction of laparoscopic surgery aptitudes to the OR, and increment safety for patients. Nevertheless, more research ought to be directed to decide whether and how this training can become a part of surgical curriculum.

Keywords: Laparoscopic training, Simulation, Surgical skills.

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INTRODUCTION

Laparoscopic approach has turned into a “gold standard” for a lot of common surgical procedures, e.g., cholecystectomies and appendectomies, and is associated with less surgical trauma, faster postoperative recovery, shorter hospital stays, and better cosmetic results. There is a common agreement that simulation-based training enhances information and formation and that preparation outside the working room (OR) diminishes the danger of unfavorable surgical events.

As the surgeon community establishes and keeps up new instructing strategies to prepare capable specialists, learning ways that exist outside the OR are turning into a prescribed strategy for creating laparoscopic surgery abilities. Preparing outside the OR lessens the danger of unfavorable surgical events. Simulation-based surgical aptitudes and methods enable unpracticed specialists to secure abilities through repetitive practice in a safe, nonthreatening condition, preceding experiencing the hazard and time pressures intrinsic in the OR. Those in charge of planning training centers work with restricted proof to determine complex inquiries identifying with training, interpretation of abilities learned, and safety concerns about learning laparoscopic surgery.

Supervision by an expert during laparoscopic colorectal surgery aims at similar results among learners, according to a systematic review in 2006. In an alternate review, investigators revealed that simulation training may not be a superior strategy than patients, corpses, and creatures for instructing surgical abilities, yet the aptitudes learned by simulation-based preparation gave off an impression of being transferable to the OR. This review was restricted to 11 distributed investigations and was led in 2008.

One study found that virtual reality training can supplement laparoscopic surgery training, yet fluctuation crosswise over research outlines and clashing discoveries in the published results kept the affirmation of clear best procedures. Cook et al considered technology-enhanced simulation training and reasoned that simulation training is related with vast impacts on clinician practices and mild consequences for patient care.

This systematic review aims to analyze the topic of whether laparoscopic simulation deciphers the gain of surgical aptitudes to the OR. The scope of this document is centered around the significance and pertinence identified with the gaining of surgical aptitudes, the interpretation of surgical abilities obtained outside of the OR, and enhancements concentrated on well-being for patients.
review of available articles was completed to depict the

effect of simulation-based training in light of the securing

of laparoscopic surgery aptitudes and the reproducibility

of these abilities to the OR. Training skills were surveyed

for execution time; worldwide rating; suturing, cutting,

and searing abilities; mistakes; and ergonomy.

MATERIALS AND METHODS

This systematic review aims to analyze the topic of

whether laparoscopic simulation deciphers the gain of

surgical aptitudes to the OR. The studies were recognized

via seeking PubMed from the initiation of the database to

December 2016 and Specific search: Simulation in Health

Care, Annals of Surgery, Journal American Surgery,

International Journal of Surgery, Surgery, Archives of

Surgery, and The British Journal of Surgery from 2000
to December 2016. Different mixes of a few pertinent

watchwords were utilized to recognize articles for audit

(haptic or simulation or simulation education or simulation

medicine or laparoscopic simulation or simulation

training or translation and laparoscopic surgery).

Inclusion criteria required for inclusion in the review

are of as follows:

• Utilization of a randomized controlled plan that

incorporates at least one intervention group and one

control group that either got no training or traditional

training in the OR;

• Single-bunch pretest–posttest;

• Two group nonrandomized;

• Parallel group;

• Crossover designs;

• Utilize simulation-based training as the instruc-
tive intercession for showing laparoscopic surgery

abilities;

• Interpretation of aptitudes was measured in the OR

setting.

Simulation-based training was characterized exten-
vively to incorporate gear that imitated the required

conditions with adequate authenticity to fill in as training

instrument. Cases of the test systems incorporated into

this study were box trainers, PC programming, virtual

reality systems, undertaking mentors, and high loyalty

and static mannequins.

The exclusion criteria were:

• Articles that did not utilize simulation as the instruc-
tive mediation for learning laparoscopic surgery

abilities.

• Interpretation of aptitudes was not measured in the OR

setting.

A scope based on PRISMA13 and Cochrane hand-
book14 was utilized to survey the writing. The primary

writer autonomously coded each of the articles found

through the research. While checking on the results,
a few abstracts gave enough detail and data identified

with the strategies to decide whether the incorporation

criteria were met; if not, the full composition was perused
to decide whether the techniques met the consideration
criteria. The original copies were dispensed with in light

of the fact that the strategies did not meet the consider-

ation criteria.

RESULTS

The outcomes detailed in this segment depend on the

20 articles that we decided met our inclusion criteria. A

total of 21 studies were examined. All posttraining eval-

uations were translational to either a Porcine model or the

OR, 9 (43%) led the posttest in a Porcine model, 12 (57%)

led the posttest in the OR with patients.

In Table 1, we describe the types of simulators imple-

mented in the 21 studies, manufacturers for the simula-
tors, descriptions for the simulators, and performance

skills the simulators provide. A total of 21 studies were

assessed/reviewed; the specific simulators, members,

assessments, and details of the 21 studies are provided

in Tables 2 and 3.

