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Evaluation of Procedural Simulation as a Training and Assessment Tool in General Surgery—Simulating a Laparoscopic Appendectomy

Flemming Bjerrum, MD, Jeanett Strandbygaard, PhD,* Susanne Rosthøj, PhD,† Teodor Grantcharov, PhD,‡ Bent Ottesen, DMSc,* and Jette Led Sorensen, PhD**

*Department of Obstetrics and Gynecology, The Juliane Marie Centre for Children, Women and Reproduction, Rigshospitalet, University of Copenhagen, Copenhagen, Denmark; †Section of Biostatistics, Institute of Public Health, University of Copenhagen, Copenhagen, Denmark; and ‡Department of Surgery, St Michael's Hospital, University of Toronto, Toronto, Canada

BACKGROUND: Laparoscopic appendectomy is a commonly performed surgical procedure, but few training models have been described for it. We examined a virtual reality module for practising a laparoscopic appendectomy.

METHODS: A prospective cohort study with the following 3 groups of surgeons ($n = 45$): novices (0 procedures), intermediates (10-50 procedures), and experienced (>100 procedures). After being introduced to the simulator and 1 familiarization attempt on the procedural module, the participants practiced the module 20 times. Movements, task time, and procedure-specific parameters were compared over time.

RESULTS: The time and movement parameters were significantly different during the first attempt, and more experienced surgeons used fewer movements and less time than novices ($p < 0.01$), although only 2 parameters were significantly different between novices and intermediates. All 3 groups improved significantly over 20 attempts ($p < 0.0001$). The intraclass correlation coefficient varied between 0.55 and 0.68 and did not differ significantly between the 3 groups ($p > 0.05$).
When comparing novices with experienced surgeons, novices had a higher risk of burn damage to cecum (odds ratio [OR] = 3.0 [95% CI: 1.3; 7.0] $p = 0.03$), pressure damage to appendix (OR = 3.1 [95% CI: 2.0; 4.9] $p < 0.0001$), and grasping of the appendix (OR = 2.9 [95% CI: 1.8; 4.7] $p < 0.0001$). The risk of causing a perforation was not significantly different among the different experience levels (OR = 1.9 [95% CI: 0.9; 3.8] $p = 0.14$). Only 3 out of 5 error parameters differed significantly when comparing novices and experienced surgeons. Similarly, when comparing intermediates and novices, it was only 2 of the parameters that differed.

DISCUSSION: The simulator module for practising laparoscopic appendectomy may be useful as a training tool, but further development is required before it can be used for assessment purposes. Procedural simulation may demonstrate more variation for movement parameters, and future research should focus on developing better procedure-specific parameters. (J Surg Ed ▮:▮▮▮-▮▮▮. ©2016 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: laparoscopy, appendectomy, procedural training, simulation, virtual reality

COMPETENCIES: Practice-Based Learning and Improvement

INTRODUCTION

Appendectomy is the most commonly performed surgical procedure and is now predominantly performed using laparoscopy.[1] Laparoscopic appendectomy is one of the first surgical procedures performed by junior surgeons. It is an emergency procedure that is performed at all hours of the day and therefore calls for a structured approach for training, making it a relevant procedure to practise in a simulated setting first.[2-7]

Surgical simulation is widely recognized as an important tool in surgical training that makes it possible to practice

Correspondence: Inquires to Flemming Bjerrum, MD, Department of Obstetrics and Gynaecology, The Juliane Marie Centre for Children, Women and Reproduction, Rigshospitalet, Blegdamsvej 9, Copenhagen 2100, Denmark; e-mail: fbjerrum@gmail.com

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skills and procedures before entering the operating room. Virtual reality simulators have improved substantially over the past 5 years, and it is now possible to practise procedures on virtual reality simulators, although sufficient validity evidence is only available for a few procedural modules.[8-10] One of the benefits of virtual reality simulation compared to box trainers, apart from offering automated feedback, is the ability to practise many different procedures using the same equipment.[8]

Procedural training on simulators typically involves practising procedural steps, integrating instrument movement, and elements of planning and decision-making. Consequently, it is more difficult to develop realistic and useful simulator parameters for procedural modules.[11] This could explain why, despite the fact that laparoscopic appendectomy is one of the most commonly performed surgical procedures, only a few training models for it exist.[12-14]

The objective of this study was to examine a simulator module for laparoscopic appendectomy and determine its usefulness as an assessment tool or training tool.

