

Smartphone/Tablet-based Laparoscopy Simulation System: A Low-cost Training Module for Beginners in Minimally Invasive Surgery

Ashish Saxena

ABSTRACT

Laparoscopic surgery is a well-established domain of surgery and it has become essential for surgical practitioners to be well versed in the technique. It has a steep learning curve which exists because of a number of additional skills required for a successful transition from open surgery to minimally invasive procedures. Hence, it is desirable that a trainee should practice laparoscopy upon simulation devices before attempting an actual procedure on a patient. Two types of simulators are currently available in the market: box type and virtual reality type. The major limitation in their use is the cost factor involved. These simulators are relatively expensive, which the trainees in developing countries can ill afford. My efforts were directed at developing a low-cost simulator that is easy to assemble, requires minimal investment, and helps in improving depth perception and ambidexterity at the same time. I devised a simulation system based on smartphone/tablet. These gadgets (smartphone/tablet) are easily available everywhere at a reasonable cost. In the apparatus devised by me, the rear camera of a smartphone works as a laparoscopic camera and its screen works as the monitor. Light-emitting diode flash of the device functions as the light source. The smartphone has to be attached to a specially designed box fitted with accessories to perform various tasks. The practice sessions can be recorded and used for monitoring and evaluation by experts. A satisfactory level of elementary laparoscopy training can be imparted at a lower cost using smartphone-based simulation system.

Keywords: Box-type trainer, Depth perception, Laparoscopy training, Simulation system, Smartphone, Virtual reality trainer.

How to cite this article: Saxena A. Smartphone/Tablet-based Laparoscopy Simulation System: A Low-cost Training Module for Beginners in Minimally Invasive Surgery. *World J Lap Surg* 2016;9(1):26-29.

Source of support: Nil

Conflict of interest: None

Senior Resident

Department of General Surgery, North Delhi Municipal Corporation Medical College & Hindu Rao Hospital, New Delhi, India

Corresponding Author: Ashish Saxena, Senior Resident Department of General Surgery, North Delhi Municipal Corporation Medical College & Hindu Rao Hospital, New Delhi, India, Phone: +919654249322, e-mail: docashish4u@gmail.com

INTRODUCTION

Laparoscopic surgery is a well-established domain of surgery. It has largely become the standard approach and has gradually surpassed open surgery for most of the abdominal conditions.¹ Therefore, expertise in the laparoscopy technique has become indispensable for the optimum career growth of practicing surgeons and surgical trainees alike.

A steep learning curve exists for beginners in laparoscopy.² This learning curve is attributed to various newer skills required for a minimally invasive procedure. These skills include depth perception, adjustment to fulcrum effect, hand-eye coordination, bimanual manipulation, handling of laparoscopic instruments, and ambidexterity.³ Normally, the human eye is adapted to three-dimensional (3D) vision, that is, it can appreciate the depth or distance of an object, along with its length and width. But during laparoscopy, the monitor provides only a two-dimensional (2D) visual field. The perception of depth or distance is lost. It results in severe impairment in hand-eye coordination, which in turn leads to the difficulty in instrument handling and may also lead to inadvertent visceral organ damage.

With repetitive exposure to the laparoscopic procedures, the surgeon's eyes get acclimatized to 2D vision, and gradually attain the dexterity required to handle the instruments smoothly and perform a procedure safely. However, it is preferable that the above-mentioned skills are acquired outside the operation theater on simulation devices.

Studies have shown that experience gained upon simulators results in an increase in operator comfort and patient safety and also reduction in healthcare expenditure.⁴ It has also been demonstrated that surgeons who regularly play video games learn laparoscopic skills faster than their nongamer colleagues.⁵ Therefore, it is obvious that the importance of simulator-based training cannot be overemphasized.

AIM

Training in laparoscopy is traditionally imparted with box-type trainer or with virtual reality trainer. Both of these have been proven to be effective tools for

laparoscopic training.³ However, their utility is severely impaired by exuberant prices. Virtual reality trainers, in particular, by the virtue of their high original cost and maintenance expenditure are beyond the reach of a surgical trainee in developing nations.⁶ Box-type trainers, while being relatively cheaper than virtual reality one, still require a conventional laparoscopic camera or webcam and a monitor, contributing significantly to the financial burden.

My efforts were directed at developing a low-cost simulator that is easy to assemble, requires minimal investment, and effectively imparts laparoscopic skills to the trainee. Smartphone-based laparoscopy simulation system uses the camera of the smartphone as laparoscopic camera, its light-emitting diode (LED) flash as light source, and screen as the monitor, thereby reducing the cost of the apparatus considerably. The apparatus was intended to instill the essential laparoscopy skills, such as depth perception, adjust to fulcrum effect, hand-eye coordination, bimanual manipulation, and ambidexterity in the trainees' psyche.