Performance Time (n = 13 studies)

Performance time1,5,7,8,15-22 was accounted for as the

measure of time taken to play out the laparoscopic pro-

cedure at the posttest assessment. Of the 21 studies that

surveyed whether the training intercession brought about

the change of execution time, 13 (62%) investigations

announced factually statistically significant improve-

ment. For instance, in one study scientists announced

that the control group took 58% longer to play out the

surgery23 and in another study specialists detailed that

the control group, all things considered, played out

the surgery twice the length of the intervention group

(24 minutes when contrasted with 12 minutes, p < 0.001).24

In yet another investigation the intervention group was

29% quicker in dismembering the gallbladder during

a cholecystectomy than the control one.24 Then again,
two investigations1,15 detailed no noteworthy changes in

time between the intervention and control groups when

execution time was measured.

Global Ratings (n = 7 studies)

Global appraisals were led utilizing the Objective Struc-
tured Assessment of Technical Skill (OSATS) rating

scale.6,7,17,25-29 The OSATS assessment tool assesses

members on regard for tissue dissection, time and

movement, instrument ergonomy, information of instru-

ments, stream of operation, utilization of collaborator,

and learning of methodology. GOALS rating scale30
Table 1: Laparoscopic training tools, definitions, and manufacturers

<table>
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<tr>
<th>Type of simulation</th>
<th>Definition</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box trainer</td>
<td>A box that incorporates conventional laparoscopic equipment to perform basic skills, is versatile, and enables training on animal parts as well as synthetic inanimate models. A partial component of a simulator or simulation modality, for example, an arm, leg, or torso</td>
<td>Simulab Corporation</td>
</tr>
<tr>
<td>Task trainer</td>
<td>A partial component of a simulator or simulation modality, for example, an arm, leg, or torso</td>
<td>Limbs and Things</td>
</tr>
<tr>
<td>MIST-VR</td>
<td>A virtual reality simulator with six different tasks to simulate maneuvers performed during laparoscopic cholecystectomy in a computerized environment</td>
<td>Mentice AB</td>
</tr>
<tr>
<td>LapMentor/LapMentor II</td>
<td>A virtual reality simulator consisting of a camera and two calibrated working instruments for which the motion of the instruments is translated to a two-dimensional computer screen for student practices</td>
<td>Simbionix Ltd.</td>
</tr>
<tr>
<td>LapSim</td>
<td>A computer-based simulator creating a virtual laparoscopic setting through a computer operating system, a video monitor, a laparoscopic interface containing two pistol-grip instruments, and a diathermy pedal without haptic feedback</td>
<td>Surgical Science</td>
</tr>
<tr>
<td>EndoTower</td>
<td>EndoTower software consists of an angled telescope simulator composed of rotating camera and telescopic components</td>
<td>Verefi Technologies, Inc.</td>
</tr>
<tr>
<td>MISTELS/FLS trainer</td>
<td>McGill Inanimate System for Training and Evaluation of Laparoscopic Skills—this inexpensive, portable, and flexible system allows students to practice in a virtual Endotrainer box</td>
<td>SAGES</td>
</tr>
<tr>
<td>SIMENDO VR</td>
<td>Computer software used to train eye–hand coordination skills by camera navigation and basic drills</td>
<td>Delta Tech</td>
</tr>
<tr>
<td>URO Mentor</td>
<td>A hybrid simulator consisting of a personal computer-based system linked to a mannequin with real endoscopes. Cystoscopic and ureteroscopic procedures are performed using either flexible or semirigid endoscopes</td>
<td>Simbionix Ltd.</td>
</tr>
<tr>
<td>Da Vinci Skills Simulator</td>
<td>A portable simulator containing a variety of exercises and scenarios specifically designed to give users the opportunity to improve their proficiency with surgical controls</td>
<td>Intuitive Surgical</td>
</tr>
</tbody>
</table>

measures execution in five spaces: Three of the areas are particular to laparoscopic surgery (e.g., depth perception, bimanual skill, and tissue dissection) and two of the spaces are bland (e.g., efficiency and autonomy). The standard Fundamentals of Laparoscopic Surgery (FLS) measurements26 are the essential psychomotor abilities fundamental before figuring out how to perform and build up a laparoscopic surgical case. An alternate report revealed that global evaluation scores expanded and their standard deviation diminished in the intervention group when contrasted with the nonprepared group (p = 0.004).25 Also, in the same article, 100% of intervention members achieved the passing score level whereas it was just 37.5% of the control group. Researchers did not locate any statistical significance between the two groups; nonetheless, the members with low benchmark execution expanded their scores altogether after simulation training.31

Suturing, Cutting, and Cautery Skills (n = 3 studies)

Three (14%) of the 21 examines detailed huge change on suturing, cutting, and cauterizing abilities8,23,24 in the training group when contrasted with the control group. Researchers assessed that the trained members beat the control members in the execution of safe electrocautery (p < 0.01).8

Mistakes (n = 7 studies)

