Laparoscopic Simulators : Are They Useful!

Col PVR Mohan*, Brig R Chaudhry, vsm⁺

Abstract

Background: Laparoscopic surgery has changed the face of medical care forever . The benefits of laparoscopic open surgery have been demonstrated in virtually all major abdominal surgical procedures. Laparoscopy has introduced a new skill set that must be mastered and requires dedicated training. The teaching of laparoscopic operative skills in the clinical setting is constrained by the complexity of procedures, medicolegal and ethical concerns, fiscal and time limitations. This has created the need for formal training outside the operating room. Simulator-based training holds great promise in enhancing surgical education and providing a safe, cost-effective means for practicing techniques prior to their use in the operating room.

Methods: The surgical residents of two batches were recruited for the study. The residents were randomized to either a group that received training on a simulator or a controlled group that did not receive the training or to a group that received training twice. **Result:** The residents who received training on a simulator demonstrated better psychomotor skills in the operation theatre than those who did not. Training in simulator environment can contribute to the development of technical skills relevant to the performance of laparoscopic surgery in vivo. Training at regular intervals will benefit the residents in gaining significant improvement of their psychomotor skills.

Conclusion: Laparoscopic trainer is a promising tool for training in laparoscopic surgery.

MJAFI 2009; 65 : 113-117

Key Words: Laparoscopic simulator; Endotrainer; Training; Laparoscopic surgery

Introduction

The first resident system of training surgeons started in USA in 1889 by Halstead, the structure of which has not changed appreciably. However, the “advances in technology” have changed the face of medical care. One such change is laparoscopic surgery, the benefits of which have been demonstrated in all major abdominal surgical procedures. The benefits include decreased postoperative pain and narcotic use, decreased length of postoperative ileus, decreased hospital length of stay, improved cosmesis and high patient satisfaction. This surgical breakthrough now represents the “standard of care” [1]. Laparoscopy has introduced a new skill set that must be mastered and requires training. The main constraints in laparoscopic surgery are loss of depth perception and haptic feedback [2], the fulcrum effect, and the use of instruments with limited range of motion [3] which make laparoscopic tasks difficult. Lack of appropriate training can lead to adverse patient outcomes [4]. The teaching of operative skills in the clinical setting is constrained by the complexity of procedures, medicolegal and ethical concerns, fiscal and time limitations, and has created the need for formal training outside the operating room [5-7].

Material and Methods

The study aimed at examining the impact of simulator training on improvement of psychomotor skills relevant to the performance of laparoscopic cholecystectomy. Twenty four surgical residents (twelve in each group) were enrolled for the study. These residents had no prior exposure to laparoscopic surgery. These residents after gaining sufficient theoretical knowledge and familiarity with the operative procedure were then randomized to either a group that received training on a simulator or a controlled group that did not receive such training. The trained batch was given enhanced training for another three months after a gap of three months. Simulator training included ten repetitions of twelve tasks on the minimally invasive surgical trainer, the Ethicon endosurgery laparoscopic kit. The tasks were of progressive complexity and were designed to simulate the techniques used during the laparoscopic cholecystectomy. These drills involved movement and coordination exercises using peg boards or small objects such as beans and sugar cubes. Suturing skills are practiced using standard sutures and needles through plastic drains and other simulated tissue.

Results

Two types of assessments were carried out on these three groups: Control group, once trained group, twice trained group.

1. Assessment in the operation theatre while performing

* Associate Professor (Department of Surgery); Armed Forces Medical College, Pune. *Dy DGAfMS (Plg), O/o DGAfMS, 'M' Block, Ministry of Defence, New Delhi.

laparoscopic cholecystectomy

2. Assessment on laparoscopic trainer

For the laparoscopic cholecystectomy assessment all the participants and the controlled group were allowed to perform laparoscopic cholecystectomy supervised by the respective unit chief. The operative performance assessment was performed by using the predefined rating scale originally developed and validated by Reznick et al [8] (Appendix A). In this rating system, higher the score, lesser is the efficiency. The scores obtained by three groups in the laparoscopic cholecystectomy were compared. The residents who received training twice performed significantly better. There was a clear demarcation in the scores noted between the residents trained twice, once and control groups. This was proved by a statistical analysis (Table 1). Statistical significance was set

at a level of $p=0.01$ (asymptomatic significance 0.000). The SPSS v14.0 (SPSS, Inc, Chicago, IL) was used for analyses.

For the laparoscopic trainer assessment all subjects were given brief instructions in the use of surgical instruments. No prompting or guidance was given to any candidate during the assessment. They performed three tasks:

Task 1 - to place a cube from one dish on to another box by grasping with instruments in both the hands.

Task 2 - to grasp alternative segments of a long pipe from the beginning to the end as if they were following a segment of intestine in diagnostic laparoscopy.

Task 3 - to cut a thread at different locations.