MATERIALS AND METHODS

A plastic box with dimensions of $26 \times 20 \times 12$ cm was taken and modified into a laparoscopy simulation box (Fig. 1). Its lid was fixed in partially open position to provide an inlet for instruments as well as for visualization through the smartphone camera (Fig. 2). The floor of the box was covered with cardboard and two pillars were installed near the rear wall of the box to act as landmarks for maneuvering of objects. A slot was created in the front wall of the box to keep the smartphone in optimum position. This optimum position was determined by visualizing the interior of the box with the camera of smartphone running in video mode. Two rubber disks with a central aperture were fixed in the front wall of the box to work as the entry

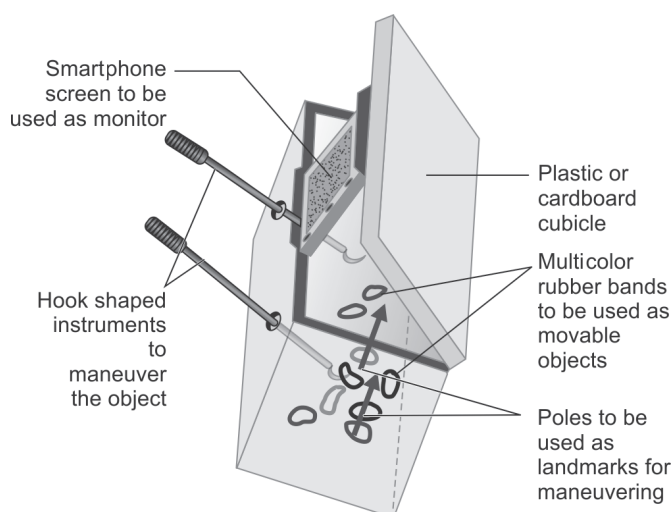


Fig. 1: Schematic diagram of the apparatus

ports. The hook-shaped instruments were contrived by using common household objects. Multicolored rubber bands were put in the box to be used as movable objects to be manipulated by the instruments.

Practice session began by keeping the smartphone camera in video mode with LED flash on, so that the interior of the box was clearly visible in the screen of smartphone (Fig. 3). Two hooks were now used to transfer the rubber bands between themselves and to maneuver them over the pillars. These sessions were duly recorded and later on evaluated to appreciate the efficiency gained in laparoscopy skills (Fig. 4).