Seven (33%) of the investigations evaluate whether simulation-based training brought about a lessening in errors.5,6,18,19,21,22,32 These were accounted for as clipping errors, dissection errors, tissue damage, incorrect plane for dissection, lack of progress, and instrument out of view. Each one of the seven investigations looked into articles for detailed statistical discoveries that the intervention diminished and the number of errors that happened. For instance, the intervention group made altogether less mistakes identified with tissue division (p = 0.008) and dissection (p = 0.03) with the control group creating three-fold the number of blunders.23

Ergonomics (n = 8 studies)

Eight of the examinations surveyed found that simulation-based training brought about an expansion in the ergonomics.1,7,8,15,23,25,28,33 It was accounted for as camera navigation, efficiency of instrument, total path length, number of movements, navigation, and bimanual dexterity. The eight investigations (38%) revealed statistical significances that the intervention expanded the ergonomics. In particular, training was essentially identified with path length (p < 0.001) and aggregate number of developments (p = 0.009).7 Interestingly, agents found no distinction in ergonomics between the control and intervention groups (p = 0.40).1 In two distinct studies, specialists found that
<table>
<thead>
<tr>
<th>Citation</th>
<th>Participants</th>
<th>Prestudy data collected</th>
<th>Simulation intervention</th>
<th>Additional training</th>
<th>Time between initial assessment and final assessment</th>
<th>Training time</th>
<th>Training tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggarwal et al(^7)</td>
<td>19 novice surgeons</td>
<td>None</td>
<td>LapSim VR</td>
<td>None</td>
<td>Not specified final assessment conducted over 4 weeks</td>
<td>Not specified</td>
<td>7 basic tasks; 3 levels of difficulty Skills for: Instrument navigation—Grasping Tissues—Clip</td>
</tr>
<tr>
<td>Ahlberg et al(^8)</td>
<td>29 fourth-year medical students</td>
<td>None</td>
<td>MIST-VR</td>
<td>None</td>
<td>Not specified</td>
<td>3 hours</td>
<td>Six tasks simulate the maneuvers performed during a laparoscopic cholecystectomy</td>
</tr>
<tr>
<td>Andreatta et al(^8)</td>
<td>19 surgical interns: (1) 10 in the training group, (2) 9 in the control group</td>
<td>Computer game experience</td>
<td>Simbionix LapMentor</td>
<td>None</td>
<td>Four weeks duration is not specified</td>
<td>At least 10 repetitions were performed in order to reach proficiency by trainees</td>
<td></td>
</tr>
<tr>
<td>Ahlberg et al(^3)</td>
<td>13 surgical residents</td>
<td>Mental rotation, cognitive tests, verbal working memory, attitude toward simulator</td>
<td>LapSim</td>
<td>None</td>
<td>The first surgery performed within 2 weeks of baseline measurement. The last surgery performed within 6 months of the start</td>
<td>Maximum of 40 hours in 1 week</td>
<td>Grasping, lift grasp, cutting right, cutting left, clip application</td>
</tr>
<tr>
<td>Banks et al(^3)</td>
<td>20 postgraduate year (PGY)1 residents</td>
<td>Laparoscopic experience</td>
<td>Task Trainer Laparoscopic BTL</td>
<td>None</td>
<td>Not specified, estimated to be approximately 4 hours</td>
<td>1 hour of didactics; 2 hours of hands-on teaching in the skills lab with three stations: (1) Suturing pig's feet; (2) knot tying board; (3) a lap simulator and an operative lap tower</td>
<td></td>
</tr>
<tr>
<td>Bennett et al(^3)</td>
<td>70 medical students</td>
<td>Interest in surgical specialty Angled laparoscope</td>
<td>Box trainer</td>
<td>None</td>
<td>6 weeks</td>
<td>10 minutes</td>
<td>Tutorial on camera simulator navigation</td>
</tr>
<tr>
<td>Gala et al(^5)</td>
<td>44 residents (PGY 1 and 2); 66 (PGY 3 and 4)</td>
<td>Baseline data laparoscopic Pomeroy Bilateral tubal ligation</td>
<td>Psychomotor board testing with a peg board test</td>
<td>Two times till mastery accomplished on all 5 validated laparoscopic simulators</td>
<td>Not reported</td>
<td>30 minutes with faculty member Clipping, grasping, lifting, time, peg transfer, pattern cutting</td>
<td></td>
</tr>
<tr>
<td>Ganai et al(^6)</td>
<td>19 third-year medical students: (1) 9 training group, (2) 10 control group</td>
<td>Laparoscopic cases observed or participated in were measured between baseline and performance</td>
<td>Endo Tower</td>
<td>None</td>
<td>3–4 weeks</td>
<td>1-hour sessions, Limit of 10 sessions per difficulty level (3 levels). Had to train to proficiency</td>
<td>Navigation around a complex geometric structure to achieve specific view of target objects</td>
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<tr>
<td>Grantcharov et al(^{17})</td>
<td>16 surgical residents with limited laparoscopic experience</td>
<td>None</td>
<td>MIST-VR</td>
<td>None</td>
<td>14 days</td>
<td>3 hours</td>
<td>Task 1: Virtual sphere to box transfer; Task 2: Hand to hand transfer Task 3: Grasping the segments of virtual pipe Task 4: Grasp virtual sphere, touch tip of other instrument, withdraw and reinsert, and touch sphere again. Task 5: Virtual sphere was grasped, three plates appear on the surface of sphere, these are then touched by the other instruments Task 6: Combines actions of 4 and 5 with diathermy of the plates while holding the sphere</td>
</tr>
<tr>
<td>Hogle et al(^{25})</td>
<td>Study 1: (1) 6 trained; (2) 6 control Study 3: 10 trained; 11 control</td>
<td>Study 1 and 3: None</td>
<td>Study 1 and 3: LapSim</td>
<td>Study 1 and 3: None</td>
<td>Study 1: 1 month</td>
<td>Study 1 and 3: None specified</td>
<td>Camera navigation, instrument navigation, coordination, grasping, lifting and grasping, cutting, clip applying</td>
</tr>
<tr>
<td>Hung et al(^{31})</td>
<td>24 robotic surgery trainees</td>
<td>Completed fewer than 10 robotic cases</td>
<td>Vinci Si</td>
<td>None</td>
<td>5 weeks</td>
<td>45 minutes</td>
<td>Run bowl and cut on circumferentially inked line on bowl Cut 2.5 cm inked line on anterior surface of bladder and water tight repair Resect Styrofoam tumor with a clean margin of renal parenchyma</td>
</tr>
<tr>
<td>Korndorffer et al(^{32})</td>
<td>17 surgical residents PGY1–5</td>
<td>Demographic video game ability</td>
<td>MISTELS</td>
<td>None</td>
<td>8 weeks</td>
<td>8 hours (8 weeks during 1-hour weekly sessions)</td>
<td>Trainees trained on suturing</td>
</tr>
<tr>
<td>Larsen et al(^{16})</td>
<td>21 first and second year students specializing in obstetrics/gynecology</td>
<td>None</td>
<td>LapSim Gyn</td>
<td>None</td>
<td>Unclear</td>
<td>7 hours and 15 minutes</td>
<td>Trained on “lifting and grasping” and “cutting” and performed salpingectomy sparing ovary 0 and 30° camera manipulation, hand–eye coordination, clipping, grasping and clipping, two-handed maneuvers, cutting, fulguration, and object translocation</td>
</tr>
<tr>
<td>Seymour et al(^{26})</td>
<td>16 PGY1–4 surgical residents</td>
<td>Visuospatial, perceptual</td>
<td>MIST-VR</td>
<td>Video demonstrating optimal procedure performance</td>
<td>No initial assessment other than ability tests</td>
<td>1 hour</td>
<td>Manipulate and diathermy task</td>
</tr>
</tbody>
</table>