Each task was performed ten times. Each subject's performance was independently rated by the observer for each of the three tasks. The assessment parameter was- time taken to completion. Then residents with best scores in placing the cubes task were assessed for the learning curve patterns by analyzing the number of attempts taken to reach minimum time for the task. The analysis of time score of all the three tasks of assessment (Time for grasping and placing the cubes, Time for running the bowel, Time for cutting the thread task) showed that the twice trained group shows significantly better score than the other groups in all the three tasks (Tables 2,3). The scores of once trained group was close to the twice trained group. The difference between the trained and untrained group was significant.

Appendix A

ECONOMY OF MOVEMENTS

a. Unnecessary movements

Clear economy & Maximum efficiency	1
Some unnecessary movements	3
Many unnecessary movements	5

b. Confidence of movements

Fluent movements with instruments and no awkwardness	1
Competent use of instruments but occasional stiff or awkward	3
Repeated tentative awkward or inappropriate moves with instruments	5

ERRORS

c. Respect for tissue

Consistently handling tissue appropriately with minimal damage	1
Handled tissue carefully but occasionally caused inadvertent damage	3
Frequently used unnecessary force on tissue or caused damage by inappropriate use of instruments	5

d. Precision of operative technique

Fluent secure & correct technique in all stages of the operative procedure	1
Careful technique with occasional errors	3
Imprecise, wrong technique in approaching operative intentions	5

TOTAL

Discussion

The training of laparoscopic surgeons is a subject of extensive debate. The reports of serious complications occurring in the initial stages have highlighted the importance of adequate training and evaluation before attempting surgical procedures on patients [9]. Clinical experience has shown that there is a significant learning curve for each surgeon and for each new laparoscopic procedure [10]. This learning phase includes 10 to 30 patients and results in longer operating room time, higher complication rates and higher conversion rates to open laparotomy [11], all contributing to higher costs. It led to

Table 1

Analysis of laparoscopic cholecystectomy assessment

Activity	Group	Mean	Standard deviation	Mean rank	Chi- Square	df	Asymp. Significance
Unnecessary movements	CG	4.67	0.778	2.75	17.756	2	0.000
	OT	3.33	1.115	2.08			
	TT	1.63	0.985	1.17			
Confidence of movements	CG	4.67	0.778	2.79	18.143	2	0.000
	OT	3.33	0.778	2.04			
	TT	1.83	1.030	1.17			
Respect for tissues	CG	4.67	1.030	2.79	19.000	2	0.000
	OT	2.67	1.155	2.00			
	TT	1.17	0.577	1.21			
Precision of operative technique	CG	4.67	0.778	2.92	20.600	2	0.000
	OT	2.83	1.030	1.83			
	TT	1.67	0.985	1.25			

CG: Control group; OT : Once trained; TT : Twice trained

Table 2**Analysis of time taken for cutting the thread task**

Group	n	Mean	Standard Deviation	Minimum	Maximum	Mean rank
Control	12	105	8.676	92	119	3.00
Once trained	12	67.50	4.758	60	76	1.83
Twice trained	12	60.00	6.509	51	70	1.17

Test statistics* : n - 12, Chi square - 20.667, df - 2, Asymp sig - 0.000,

*Friedman Test, df- degree of freedom

Table 3**Analysis of time taken for placing the cubes task**

Group	n	Mean	Standard Deviation	Min	Max	Mean rank
Control	12	130	8.965	117	149	3.00
Once trained	12	102	9.964	90	122	2.00
Twice trained	12	91	9.872	79	111	1.00

Test statistics* : n - 12, Chi square - 20.667, df - 2, Asymp sig - 0.000

*Friedman Test, df- degree of freedom

the thinking that for surgeons and surgical residents laparoscopic training with a laparoscopic simulator would be more efficient than training on patients and may replace some of the learning curve typical of new laparoscopic procedures [12]. The currently available trainers are of four types [13].

The box trainer is a type of surgical simulator that uses real surgical instruments and equipment including video monitors, cameras, and laparoscopes. It is an opaque box that approximates the size of the adult human abdominal cavity. Slits are prefabricated on the anterior surface of the box, through which trocars (access ports) may be placed. Practicing skills and tasks in the box trainer that resemble parts of real operations has been shown to stimulate the learning of psychomotor skills. The physical sensory feedback conferred via the instruments in a box trainer is equivalent to that of surgery. The sensory feedback and low acquisition cost makes box trainer simulator the most widely available training system.

Animal models simulators involve the use of a live, anesthetized animal. This is the most realistic, non-patient environment for laparoscopic training. Ethical issues regarding the use of animals for training and studies are not to be discounted and for most programs the cost issues are prohibitive.

Virtual reality (VR) surgical simulators are the latest and most promising development in the area of surgical simulation. Many of these simulators provide a more believable practice environment. Virtual reality system is an advanced and effective training method by some, however it is yet to be adopted in India due to its cost and the technology required [14].