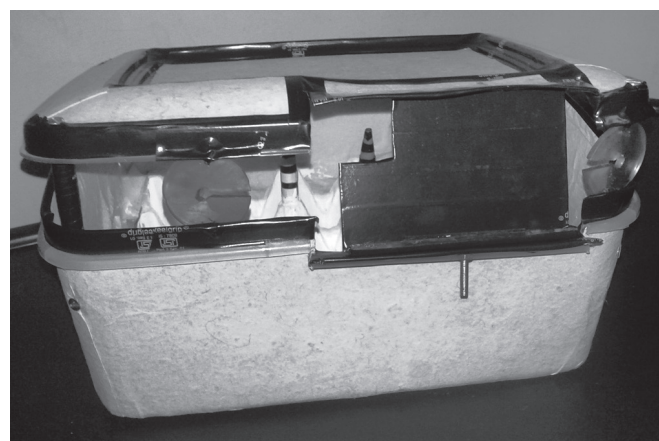


Fig. 2: Prototype of the apparatus

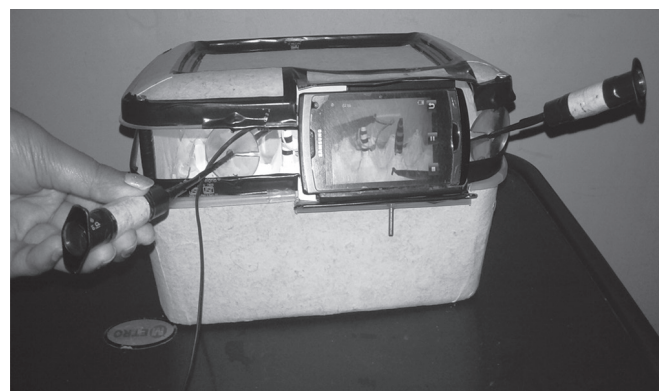


Fig. 3: Apparatus while in use



Fig. 4: Interior of the apparatus as seen on smartphone screen

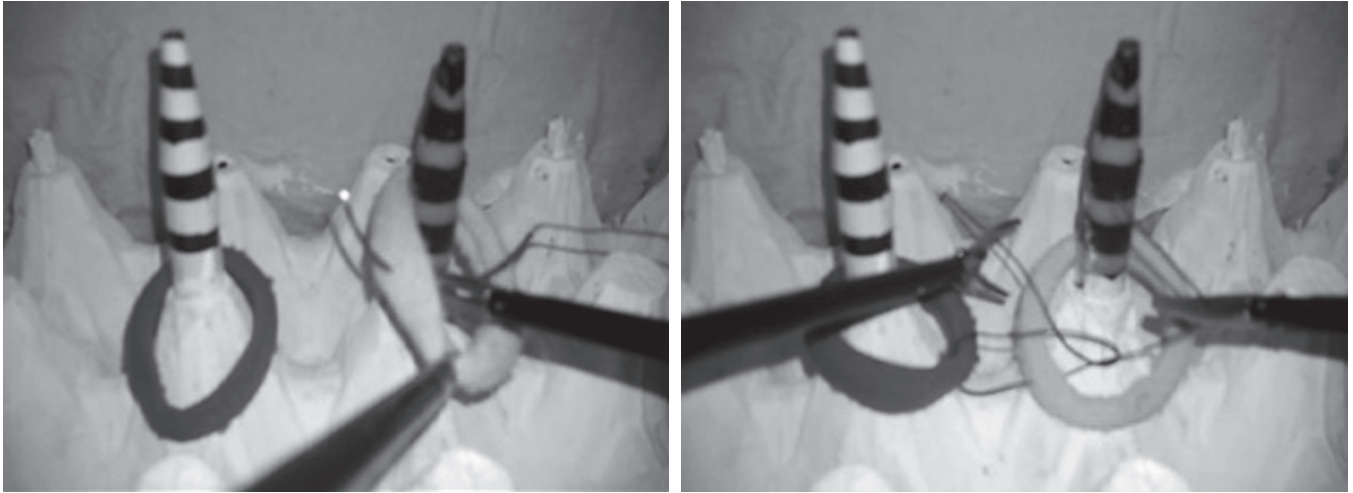


Fig. 5: Images depicting the laparoscopic suturing practice

With further improvisation, newer exercises with increasing complexity can be designed and installed in the simulator box to raise the level of challenge for trainees. With actual laparoscopic instruments, such as needle holder and Maryland forceps, trainees can also refine their suturing skills (Fig. 5).

DISCUSSION

Simulation is the imitation or modeling of a real-life situation for training or instruction.⁶ It is an important tool for the training of novices. It works largely by way of a reduction in learning curve.³ One industry that has largely benefited from the use of simulation technology is aviation industry, where pilots have long been trained to tackle real life-like scenarios before entering into the cockpit.⁷ Surgical endeavors are not much different from the aviation industry as both the fields demand high levels of technical skill and allow small margins for error.³

The need for a simulation-based training program arose when surgeons found that their skills in open surgery did not transfer to the newer domain of laparoscopy.⁸ Principles of laparoscopic surgery became the subject of extensive research. Gallagher et al⁹ identified a set of special skills that were deemed essential to perform a laparoscopic procedure: (i) depth perception: the ability to perform 3D maneuvers with a 2D view; (ii) adjustment to fulcrum effect: to resolve the conflict between visual and proprioceptive feedback; (iii) hand-eye coordination; (iv) bimanual manipulation; (v) handling of laparoscopic instruments; and (vi) ambidexterity: The ability to use both left and right hands with equal ease.

Minimally, invasive surgery had already been ushered into the era of simulation-based training by Markman,¹⁰ when he introduced endoscopic simulation system for proctosigmoidoscopy in 1969. Gradually, various simulators, such as mechanical simulators, live animal

models, and computerized or virtual reality devices were launched in the market. While detailed description of these modalities is beyond the scope of this article, it is obvious that all of them require separate telescope, light source, and monitor.

Further studies recognized that complicated functioning of operative tools degrades a surgeon's performance, and extensive training is necessary to gain expertise in handling a tool, thus validating the need of simulator-based learning.^{11,12}

While simulator training is suggested to be useful for acquiring psychomotor skills, these skills do not transfer to the operation theater immediately. An actual surgical experience under good supervision is necessary to increase the effectiveness of training.¹³

Considering the cost of commercially available simulators, a number of low-cost alternatives have been developed using mirrors, digital camera, web camera, spy camera, etc., the cost of which varies from 43 to \$116.¹⁴

At an approximate cost of \$3–4, smartphone-based simulation system devised by me is most economical when compared to other low-cost simulators. The whole apparatus is constructed of nonexpensive material, such as plastic box, ballpoint pens, rubber bands, etc., which are easily obtainable. The practice materials do not get consumed during sessions and need not be refurbished. It is simple in its design, durable, and easy to assemble. The maintenance cost is virtually zero.