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<tr>
<td>Stefanidis et al</td>
<td>32 medical students: (1) 6 control group, (2) 13 trained group, (3) 13 trained group plus environmental and more complex</td>
<td>Demographic data Simulor experience Laparoscopic experience- NASA TLX work load</td>
<td>FLS video trainer model Assessed on the trainer for retention before being assessed for transfer on Porcine model</td>
<td>Retention and transfer tests conducted on same day Average time between baseline and completion of training was 8.4 days</td>
<td>For group II average training time was 239 minutes For group III average training time was 329 minutes</td>
<td>Stefanidis et al</td>
<td>Group II a: Trained to proficiency in lap suture on an FLS video trainer model  Group III: Trained until proficiency Perform the task in a constrained space Had to listen to OR noise through headphones Had to practice with shorter suture Had to start with a dropped whose tip was facing away from the FLS model These four conditions were introduced gradually Laparoscopic suturing was assessed</td>
</tr>
<tr>
<td>Stefanidis et al</td>
<td>15 Novices</td>
<td>Demographics: Experience with surgery and simulators</td>
<td>Simulator None</td>
<td>Not specified (approximately from 4–5)</td>
<td>Average training was 4.7 hours (1.2 SD) 41 reps (10 SD) Lasted 6 days (4 SD)</td>
<td>Stefanidis et al</td>
<td></td>
</tr>
<tr>
<td>Sroka et al</td>
<td>16 Surgical residents (PGY1–3) with no prior fundamentals of laparoscopic surgery training: (1) 8 trained, (2) 8 control</td>
<td>None</td>
<td>MISTELS -Box Trainer None</td>
<td>Mean time between pre and post training evaluations was 145 days</td>
<td>Average training time on the simulator was 450 minutes.</td>
<td>Sroka et al</td>
<td>Peg transfer Circle cut Placement of a ligating loop Simple suture tied with extra and intracorporeal techniques</td>
</tr>
<tr>
<td>Van Sickle et al</td>
<td>22 senior surgical residents (PGY3–6): (1) 11 control group, (2) 11 trained group (simulation and box trainer)</td>
<td>Demographic: Perceptual ability Previous laparoscopic surgery experience</td>
<td>MIST-VR -Box trainer None</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Van Sickle et al</td>
<td>Suturing on the VR trainer and box trainer -Knot tying on the box trainer</td>
</tr>
<tr>
<td>Verdaasdonk et al</td>
<td>19 surgical trainees (1st and 2nd year): (1) 10 control group, (2) 9 training group</td>
<td>None</td>
<td>SIMENDO VR simulator None</td>
<td>1 week</td>
<td>Not specified</td>
<td>Verdaasdonk et al</td>
<td>Double surgical knot tying</td>
</tr>
<tr>
<td>Zendejas et al</td>
<td>50 PGY1–5: (1) 26 trained group, (2) 24 control group</td>
<td>Demographics: Video game ability</td>
<td>Guildford MATTU TEP task trainer None</td>
<td>Approximately 10 days</td>
<td>Unclear</td>
<td>Zendejas et al</td>
<td>Trainees reduced the hemia sacs of right-sided indirect and femoral hemias and to position and tack a piece of 3.5 inches × 5 inches polypropylene mesh over the myopectineal orifice covering all potential right-sided hemia defects</td>
</tr>
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</table>

