

A Virtual Reality Training Curriculum for Laparoscopic Colorectal Surgery

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OBJECTIVE: Training within a competency-based curriculum (CBC) outside the operating room enhances performance during real basic surgical procedures. This study aimed to design and validate a virtual reality CBC for an advanced laparoscopic procedure: sigmoid colectomy.

DESIGN: This was a multicenter randomized study. Novice (surgeons who had performed <5 laparoscopic colorectal resections as primary operator), intermediate (between 10 and 20), and experienced surgeons (>50) were enrolled. Validity evidence for the metrics given by the virtual reality simulator, the LAP Mentor, was based on the second attempt of each task in between groups. The tasks assessed were 3 modules of a laparoscopic sigmoid colectomy (medial dissection [MD], lateral dissection [LD], and anastomosis) and a full procedure (FP). Novice surgeons were randomized to 1 of 2 groups to perform 8 further attempts of all 3 modules or FP, for learning curve analysis.

SETTING: The 2 academic tertiary care centers—division of surgery of St. Mary's campus, Imperial College Healthcare NHS Trust, London and Nord Hospital, Assistance Publique-Hôpitaux de Marseille, Aix-Marseille Université, Marseille, were involved.

PARTICIPANTS: Novice surgeons were residents in digestive surgery at St. Mary's and Nord Hospitals. Intermediate and experienced surgeons were board-certified academic surgeons.

RESULTS: A total of 20 novice surgeons, 7 intermediate surgeons, and 6 experienced surgeons were enrolled. Evidence for validity based on experience was identified in MD, LD, and FP for time ($p = 0.005$, $p = 0.003$, and $p = 0.001$, respectively), number of movements ($p = 0.013$, $p = 0.005$, and $p = 0.001$, respectively), and path length ($p = 0.03$, $p = 0.017$, and $p = 0.001$, respectively), and only for time ($p = 0.03$) and path length ($p = 0.013$) in the anastomosis module. Novice surgeons' performance significantly improved through repetition for time, movements, and path length in MD, LD, and FP. Experienced surgeons' benchmark criteria were defined for all construct metrics showing validity evidence.

CONCLUSIONS: A CBC in laparoscopic colorectal surgery has been designed. Such training may reduce the learning curve during real colorectal resections in the operating room. (J Surg Ed ■■■-■■■. © 2016 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: simulation, education, colorectal, laparoscopy, advanced surgery

COMPETENCIES: Practice-Based Learning and Improvement, Systems-Based Practice, Medical Knowledge

INTRODUCTION

Surgical training outside the operating room (OR) using simulation has widely spread this last decade, especially in laparoscopic surgery.^{1,2} Many studies have assessed simulation for basic laparoscopic skills and procedures (such as basic drills, laparoscopic cholecystectomy, appendectomy, and hernia repair),^{3,4} and training out of the OR has proven

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its positive effect in basic skills during real laparoscopic procedures in patients.⁵⁻⁸ Virtual reality (VR) simulators have the advantage to provide automatic and instantaneous measures of performance. These metrics can serve to monitor progress while learning a technical skill, can aid in the provision of structured feedback, and can ultimately ensure that proficiency criteria have been reached.^{9,10} By drawing attention to only the most educationally valuable tasks and performance metrics, VR training can make an important contribution to the effectiveness of competency-based curricula (CBC). Such curricula were implemented in basic laparoscopic surgery and endoscopy.¹¹⁻¹³

A further step in education would be to design CBC for advanced training in laparoscopic abdominal surgery (ATLAS).¹⁴ Such training may reduce learning curves and improve patients' safety in the OR. Indeed, junior surgeons have limited access to these complex procedures as primary operator¹⁵; although, for example, the learning curve in laparoscopic colorectal surgery (LCS) is estimated between 30 and 60 cases.¹⁶⁻¹⁸ However, this field of research is still quite poor, as most studies appraising education in ATLAS are purely descriptive.¹⁴ In their systematic review, Miskovic et al.¹⁵ found only 6 studies assessing simulation in LCS. They concluded that there was a "notable lack of available data on the educational value of simulated training." The aim of the present study was to design and validate a VR CBC for an advanced laparoscopic procedure: a sigmoid colectomy.

METHODS

Participants

This was a multisite project. Surgeons of 3 different levels of experience (novice, intermediate, and experienced surgeons) were recruited to participate in the study, in the United Kingdom and in France. Residents in surgery, who had performed more than 5 basic laparoscopic procedures (i.e., cholecystectomy, appendectomy, and hernia repair) and less than 5 laparoscopic colorectal resections (LCR) as primary operator, were eligible for recruitment to the novice group. Surgeons who had performed between 10 and 20 LCR as primary operator were eligible for the intermediate group, and surgeons who had performed more than 60 LCR were eligible for the experienced group, based on learning curves previously published in LCS, e.g., between 30 and 60 cases.¹⁶⁻¹⁸ The intermediate group were junior attending surgeons who had completed specialty training only in gastrointestinal surgery, whereas the experienced group were senior surgeons who had completed specialty training both in minimally invasive and colorectal surgery.

All participants completed a questionnaire (Annex 1) concerning their age, sex, and seniority, their experience in laparoscopic and colorectal surgery (as primary operator and

assistant), their dominant hand, and their video games practice. Participation was based on voluntary basis.

Simulation Tool

The LAP Mentor (Simbionix, Cleveland, OH) is the latest generation VR simulator, incorporating haptic feedback. It comprises basic tasks, suturing tasks, procedural tasks or modules, and full procedures that range from basic (cholecystectomy and hernia repair) to advanced laparoscopic surgery (gastric bypass, hysterectomy, and sigmoid colectomy). The VR images are based on magnetic resonance imaging and in vivo laparoscopy for procedural tasks and full procedures. In the present study, the colorectal training of a LAP Mentor II platform was used, as described below.

Procedural Tasks and Metrics

Colorectal training encompasses 2 items on the LAP Mentor: a full laparoscopic sigmoid colectomy (LSC) performed for carcinoma of the sigmoid colon, which comprises the whole dissection (Fig. 1) and an anastomotic module. Procedural tasks of medial and lateral dissection were defined within the full sigmoid colectomy. Hence, 3 procedural tasks (medial dissection, lateral dissection, and anastomosis) and a full procedure were chosen for this study (Table 1).

Definitions

The qualities of procedural tasks and full LSC were assessed according to standard definitions¹⁹: validity evidence for the tested metrics was defined as the simulator ability to distinguish between groups of individuals with different levels of experience; fidelity was defined as the extent to which the examination resembled real life situations; and content validity was defined as the extent to which the domain that was being measured was measured by the assessment tool.

Study Design

Intermediate and experienced participants performed 2 repetitions of all procedural tasks and the full procedure. Novice surgeons were randomized, e.g., sealed envelopes, into 2 groups to perform 10 repetitions of all 3 procedural tasks (group 1), or the full procedure (group 2). Beforehand, all novice surgeons performed 2 basic tasks that previously demonstrated validity evidence based on relations to experience on the LAP Mentor (task 5: clipping and grasping; task 6: 2-handed maneuvers)¹²; the same simulator setup was used in both the studies. All sessions were completed at least 1 hour apart, and those in the novice groups completed no more than 2 sessions per day (Fig. 2). Novice surgeons had no specific training between sessions, but they received

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