The smartphone is fixed in its slot while practicing upon the apparatus, thus obviating the need of a camera-holding assistant. One can practice for long duration without being dependant on anybody else. The smartphone slot can be rotated around a vertical axis to focus upon different parts of the visual field. Interior of the box is coated with white color to maximize the illumination obtained from LED flash of smartphone.

It can effectively impart training in most of the elementary laparoscopic skills, such as depth perception, adjustment with fulcrum effect, hand–eye coordination, bimanual manipulation, and ambidexterity. Trainees can also practice handling of laparoscopic instruments if they have access to them. Adaptability of the apparatus with the conventional laparoscopy instruments is another salient feature that makes it useful for training of more complex maneuvers such as intracorporeal suturing and knot tying.

The practice sessions are by default recorded in video format, and can therefore be subjected to critical analysis by the experts. Recent studies have demonstrated that feedback provided by these experts can go a long way in improving the laparoscopic skills of trainees.¹⁵

CONCLUSION

A simulator-based system is a widely recognized method to train novices in minimally invasive surgical skills. They are proved to be beneficial for instructor, trainee, and patient alike. However, their utility is severely compromised because of high cost, which is beyond the means of beginners in the discipline. The smartphone/tablet-based laparoscopy simulation system is a cheaper and easy-to-assemble version of existing simulators. One can easily construct an apparatus at home and practice all the basic laparoscopic skills at negligible expenditure using his or her smartphone device. However, regular monitoring and instruction by experts is essential to acquire and sustain skills that are transferable to the operation theater.

REFERENCES

- Larsen CR, Oestergaard J, Ottesen BS, Soerensen JL. The efficacy of virtual reality simulation training in laparoscopy: a systematic review of randomized trials. *Acta Obstet Gynecol Scand* 2012 Sep;91(9):1015-1028.
- Borahay MA, Jackson M, Tapisiz OL, Lyons E, Patel PR, Nassar R, Kılıç GS. Assessment of minimally invasive surgical skills of pre-medical students: what can we learn from future learners? *J Turk Ger Gynecol Assoc* 2014 Jun;15(2):69-73.
- Sharma PV, Knowles J, Patel B. Acquisition of fundamental laparoscopic skills: is a box really as good as a virtual reality trainer? *Int J Surg* 2011;9(8):659-661.
- Grantcharov T, Kristiansen VB, Bendix J, Bardram L, Rosenberg J, Funch-Jensen P. Randomized clinical trial of virtual reality simulation for laparoscopic skills training. *Br J Surg* 2004 Feb;91(2):146-150.
- Lynch J, Aughwane P, Hammond TM. Video games and surgical ability: a literature review. *J Surg Educ* 2010 May-Jun;67(3):184-189.
- ASGE Technology Committee. Endoscopic simulators. *Gastrointest Endosc* 2011;73(5):861-867.
- Garibay AM, Young JP. Reducing general aviation accidents by utilizing airline operational strategies. *Aviation Technology Graduate Students Publications; MSc Thesis, Purdue University, April 12, 2013: 1-21.*
- Driscoll PJ, Paisley AM, Paterson-Brown S. Video assessment of basic surgical trainees' operative skills. *Am J Surg* 2008 Aug;196(2):265-272.
- Gallagher AG, Richie K, McClure N, McGuigan J. Objective psychomotor skills assessment of experienced, junior, and novice laparoscopists with virtual reality. *World J Surg* 2001 Nov;25(11):1478-1483.
- Markman HD. A new system for teaching proctosigmoidoscopic morphology. *Am J Gastroenterol* 1969 Jul;52(1):65-69.
- Buckley CE, Kavanagh DO, Traynor O, Neary PC. Is the skillset obtained in surgical simulation transferable to the operating theatre? *Am J Surg* 2014 Jan;207(1):146-157.
- Zheng B, Fu B, Al-Tayeb TA, Hao YF, Qayumi AK. Mastering instruments before operating on a patient: the role of simulation training in tool use skills. *Surg Innov*. 2014 Dec;21(6):637-642.
- Kimura T, Kawabe A, Suzuki K, Wada H. Usefulness of a virtual reality simulator or training box for endoscopic surgery training. *Surg Endosc* 2006 Apr;20(4):656-659.
- Walczak DA, Piotrowski P, Jędrzejczyk A, Pawełczak D, Pasięka Z. A laparoscopic simulator—maybe it is worth making it yourself. *Wideochir Inne Tech Maloinwazyjne* 2014 Sep;9(3):380-386.
- Paschold M, Huber T, Zeißig SR, Lang H, Kneist W. Tailored instructor feedback leads to more effective virtual-reality laparoscopic training. *Surg Endosc* 2014 Mar;28(3):967-973.