SD: Standard deviation
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<tr>
<th>Citation</th>
<th>Contextual setting for final assessment</th>
<th>Source of final assessment ratings</th>
<th>Skills assessed posttraining</th>
<th>Results from research studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggarwal et al</td>
<td>Porcine model (pre on box trainer)</td>
<td>Two observers (OSATS global rating and a motion tracking device)</td>
<td>Change in operative performance: (1) Time taken; (2) total path length; (3) total number of movements</td>
<td>Trained group performed significantly better on time (p = 0.038), total path length (p = 0.001), total number of movements (p = 0.009), and overall rating scores (p = 0.001) Group demonstrated dexterity scores equivalent to expert levels</td>
</tr>
<tr>
<td>Ahlberg et al</td>
<td>Porcine model</td>
<td>Two observers (reliability greater 0.98)</td>
<td>Exposure errors, clipping and tissue division errors, and dissection errors Performance was broken up into phases: (1) Exposure of the cystic duct and artery; (2) clip placement followed by division of the cystic duct and artery; (3) gallbladder excision: Total time, path length, angular path, tissue damage, and max damage</td>
<td>Intervention group made significantly fewer errors. The trained group made significantly fewer objectively assessed, intraoperative errors during the exposure portion of the procedure (p &lt; 0.04), clipping and tissue division (p &lt; 0.008), and dissection (p &lt; 0.03). The control group made three times as many errors and used 58% longer surgical time</td>
</tr>
<tr>
<td>Ahlberg et al</td>
<td>Patients in OR (pre on a simulator)</td>
<td>Two observers (reliability greater 0.98)</td>
<td>Exposures, exposures errors, clipping and tissue division errors, and dissection errors Performance was broken up into phases: (1) Exposure of the cystic duct and artery; (2) clip placement followed by division of the cystic duct and artery; (3) gallbladder excision: Total time, path length, angular path, tissue damage, and max damage</td>
<td>Intervention group outperformed the control group in: Camera navigation skills (p &lt; 0.05), efficiency of motion (p &lt; 0.001), optimal instrument handling (p &lt; 0.001), perceptual ability (p &lt; 0.001), and performance of safe electrocautery (p &lt; 0.01) Time and accuracy ratings on 30° navigation (p &lt; 0.05), and eye–hand coordination two-handed transfer of ski needle (p &lt; 0.001) was better in the trained group. Prior training with LapMentor leads to improved resident performance of basic skills in the animate OR</td>
</tr>
<tr>
<td>Andreatta et al</td>
<td>Porcine model</td>
<td>Two surgeons (0.99 reliability)</td>
<td>30° Camera navigation: (1) Time, (2) Accuracy, (3) Efficiency of motion, (4) Instrumentation use eye–hand coordination: Two handed transfer of ski needle: (1) Time, (2) Efficiency of motion, (3) Instrument handling Eye–hand coordination: 0° camera navigation and one handed object transfer: (1) Time, (2) Accuracy, (3) 0° camera navigation skills, (4) Perceptual ability safe, placement of clips, and application of electrocautery (1) Clipping, (2) Electrocautery performance</td>
<td>Intervention group outperformed the control group in: Camera navigation skills (p &lt; 0.05), efficiency of motion (p &lt; 0.001), optimal instrument handling (p &lt; 0.001), perceptual ability (p &lt; 0.001), and performance of safe electrocautery (p &lt; 0.01) Time and accuracy ratings on 30° navigation (p &lt; 0.05), and eye–hand coordination two-handed transfer of ski needle (p &lt; 0.001) was better in the trained group. Prior training with LapMentor leads to improved resident performance of basic skills in the animate OR</td>
</tr>
<tr>
<td>Banks et al</td>
<td>Patients in OR (post only. Preassessment was done on simulator and then the training group performed on the simulator again before being evaluated in the OR)</td>
<td>Observers</td>
<td>Task-specific checklist assessed 4 categories of skills: (1) Preoperative skills, (2) surgical technique, (3) laparoscopic technique, (4) laparoscopic BTL-specific skills Global rating scale: (1) Respires for tissue, (2) time and motion, (3) instrumental handling, (4) knowledge of instruments, (5) flow of operation, (6) use of assistants, (7) knowledge of the specific procedure – Pass/fail</td>
<td>Intervention group performed significantly better than control group on all three surgical assessment tools (p = 0.002, checklist; p = 0.003, global score; p = 0.003, pass rate; p = 0.003, posttest) and scored significantly better on the knowledge posttest (p = 0.009)</td>
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<tr>
<td>Bennett et al</td>
<td>Patients in OR (post only)</td>
<td>Observers</td>
<td>Identification of all four target numbers and the ability to maintain correct orientation of the camera at each target and to properly position the post at each target for a maximum total score of 12 points Max time was 120 seconds</td>
<td>No difference in learning between groups (p = 0.40)</td>
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<tr>
