Construction and Validation of a Low-Cost Laparoscopic Simulator for Surgical Education

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INTRODUCTION: To construct a trainer that would achieve the equivalent goals of the Fundamentals of Laparoscopic Surgery (FLS) trainer at an economical cost. A validation study comparing our homemade (HM) trainer vs the FLS trainer was performed. A literature search as well as a price comparison with other commercially available laparoscopic trainers is presented.

METHODS: The HM laparoscopic trainer was constructed using a prefabricated hard plastic frame with a vinyl plastic sheet affixed as the roof. A row of light-emitting diode lights and a charge-coupled device camera were mounted on the inside roof of the frame. Electrical wires were spliced to supply power to both the light-emitting diode lights and the camera. The charge-coupled device camera was connected to a liquid crystal display screen which was affixed directly across from the user. Subjects were prospectively randomized to perform the 5 tasks put forth by the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills on both the HM trainer and the FLS trainer (pegboard transfer, pattern cut, placement of ligating loop, extracorporeal knot suture, and intracorporeal knot suture). Simple paired t test was performed to compare times between the trainers.

SETTING: The construction of the trainer and the validation study were performed at the Central Michigan University College of Medicine Department of Simulation.

PARTICIPANTS: Subjects consisted of third- and fourth-year medical students (n = 30).

RESULTS: A laparoscopic trainer box was constructed and assembled in 2 hours. The HM trainer cost $309 representing a cost savings of $1371. Results of the validation study demonstrated no statistical difference in times to complete 3 out of the 5 tasks as well as no difference in total time to complete all 5 tasks (p value < 0.05).

CONCLUSION: Valid laparoscopic simulators can be constructed at an economical cost. (J Surg 70:443-450. © 2013 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: surgical education, laparoscopic trainer, Fundamentals of Laparoscopic Surgery, surgical simulation

COMPETENCIES: Systems-Based Practice, Medical Knowledge, Patient Care

INTRODUCTION

The effect of duty hour restrictions, the rapid advancement of surgical technology, and a public concern for patient safety have created the need for surgical training to extend beyond the operating room to involve surgical simulation. Surgical simulation is now a mandatory part of any surgical program. Laparoscopic simulators are an essential component of surgical simulation labs and have documented efficacy in improving the operating room performance of surgical residents.[1]

The Fundamentals of Laparoscopic Surgery (FLS) course is a nationally standardized simulation curriculum module that teaches and assesses basic laparoscopic skills through the use of laparoscopic simulators.[2] Obtaining FLS certification is a prerequisite for the American Board of Surgery certifying examination. The FLS certification process consists of a 2-part proctored examination that evaluates cognitive knowledge and manual skills. The skills portion is based on the performance of 5 basic laparoscopic tasks termed the McGill Inanimate System for Training and Evaluation of Laparoscopic Skills.[19]

The laparoscopic trainer box that has been approved for FLS training is commercially available. But with a listed price of $1680 per trainer, it may be cost prohibitive for

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  1931-7204/$30.00 http://dx.doi.org/10.1016/j.jsurg.2013.02.004

TABLE 1. Breakdown of the Cost of Materials to Build the HM Trainer

Equipment List	Price (US$)	Company/URL
Pop-up trainer (Simulab Corporation)	195.00	Simulab Corporation, 1600 West Armory Way, Seattle, WA 98119; www.simulab.com
Advanced technology miniature CCD camera KPC-VSN500NHB 3.6 mm resolution 550TVL size 25 × 25 mm	79.95	123 Security Products, Inc, 731 Union Parkway Ronkonkoma, NY 11779; www.123securityproducts.com
SMD white LED rigid strip 15 LED	17.50	The LED Light, Inc, 511 Fairview Drive Carson City, NV 89701; www.theledlight.com
Transformer TX-1A with plug	12.60	The LED Light, Inc, 511 Fairview Drive Carson City, NV 89701; www.theledlight.com
Power connector	3.75	RadioShack World Headquarters 300 RadioShack Circle Fort Worth, TX 76102-1964; www.radioshack.com
Dynex LCD 19 in 720 p 60 Hz HDTV DVD combo model: DX-19LD150A11	179.99	Best Buy Corporate Customer Care P.O. Box 9312 Minneapolis, MN 55440; www.bestbuy.com
Total cost of HM trainer with display device	**488.79**	

SMD, surface mount device; HDTV, high-definition television; DVD, digital video disk.

some surgical residency programs and create difficulty in providing surgical residents a required part of their residency education. In this paper, we present a step-by-step guide for the construction of an inexpensive ''home-made'' (HM) laparoscopic simulator that is comparable with the FLS-sponsored trainer, but at a fraction of the cost. To ensure that we had created a simulation environment without a loss of effectiveness in comparison to the FLS trainer, a validation study was conducted involving medical students performing the FLS skills module on our HM trainer and the FLS trainer. A relevant literature review and a cost comparison of the current commercially available laparoscopic trainers are also presented.

MATERIALS AND METHODS

1. Construction of Trainer Box

Construction of our HM laparoscopic trainer is outlined later. It was assembled by staff from the Central Michigan University (CMU) Department of Medical Simulation and CMU facilities department. Basic knowledge of carpentry and electrical circuits was required. Construction time was roughly 2 hours. A cost breakdown of the materials used for construction is presented in Table 1.

A. Materials

1. Simple laparoscopic box trainer (Simulab Corporation, Seattle, WA).
2. Light-emitting diode (LED) lighting strip with 15 diodes (The LED Light, Inc, Carson City, NV).
3. High-resolution, miniature charge-coupled device (CCD) color camera of 25 mm × 25 mm with 3.6 mm pinhole lens, BNC video connector with coaxial video adapter and 12 V power cord (KT&C America, Inc, Hasbrouck Heights).
4. Female 12 V connector (RadioShack, Fort Worth, TX).
5. 12 V power supply (I.T.E. Power Supply, China).
6. Double-sided adhesive strip (3M, St. Paul, MN).

B. Assembly Instructions

1. The laparoscopic box trainer was assembled as per the manufacturer-provided instructions. The box consists of collapsible hard plastic components to form a 6-sided box frame measuring 16-in length × 16-in width × 8.5-in height (ports not included) (Fig. 1A). The sides of the frame were opened to allow for easy exchange of equipment in and out of the box trainer. Support to the trainer was provided by 2 large hollow-ridged spacers. The base and the roof formed a ''tongue and groove joint'' with the spacers (Fig. 1B). The roof of the frame consisted of a preglued opaque vinyl membrane secured to the hollow plastic frame. A 10 mm opening in the roof frame was predrilled with a scope holder attached for optional laparoscope placement.
2. 2 holes were created in the vinyl membrane, with each hole 3 in from the inside edge of the membrane on the nearest mounted camera (Fig. 1C). The 2 holes were at a distance of 6 in from each other. These holes easily accommodated standard 12-mm laparoscopic ports.
3. The LED lighting strip was then mounted on the underside of the roof of the trainer box, approximately 2 in from the *far* edge. The strip was adhered to the frame of the roof with double-sided adhesive strip (Fig. 1D).
4. The adjustable CCD color camera (Fig. 2A and B) was then mounted on the underside of the