Face, Content, and Construct Validity of a Novel Portable Ergonomic Simulator for Basic Laparoscopic Skills

Dongjuan Xiao, MD,[*] Jack J. Jakimowicz, PhD,[‡§] Armagan Albayrak, PhD,[*] Sonja N. Buzink, PhD,[*] Sanne M.B.I. Botden, PhD,[‖] and Richard H.M. Goossens, PhD,[*†]*

[*]Industrial Design Engineering, Delft University of Technology, Delft, the Netherlands; [†]Department of Neuroscience, Erasmus MC, Rotterdam, the Netherlands; [‡]Department of Surgery, Catharina Hospital Eindhoven, Eindhoven, the Netherlands; [§]Department of Research and Education, Catharina Hospital Eindhoven, Eindhoven, the Netherlands; and [‖]Department of Surgery, Máxima Medical Centre, Veldhoven, the Netherlands

OBJECTIVE: Laparoscopic skills can be improved effectively through laparoscopic simulation. The purpose of this study was to verify the face and content validity of a new portable Ergonomic Laparoscopic Skills simulator (Ergo-Lap simulator) and assess the construct validity of the Ergo-Lap simulator in 4 basic skills tasks.

DESIGN: Four tasks were evaluated: 2 different translocation exercises (a basic bimanual exercise and a challenging single-handed exercise), an exercise involving tissue manipulation under tension, and a needle-handling exercise. Task performance was analyzed according to speed and accuracy. The participants rated the usability and didactic value of each task and the Ergo-Lap simulator along a 5-point Likert scale.

SETTING: Institutional academic medical center with its affiliated general surgery residency.

PARTICIPANTS: Forty-six participants were allotted into 2 groups: a Novice group ($n = 26$, <10 clinical laparoscopic procedures) and an Experienced group ($n = 20$, >50 clinical laparoscopic procedures).

RESULTS: The Experienced group completed all tasks in less time than the Novice group did ($p < 0.001$, Mann-Whitney U test). The Experienced group also completed tasks 1, 2, and 4 with fewer errors than the Novice group did ($p < 0.05$). Of the Novice participants, 96% considered that the present Ergo-Lap simulator could encourage more frequent practice of laparoscopic skills. In addition, 92% would like to purchase this simulator. All of the experienced participants confirmed that the Ergo-Lap simulator was easy to use and useful for practicing basic laparoscopic skills in an ergonomic manner. Most (95%) of these respondents would recommend this simulator to other surgical trainees.

CONCLUSIONS: This Ergo-Lap simulator with multiple tasks was rated as a useful training tool that can distinguish between various levels of laparoscopic expertise. The Ergo-Lap simulator is also an inexpensive alternative, which surgical trainees could use to update their skills in the skills laboratory, at home, or in the office. (J Surg 71:65-72.

KEY WORDS: ergonomic, laparoscopy, simulator, surgical trainee

COMPETENCIES: Medical Knowledge, Practice-Based Learning and Improvement, Interpersonal and Communication Skills

INTRODUCTION

Technique and skills are essential to be able to perform laparoscopic procedures safely and effectively. One practical solution for acquiring these skills involves the use of a laparoscopic simulator.[1] Studies have shown that specialists can improve their clinical performance through dedicated practice of their laparoscopic skills.[2]

Several types of simulators are currently being used for training purposes: traditional box trainers, virtual reality (VR), and augmented reality simulators. These simulators play important roles in surgical education.[3,4] Several useful yet expensive VR and augmented reality simulators (e.g.,

Correspondence: Inquiries to D.J. Xiao, Delft University of Technology, Faculty of Industrial Design Engineering, Landbergstraat 15, 2628 CE Delft, the Netherlands; fax: +31 15-278-7179; e-mail: d.xiao@tudelft.nl

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Surgical Science AB LapSim, Simbionix LAP Mentor, and CAE Healthcare ProMIS) are commercially available, along with training modules ranging from basic skills to complex laparoscopic procedures. With prices ranging from €1560 to €70,000,[5,6] however, these tools are too expensive for many hospitals, particularly in developing countries.

Many medical centers also use inexpensive box trainers for practicing basic and advanced laparoscopic skills, although these tools are somewhat limited in their application. For example, the Karl Storz box trainer with multiple tasks, which has been used in the skills laboratory of Catharina Hospital Eindhoven, requires a special display, cables, or other cumbersome equipment. Various efforts have been devoted to developing portable box simulators that can improve the convenience and efficiency of surgical training. Examples include the portable Fundamentals of Laparoscopic Surgery box trainer developed by the Fundamentals of Laparoscopic Surgery program,[7] the mirrored-box simulator produced by Keyser et al.,[8] and the portable trainer assessed by Hruby et al.[9] Several investigations have focused on homemade simulators involving cards or plastic box trainers.[1,10-12] These portable box trainers provide convenient and effective alternatives with which trainees can practice basic skills at home or in the office.

One major shortcoming of the simulators that are currently available is that they do not support the ergonomic guidelines for laparoscopic surgery, thus failing to offer an ergonomic training setup.[13,14] According to the studies by Hanna et al., the performance of bimanual tasks could be improved by obtaining an optimal manipulation angle of 60° (with equal azimuth angles) and an optimal elevation angle between 30° and 60°.[1,15] Furthermore, according to a study by Emma et al.,[16] intracorporal/extracorporal instrument length ratios below 1.0 cause deterioration in task performance, expand the range of movement at the elbow and shoulder, and increase angular velocity at the shoulder. It is important for trainees to become accustomed to proper ergonomic working conditions, as this can improve task performance and minimize physical discomfort.[14]

Nevertheless, a portable and ergonomic simulator has yet to become available. The authors have developed a new portable Ergonomic Laparoscopic Skills simulator (Ergo-Lap simulator) from a user-centered perspective, following the ergonomic guidelines.[13,16]

Before a surgical simulator can be used to assess surgical skills, its validity must be subjected to rigorous verification.[17,18] This study focuses on 3 basic and valuable forms of validity: construct validity, face validity, and content validity. Construct validity indicates the extent to which the simulator can distinguish between different levels of expertise based on the performance scores. Content validity indicates the extent to which the simulator is able to teach the trainees what it is intended to teach, as evaluated by experts dedicated to the device. Face validity refers to the relative realism of the simulator, as evaluated by nonexperts.[18] This study aims to verify the construct validity of 4 innovative tasks on the Ergo-Lap simulator for training basic laparoscopic skills, in addition to evaluating the face validity and content validity of this new ergonomic portable simulator.

MATERIALS AND METHODS

Ergo-Lap Simulator

In the context of this study, the Ergo-Lap simulator with multiple tasks is used to train basic laparoscopic skills. Its dimensions are similar to those of a folded briefcase (55 cm × 32 cm × 12 cm), and it can be stored in limited space (Fig. 1). The system weighs 3 kg, including the task materials and an integrated handle for easy transportation. The simulator can be linked to a computer, where video

FIGURE 1. Ergo-Lap simulator: The Ergo-Lap simulator ready for use (left); the flexible arrangement of the task panel allows for ergonomic training conditions (upper right); the Ergo-Lap simulator ready for transportation (bottom right).