<td>Gala et al</td>
<td>Patients in OR</td>
<td>Observers</td>
<td>Time Competence levels of participants pre and post intervention Technical skills for both groups</td>
<td>Time the intervention group improved significantly higher (p &lt; 0.01) Intervention group was significantly higher with competence levels (p &lt; 0.01) The intervention group also had higher technical skills in the operating room (p &lt; 0.03)</td>
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<table>
<thead>
<tr>
<th>Citation</th>
<th>Contextual setting for final assessment</th>
<th>Source of final assessment ratings</th>
<th>Skills assessed posttraining</th>
<th>Results from research studies</th>
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<tr>
<td>Ganai et al&lt;sup&gt;20&lt;/sup&gt;</td>
<td>Porcine model (pre and post)</td>
<td>3 External observers (90%) and from Endo Tower simulator</td>
<td>12 structured scope navigation tasks in three phases: (1) Navigation within the peritoneal cavity, (2) Navigation around the retracted gallbladder, (3) Navigation around a suspended small intestinal loop</td>
<td>Intervention group was significantly better in object visualization (p&lt;0.05), scope orientation (p&lt;0.05), and horizon errors (p&lt;0.05)</td>
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<tr>
<td>Grantcharov et al&lt;sup&gt;17&lt;/sup&gt;</td>
<td>Patients in OR</td>
<td>2 Senior surgeons rated 1 surgery (Cohen’s kappa 0.71)</td>
<td>Economy of movement: (1) Unnecessary movements, (2) confidence of movements Errors: (1) Respect for tissue, (2) Precision of operative technique</td>
<td>Intervention group showed greater improvement in error (p = 0.003) and economy of movement (p = 0.003) Intervention group was significantly faster than the control group when performing cholecystectomy (p = 0.021)</td>
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<tr>
<td>Hogle et al&lt;sup&gt;25&lt;/sup&gt;</td>
<td>Study 1: OR patients Study 3: Porcine model (pre and post)</td>
<td>Study 1: Attending surgeon Study 3: Observer</td>
<td>Study 1 and 3: GOALS rating: (1) Depth perception, (2) Bimanual dexterity, (3) Efficiency, (4) Tissue handling and autonomy</td>
<td>Study 1 and 3: No significant differences were found between groups Groups I and II were comparable in pre-study surgical experience and had similar baseline scores on simulator and tissue exercises (p&gt;0.05) Overall baseline simulator performance significantly correlated with baseline and final tissue performance (&lt;0.0001) Simulator training significantly improved tissue performance on key metrics for group I subjects with lower baseline tissue scores than their group II counterparts (p&lt;0.05) Group I tended to outperform group II on final tissue performance, although the difference was not significant</td>
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<td>Hung et al&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Porcine model</td>
<td>Three expert robotic surgeons blinded</td>
<td>GOALS: (1) Depth perception, (2) Bimanual dexterity, (3) Efficiency, (4) Tissue handling, (5) Participant autonomy to accomplish task</td>
<td>The training group and the control group demonstrated significant improvement in completion time, and overall score. The training group also demonstrated significant improvement in accuracy errors. The trained group performed significantly better in completion time and overall score when comparing posttest scores to the control group. Intervention group performed significantly better than control group</td>
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<tr>
<td>Korndorffer et al&lt;sup&gt;32&lt;/sup&gt;</td>
<td>Porcine model (pre and post)</td>
<td>Observers</td>
<td>Time, accuracy errors, knot security</td>
<td>The training group and the control group demonstrated significant improvement in completion time, and overall score. The training group also demonstrated significant improvement in accuracy errors. The trained group performed significantly better in completion time and overall score when comparing posttest scores to the control group. Intervention group performed significantly better than control group</td>
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<td>Larsen et al&lt;sup&gt;16&lt;/sup&gt;</td>
<td>Patients in OR (post only, pre was on a VR simulator)</td>
<td>Observers</td>
<td>Primary outcome measure: (1) technical performance using the objective structured assessment of laparoscopic salpingectomy; (2) 5-item general rating scale and five-item task-specific rating scale. Time</td>
<td>Intervention group gained experience equivalent to 20–50 procedures. The median score on general and task-specific scale reached 33 points for the trained group and 23 in the control group (p&lt;0.001) The median score for time was 12 minutes for the trained group and 24 minutes for the control group (p&lt;0.001)</td>
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<td>Seymour et al&lt;sup&gt;26&lt;/sup&gt;</td>
<td>Patients in OR (post only, pre was only ability tests)</td>
<td>Observers</td>
