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Original Article

An "Intermediate Curriculum" for Advanced Laparoscopic Skills Training with Virtual Reality Simulation

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ABSTRACT **Study Objective:** To estimate face and construct validity for a novel curriculum designed for intermediately skilled laparoscopic surgeons on a virtual reality simulator. It consists of 5 exercises that focus on training precision and coordination between both hands.

Design: Prospective study (Canadian Task Force II-2).

Setting: Three university hospitals and 4 teaching hospitals in the Netherlands.

Subjects: Residents, consultants, and laparoscopic experts (n = 69) in the fields of general surgery, gynecology, and urology participated. Participants were divided into 4 groups on the basis of their level of laparoscopic experience: resident, years 1–3 (n = 15); resident, years 4–6 (n = 17); consultant (n = 19); and laparoscopic experts (n = 18).

Interventions: Participants completed 3 runs of 5 exercises. The first run was an introduction, and the second and third runs were used for analysis. The parameters *time*, *path length*, *collisions*, and *displacement* were compared between groups. Afterward the participants completed a questionnaire to evaluate their laparoscopic experience and identify issues concerning the simulator and exercises.

Measurements and Main Results: The expert group was significantly faster ($p < .05$) than other groups in 4 of 5 exercises. The parameter displacement demonstrated a significant difference between the expert group and other groups in 2 of the 4 exercises in which this parameter was relevant ($p < .05$). In the questionnaire (n = 68), training capacity of the curriculum was scored with a median of 4 points on a 5-point Likert scale. Of all participants, 92.6% indicated that this curriculum is suitable as an addition to a basic skills module within their residency program.

Conclusion: Face and construct validity were estimated for an advanced virtual reality curriculum for intermediately skilled laparoscopic surgeons. The results indicate that the curriculum is suitable for training of residents and consultants and to assess and maintain their laparoscopic skills. Journal of Minimally Invasive Gynecology (2011) 18, 597–606 © 2011 AAGL. All rights reserved.

Keywords: Education; Laparoscopy; Training; Simulation; Virtual reality

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Since its introduction, laparoscopic surgery has become of great importance to the practice of surgical care. However, laparoscopic surgery requires different skills compared with open procedures, leading to a recognized learning curve [1]. Laparoscopic surgery requires distinct psychomotor abilities, ambidextrous and hand-eye coordination, depth perception, and manipulation of delicate structures with limited haptic sensation.

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It now is widely accepted that skills training outside the operating room is essential for residents. The use of animal models is prohibited in several countries. Box trainers and video trainers have the disadvantage of the lack of automated performance assessment. In comparison, virtual reality (VR) trainers provide a safe and standardized environment to practice specific skills and simultaneously measure objectively the performance of the trainee [2]. VR training can supplement standard laparoscopic box (video) training and is at least as effective [3,4]. In recent years, several VR trainers have been validated for training in general surgery [5,6], urology [7], and gynecology [8,9], and a significant correlation between operative performance and psychomotor performance on VR simulators has been demonstrated [10]. The acquired skills on a VR simulator are not procedure-specific. Rather, VR training improves overall laparoscopic surgical skills [11]. Skills acquired on a VR simulator are transferable to actual laparoscopic operations in animals and in human patients [12–17]. Implementation of standardized VR training curricula in residency training programs is preferred to acquire a predetermined level of proficiency before progression to the operating theater [15,18,19]. However, most VR curricula focus on basic laparoscopic skills and are suited for junior residents, whereas senior residents prefer live animal training and training on box/video trainers for more advanced skills training [20,21]. With attention being raised for continuous training and assessment [20], a more complex training program is needed. These more complex training programs should focus on ambidextrous skill development and precision of instrument handling, aiming at the more experienced residents and surgeons. For this study, a set of VR exercises was developed to train more advanced laparoscopic skills. The exercises provide a new challenge when the trainee has succeeded the basic exercises. This provides increasing levels of training difficulty and practice variety, which will improve the retention and transfer of simulator-acquired skills [21]. The aim of this study was to evaluate face and construct validity for the developed set of exercises for training and assessment of advanced laparoscopic skills on this VR simulator.

Materials and Methods

Curriculum Development

The new exercises for the Simendo Virtual Reality simulator (Simendo, Rotterdam, The Netherlands) were developed during the 6 months before the study. In the development phase a gynecologist and a general surgeon worked closely together with the computer programmer to design exercises appropriate for surgeons and residents who have passed the initial learning curve of laparoscopic surgery and already perform laparoscopic procedures without assistance. This resulted in an "intermediate curriculum" consisting of 5 exercises (Fig. 1, numbers *2* to *6*). Every exercise was designed to train precision, stability, ambidextrous coordination, and cooperation between the left and the right instrument. The exercises, their training goals, and the measured parameters are described in Table 1.

Participants

Surgeons and residents in gynecology, urology, and general surgery from 3 regions in the Netherlands were recruited for voluntary participation (n = 69). Four groups were formed on the basis of laparoscopic experience and status. Group 1 (n = 15) consisted of postgraduate residents years 1 to 3 (PGY 1-3), group 2 (n = 17) of postgraduate residents years 4 to 6 (PGY 4-6), group 3 (n = 19) consisted of consultants, and group 4 (n = 18) of expert laparoscopic surgeons. Consultants and laparoscopic experts were differentiated on the basis of the number of selected "advanced laparoscopic" procedures performed. For gynecologists the selected procedures were laparoscopic hysterectomy, laparoscopic sacrocolpopexy, and laparoscopic lymphadenectomy. For general surgeons the selected procedures were laparoscopic Nissen fundoplication, laparoscopic colectomy, and laparoscopic bariatric procedures. For urologists laparoscopic prostatectomy was selected as an advanced procedure. To be considered an expert the number of performed advanced procedures should be more than 10 for at least 2 of the selected procedures, or more than 50 for one of the selected procedures to be considered an expert. Characteristics of the different groups are shown in Table 2. All participants where asked for their prior experience with laparoscopic skills training. Experience with box trainers (video trainers), VR trainers, and live-animal training was estimated in hours.

Equipment

The Simendo Virtual Reality simulator (Simendo, Rotterdam, The Netherlands) was used. This system consists of a software interface and 2 hardware laparoscopic instruments (Fig. 1, number 1) connected with a USB plug to a laptop computer (Acer Aspire 5924G; Acer America Corporation, San Jose, CA). The laptop contains an Intel Core 2 Duo processor T5550 (1.83 GHz, 667 MHz FSB, 2 MB L2 cache; Intel Corporation, Santa Clara, CA), TurboCache 3 GB DDR2, with graphical card NVIDIA GeForce 8600 GT, 15.4" WXGA Acer Crystalbyte LCD monitor (Acer America Corporation) and software Microsoft Windows XP (Microsoft Corporation, Redmond, WA).

Face Validity

Face validity is defined as the extent to which the simulation (or test) resembles the experience in the real world [22]. To investigate this, participants filled out a questionnaire immediately after performing the 5 exercises on the simulator. The participant's demographics, laparoscopic training experience, and laparoscopic theatre experience were evaluated.