An inexpensive solution for laparoscopic simulation

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ABSTRACT
Teaching residents the art of laparoscopy is one of the most important and most difficult tasks of any surgical residency. The disorientation of working in a small enclosed space with a modified field of vision and limited tactile feedback requires repetition and practice to overcome. Many hands-on hours are required to become proficient. Laparoscopic trainers have allowed for training outside of the operative setting, but they are notoriously expensive. Fortunately, with the advent of inexpensive camera technology, a very serviceable laparoscopic trainer can be built with household tools for less than $150 USD. Here we describe how to construct such a device. Although simulation is never truly representative of the surgical experience, it provides a safe environment for residents to hone their laparoscopic skills. The construction and use of low-cost laparoscopic training boxes such as ours allows surgical residents to gain valuable laparoscopic skills at minimal expense.

BACKGROUND
Since its introduction to the field of general surgery in the 1980’s, laparoscopic surgery has been integrated into virtually every type and subspecialty of surgery, from General Surgery to Urology to Cardiothoracic Surgery. Rarely has a technology been more quickly adapted for widespread use than laparoscopy. However, like open surgery, laparoscopy is fundamentally defined by its operator. There is a sharp learning curve, which separates cluminess from proficiency. Overcoming this hurdle safely is the goal of simulation. Repetitive skill exercises using a laparoscopic trainer have been shown to improve a surgeon’s skill level [1,2]. Surgical residents have found trainers invaluable in honing their skills and in practicing new techniques before being allowed to try them in the operative setting.

Unfortunately, laparoscopic simulators are notoriously expensive, and may be out of reach of some surgical training programs (figure 1). Because of this limitation, new and creative methods must be developed to allow residents to obtain further laparoscopic training outside of the operative setting. We have constructed a simple, inexpensive, but effective laparoscopy simulator which can meet the educational needs of surgical residents.

METHODS
Five key components were identified as essential for the construction of a laparoscopic trainer: an enclosure, a camera, a viewing screen, a light source, and instrumentation.

Enclosure: The enclosure needs to be large enough to provide adequate training space and yet light enough to be portable. Synthetic plywood was purchased to meet these criteria with panels cut in dimensions of 16”x12” and 16”x18”. Thin white foam inserts were used to line the interior walls of the box to reflect the overhead light source and to provide a place to mount practice exercise devices.

Light Source: Because of the enclosed nature of a simulator, its light source must be bright enough to fully illuminate the entire training space. A handheld florescent light was considered ideal for this purpose due to its brightness, clean white light and long bulb life.

Camera: Advances in technology and the popularity of Internet communication have allowed small webcams to become accessible to the average consumer. In order to provide a reasonable level of detail and clarity, we recommend a webcam of at least 1.3 megapixels resolution. Also, a webcam with motion-tracking ability is useful operator does not have to adjust the camera. Auto-focus and zoom were also considered as desirable traits for our webcam.

Viewer: Although any monitor with a VGA connection will suffice, we used our personal laptops as viewers because of their portability and built-in USB & VGA interfaces. A dedicated laptop need not be attached to the trainer. Each trainee may use their own computer on the same trainer.

Instrumentation: Certain minimal instrumentation is necessary: graspers, a dissector, a self retaining suture system, and endoscopic ligating loop, an extracorporeal suture device, and scissors were identified as essential equipment. Small graspable items such as pegs were obtained to be used in passing exercises. Expired or discarded equipment was obtained at no cost from our surgery department, and a manufacturer provided us with samples of other equipment.

<table>
<thead>
<tr>
<th>Simulator</th>
<th>Cost (USD)</th>
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<tbody>
<tr>
<td>Simulab Corp® LapTrainer with SimuVision™</td>
<td>$1,795.00</td>
</tr>
<tr>
<td>Simulation® Laparoscopic Trainer TRLCD05-240</td>
<td>$2,045.00</td>
</tr>
<tr>
<td>Mentice® Procedicus MIST™</td>
<td>$36,000.00+</td>
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Figure 1. Price comparison of several commercially available laparoscopic simulators.
A list of items needed for the project includes: (a) Two plywood sheets 16x12; (b) Four plywood sheets 16x18; (c) Nails; (d) Two metal hinges; (e) Electric drill; (f) Microsoft® LifeCam X6000 or similar webcam; (g) Foam board; (h) Small Battery operated fluorescent light; (i) Double sided tape; and (j) Personal laptop.

**Building Instructions**

1. Begin by nailing your sheets of plywood to a 16x12x18 frame in order to construct a rudimentary rectangular box.
2. Add a lid by nailing hinges to one side of your box.
3. Drill 3 separate one-centimeter holes in your box; one will be for your USB port and two more for your trochar ports (Figure 2).
4. Line the inside of your box with foam board (Figure 3).
5. Using double-sided tape, mount a small battery operated fluorescent light to the superior aspect of your box’s frame to illuminate the box interior.
6. Mount your webcam so that it faces the working area with a clear view of your instruments and an unobstructed range of motion (Figure 4).
7. Attach the USB connection of the webcam to your laptop and begin using your new simulator to perform passing, tying, and suturing exercises.

**DISCUSSION**

Despite their many advantages, laparoscopic trainers do have their drawbacks. Foremost and most obvious is the fact that no trainer can completely simulate the experience of operating on living tissue. The environment inside a simulator is idealized and completely controlled. In actual practice, the patient moves with respiration, tissues bleeds, and visualization may become limited. No amount of simulated practice will ever fully prepare a surgeon for the myriad of unique and varied situations he/she will encounter in the scope of practice. Our device, like all trainers, cannot accurately re-create environments similar to those that will be encountered in the operating room.

But the goal of our laparoscopic trainer, and lap trainers in general, is not necessarily to simulate an operation, but to learn the visual-motor skills necessary to perform basic laparoscopic tasks. Using a trainer helps overcome some of the fundamental difficulties of laparoscopy: the disorientation of working in a small enclosed space with a modified field of vision and limited tactile feedback [1]. Just as beginning residents practice ties and suturing outside of the operating room to become proficient at these fundamental skills, intracorporeal knot tying and suturing may be practiced in a laparoscopic trainer before being tried in the operating room. The particular hand–eye coordination and depth perception unique to laparoscopy requires specific and directed training [3]. Surgical trainees have a finite number of opportunities to learn laparoscopic skills in the operating room, but they can practice basic technique with a trainer as much as time allows.
CONCLUSIONS

Although simulation is never truly representative of the surgical experience, it provides a safe environment for residents to hone their laparoscopic skills. After learning basic skills during practice exercises, beginning surgeons can apply these lessons in the operating room, where patient outcome is dependant upon operator technique. The construction and use of low-cost laparoscopic training boxes such as ours allows surgical residents to gain valuable laparoscopic skills at minimal expense.

REFERENCES