<td>Operative errors: (1) Lack of progress, (2) gallbladder injury, (3) liver injury, (4) incorrect plan of dissection, (5) burn nontarget tissue, (6) tearing tissue, (7) instrument out of view, (8) attending takeover</td>
<td>Intervention group was faster for gallbladder dissection (29% faster), and control group was more likely to fail to make progress (Z =2.677, p&lt;0.008) and more likely to injure the gallbladder or burn nontarget tissue (5 times more likely, chi-square = 4.27, p&lt;0.039) The mean number of scored errors per procedure was significantly greater in the control group than the trained group (p = −2.76, p&lt;0.006)</td>
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<td>Stefanidis et al&lt;sup&gt;21&lt;/sup&gt;</td>
<td>Porcine model (pre and post)</td>
<td>Objective scores based on time and errors using a published formula</td>
<td>Time errors</td>
<td>Intervention group performed substantially better than control group (p&lt;0.001) Proficiency-based simulator training results in improved operative performance</td>
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<td>Stefanidis et al (22)</td>
<td>Porcine model (pre and post). A posttest was taken right after training was done, and then a retention test was taken after 5 months</td>
<td>Observers</td>
<td>Errors time</td>
<td>Intervention group outperformed control group (p &lt; 0.001) Proficiency-based simulator training results in durable improvement in operative skill of trainees even in the absence of practice for 5 months</td>
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<td>Sroka et al (27)</td>
<td>MISTELS and Box Trainer on patients in the OR</td>
<td>Attending surgeon or external evaluator</td>
<td>FLS ratings and GOALS ratings: (1) Depth perception, (2) Bimanual dexterity, (3) Tissue handling, (4) Efficiency, (5) Autonomy</td>
<td>FLS scores: Scores increased and SD decreased in the trained group as compared with the nontrained group (p = 0.004). At baseline no participant had reached the required FLS scores. Posttraining 100% of the trained group reached required scores and 37.5% of the nontrained reached required passing scores. GOALS scores: The trained group improved significantly and clinically by a mean of 6.1 ± 1.3 (p = 0.0005 vs control, and p &lt; 0.0001 vs baseline). Gender was examined as a covariate and results remained the same; trained group scores were significantly better than the control group (p = 0.001). Of the five individual domains evaluated by the GOALS rating structure, greater improvements were shown in the specific domains than the generic domains for the trained group (bimanual dexterity, p = 0.04; depth perception, p = 0.08; tissue handling, p = 0.04)</td>
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<td>Van Sickle et al (24)</td>
<td>Patients in OR (post only)</td>
<td>2 surgeons (agreement &gt; 0.80)</td>
<td>Suturing operative errors</td>
<td>Intervention group performed significantly faster (p &lt; 0.003), made fewer errors (p &lt; 0.01), and fewer excess needle manipulation (p &lt; 0.05)</td>
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<tr>
<td>Verdaasdonk et al (6)</td>
<td>Porcine model (post only)</td>
<td>Two expert laparoscopic surgeons</td>
<td>Observer rated error assessments Global ratings of knot tying economy of movements Error assessments</td>
<td>Intervention group tied knots faster (30%, p = 0.034) and made fewer errors (33%) as compared with control group. Experimental group dropped the needle fewer times and made less frequent unnecessary contact with the tip of the needle against the tissue than the control group (p &lt; 0.05). No significant differences in the scores assigned to the groups by the two experts (economy of movement p = 0.114; error assessment p = 0.148)</td>
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<td>Zendejas et al (28)</td>
<td>OR (pre and post)</td>
<td>Observers and medical records</td>
<td>Operative performance by using a global rating using: (1) GOALS, (2) operating time, (3) proportion of procedure performed by the trainee, (4) need for overnight stay, (5) recurrence of inguinal hernia and chronic groin pain and complications</td>
<td>The trained group were on average 6.5 minutes faster than the control group (p &lt; 0.0001) Resident participation was also different between the groups with the trained group performing more of the procedure than the control group (88% vs 73%). After correcting time to account for varying participation rates, the trained group performed the procedure 13.1 minutes faster. The trained group had higher performance scores than the trained group (p = 0.001). Intraoperative and postoperative complications and overnight stay were less likely in the trained group than the control group (p &lt; 0.05). When follow-ups with patients were conducted the number of patients who experienced a hernia recurrence or were evaluated for groin pain at least 3 months post repair there was no difference between the groups</td>
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the control bunches did not demonstrate significant differences contrasted with the intervention group as identified with ergonomics.1