MATERIALS AND METHODS

The design was a prospective cohort study that examined simulator performance over time. The contemporary unitary concept of validity was used to describe validity evidence for the simulator module.[15,16]

Participants and Setting

Surgical departments in the eastern part of Denmark were contacted by e-mail, and the following 3 groups of surgeons with different surgical experience were recruited: novices (0 procedures), intermediates (10-50 procedures), and experienced surgeons (>100 procedures). Participants who had previously participated in formalized training programs using simulator training were excluded. If more than 3 weeks passed between training sessions, then participants were considered to have dropped out and training was discontinued. Data collection was done at a centrally located university hospital where the simulator was located.

Description of the Simulator, Procedural Module, and Simulator Measurements

A table-mounted and height-adjustable Lapsim virtual reality simulator (Software Version 2013, Surgical Science, Gothenburg, Sweden) with a nonhaptic Simball 4D Joystick (G-coder Systems, Gothenburg, Sweden) was used.

The procedural module consisted of laparoscopic appendectomy performed using a hook electrode and ligating loops. Before removal of the appendix, adhesions along the length of the appendix had to be removed. The mesoappendix then had to be divided to the base of the cecum, and 3 ligating loops had to be placed correctly (2 centrally on the base of the appendix, and 1 distally).[6,17] Finally, the appendix had to be divided between the ligating loops, and the specimen removed in an extraction bag (Fig. 1). In case of perforation of the appendix or cecum, which could be caused by either excessive pressure or with hook electrodes or scissors, the procedure could not be completed and the attempt was ended. The outcome was the following simulator parameters: total procedure time (minutes); right and left instrument angular path (degrees); right and left tip path length (meters); burn damage to cecum (no); pressure damage to appendix (no); and appendix grasped (yes/no) and, if so, appendix grasping time (seconds).

Data Collection

Participants started by watching a video recording of the procedure performed on the simulator. They then familiarized themselves with the simulator by performing a single attempt on a basic skill task (lifting and grasping) and then practised the procedural module for the appendectomy to become familiarized with the procedural module and the simulator parameters. They received feedback from the principal investigator after the first attempt.

All participants, regardless of previous surgical experience, were then asked to practice the procedural module 20 times using the correct technique. Training sessions lasted a maximum of 2 hours, and a maximum of 3 weeks were allowed between each session to minimize decay of skills. The simulator measurements were stored automatically after each attempt on the simulator. The principal investigator was present to assist with technical problems during the

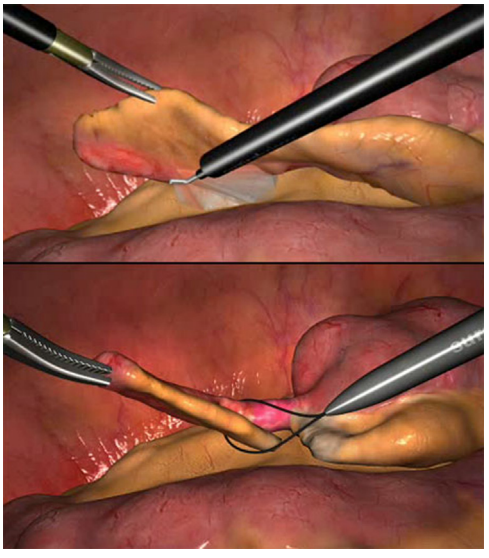

FIGURE 1. Screenshots of the simulator module (upper: dissection of adhesions and lower: positioning of endoloop). (Published with permission from Surgical Science, Gothenburg, Sweden.)