DISCUSSION

This review of available laparoscopic publications and interpretation of aptitudes outlines the proof for the simulation-based training studies and learning surgical skills in a safe way for residents to be reproducible on patients in the OR. Those in charge of instructing and surveying surgical execution ought to consider ramifications of these discoveries in three noteworthy areas: (1) Training for capability or enhanced aptitudes honed in a controlled setting, (2) interpretation of new information into execution outside the reenacted setting, and (3) well-being and safety for patients. Laparoscopic surgery educational module might be altered or supplemented with the usage simulation-based training. Recreation can prompt enhanced evaluation, enhanced preparing, blunder diminishment, and the improvement of specialized abilities in laparoscopic surgery important to work on genuine patients.24 Participants in the intervention group made less mistakes and were less inclined to harm the gallbladder or to burn nontarget tissue on genuine patients.24 Simulation-based training allows for repeated practice of standardized tasks under reproducible conditions and enables the use of objective measures for assessment purposes27 and students’ feedback. Simulation-based training modules can possibly abbreviate the learning time for laparoscopic strategies contrasted with customary showing techniques in laparoscopic surgery.26 Surgeons in training who got simulation-based educational modules essentially beat surgeons who got the standard educational programs on knot tying.28 Moreover, surgical residents who had simulation-based training played out the suturing errand quicker, made less mistakes, and were more productive in handling the suture.28 In general, surgeons who got simulation-based aptitudes exhibited speedier accomplishment of those abilities than their associates from the control group in a high-stakes condition.17 Training educational programs identified with laparoscopic surgery aptitudes consider all the more learning open doors for junior specialists to hone with simulation-based training before entering OR condition; along these lines, taking into account the capability of abilities converting into the OR.

At long last, the studies in this review demonstrate that simulation-based training ought to be fused into surgical educational program particularly focusing on novel surgeons. By and large, simulation-based training programs are offered as a supplement to conventional surgical preparing and are voluntary.24 At present, there is no standard or all-inclusive particular surgical educational program setup in surgical instructive projects; be that as it may, there has been a current change. The Fundamentals of Endoscopic Surgery was endorsed in March 2014 as an extra necessity for residents graduating in 2018 and after this is a simulation-based training program.

Additionally, inquiries about this are expected to decide the best longitudinal educational programs for fundamental and propelled abilities’ procurement and exchange to the OR condition. Simulation-based training takes into account the beginner to take in the psychomotor aptitudes and spatial judgments essential for laparoscopic surgical abilities, enabling them to concentrate more on learning agent methodologies and taking care of intraoperative inconveniences while in the OR.33 Preparing in capability-based abilities ought to be joined into an extensive surgical preparing and appraisal educational program for residents preceding working on genuine patients.35 The strain to make surgical preparing more productive and more secure for patients is generous, and simulation-based training can possibly enhance surgical educational module.18

Translational effect was accomplished in the OR with live patients when simulation-based training was utilized for the instructive intercession. Researchers found that preparation in a reenacted domain prompted enhanced surgical execution on either animals or people.5,6,18,23,24,26,28,35,36 Simulation-based training impacts the interpretation of laparoscopic surgery abilities to the OR. Because of these discoveries, simulation-based training can possibly give the foundational abilities important to future specialists to learn in a controlled domain and make an interpretation of those obtained aptitudes to the OR. With increments in innovation and the requirement for a standard surgical educational program, there is potential with recreation as an instructive apparatus to facilitate the interpretation of laparoscopic surgical aptitudes into the OR. All the more particularly, run-of-the-mill aptitudes that convert into the OR are suturing, camera navigation, and the control and manipulation of equipment.

Simulation-based Training

Simulation-based training can possibly prompt an expansion in tolerant security. Trainers who prepared with reproduction had less mistakes than control group29,24 while in the OR. Members in the intervention group had less occurrences of the administering specialist assuming control over the procedure. These sorts of occasions can essentially influence clinical results, since they speak of potential mistakes in procedure, trading off patient security.23 Utilizing simulation for training surgical abilities can profit the bigger objective of enhanced patient well-being in a few ways. With reproduction, students
can rehash a system or even a particular component of a methodology until the point that competency is illustrated. Beginner specialists enter the OR more adept to create ideal patient results and are better arranged to take part in surgical cases with live patients in the OR in the event that they already prepared on a test system. Reproduction can likewise give more chances to healing preparing to lessen ability rot.27 Laparoscopic surgical test systems give chances to prepare different ideas integral to tolerant security. For instance, collaboration abilities can be prepared through specialists interfacing with camera pilots or medical caretakers in a recreated OR. Mimicking laparoscopic surgical hardware and interfaces can even be utilized to present, test, and prepare new gear or conventions before they are executed in the OR, prompting recognizable proof of potential idle dangers to security and evasion of restorative mistakes because of poor human frameworks incorporations.

As with any writing review, our audit and results are constrained by the information given in the first examinations. Our discoveries are restricted by the absence of depictions of the information gathering procedure and intercessions of the included investigations. Specifically, it was hard to perceive a significant number of potential covariates that were utilized as a part of the information examinations and additionally the planning among pre-and posttests once the intercessions were actualized. Also, a larger part of the examinations that detailed factual outcomes revealed the outcomes utilizing p-values. The absence of impact estimate revealing adds to the trouble in really understanding the size of the impact of these mediations on the obtaining of surgical abilities. Another restriction to this investigation is that just a single database was utilized to recognize all writing, more research ought to be led to decide whether and how simulation can turn out to be separated from the surgical educational modules.

REFERENCES