Full procedural simulators go beyond the basic laparoscopic training and are designed to recreate the

specific anatomy allowing the practice of all skills necessary to perform a particular operation.

There is difference of opinion as to which is the ideal trainer. Published evidence is limited and previous studies have shown conflicting results. Some studies have shown no improvement in skills after training in a simulator [15], while others concluded that trainees could learn advanced technical skills by using simulation exclusively and the training results in durable improvement in operative skills [16-19]. Though these simulators allow repeated practice of realistically complicated maneuvers- the question that is often raised, by both surgeons and the public is whether these training sessions are effective in actually improving one's skills enough to become proficient at performing laparoscopic surgery [20,21]. In the present study we assessed the skills demonstrated during the performance of a part of laparoscopic cholecystectomy. This part of the procedure is considered as standard and independent of patient variation, thus providing a setting of similar difficulty to all the residents undergoing the assessment. There was significant agreement in the performance score provided by the all four unit chiefs indicating that the assessment method was reliable and valid. The results showed improved operative performance in laparoscopic environment by subjects who received prior laparoscopic simulator training and that the experience gained on the laparoscopic simulator does translate into a better performance in the operation theatre. Our data also suggests that in the initial learning stages, the use of laparoscopic simulator shows differentiation between levels of expertise for almost all skills. The present study also compared the learning curves of surgical residents with three experience levels who performed three simulator tasks. We found significant differences in the

Table 4**Statistical analysis of time taken for running the bowel task in laparoscopic simulator assessment**

Group	n	Mean	Standard Deviation	Minimum	Maximum	Mean rank
Control	12	226	9.695	210	242	3.00
Once trained	12	158	14.715	134	182	1.83
Twice trained	12	139	16.130	115	163	1.63

Test statistics* : n - 12, Chi square - 24.000, df - 2, Asymp sig - 0.000

*Friedman Test, df- degree of freedom

Table 5**Learning curve patterns for the three groups of residents in the grasping and placing the cubes task**

Attempt No.	1	2	3	4	5	6	7	8	9	10	Total time [sec]	Avg time [sec]
Control group	14	16	15	14	12	13	12	11	10	11	128	12.8
Once trained	12	11	12	10	11	10	9	9	8	8	100	10
Twice trained	12	11	9	8	8	9	8	8	8	8	89	8.9

familiarization curves on the simulator among the three groups. After the second simulator training the residents had a rapid learning curve regarding the time and made no significant improvements in their error and economy of motion scores. This absence of initial familiarization rate indicates the relevance of performance parameters measured by the simulator. The residents with one training session made quick improvements in their performance scores, while the residents who did not receive any training required more time and repetitions in order to reach the maximum efficiency. In the learning curve pattern analysis (Table 5), significant difference in the performance scores between the three groups was obvious in the beginning (attempt 1) but not at the end (attempt 10) indicating that the basic manual skills for the performance of laparoscopic surgery can be acquired after the 10 repetitions of each task. This finding is of importance for developing training programmes in minimally invasive surgery for residents.

We feel that laparoscopic trainer is a promising tool for training in laparoscopic surgery. There is evidence that simulator helps in the development of surgical training programmes for both residents and for the surgeons who have learned the basic laparoscopic skills [22,23]. Further studies may validate usefulness of simulator training as an integrated training programme in minimal invasive surgery for the residents.

Conflicts of Interest

This study has been funded by the research grants from the Office of DGAFMS.

Intellectual Contribution of Authors

Study Concept : Col PVR Mohan, Brig R Chaudhry, VSM

Drafting & Manuscript Revision : Col PVR Mohan

Study Supervision : Brig R Chaudhry, VSM

References

1. Robert CG, Martin II, Farid J Kehdy, Jeff W Allen. Formal training in advanced surgical technologies enhances the surgical residency. *The Am J Surgery* 2005; 190: 244–8.
2. Jones DB, Brewer JD, Soper NJ. The influence of three dimensional video systems on laparoscopic task performance. *Surg Laparosc Endosc* 1996; 6:191-2.
3. Gallagher AG, McClure N, McGuigan J, Ritchie K, Sheehy NP. An ergonomic analysis of the fulcrum effect in the acquisition of endoscopic skills. *Endoscopy* 1998; 30:617-2.
4. The Southern Surgeons Club. A prospective analysis of 1518 laparoscopic cholecystectomies. *N Engl J Med* 1991; 324: 1073-8.
5. Hamdorf JM, Hall JC. Acquiring surgical skills. *Br J Surg* 2000; 87:28-37.
6. Bridges M, Diamond DL. The financial impact of teaching surgical residents in the operating room. *Am J Surg* 1999; 177: 28-32.
7. Scott DJ, Valentine RJ, Bergen PC. Evaluating surgical competency with the American Board of Surgery In- Training Examination, skill testing and intraoperative assessment. *Surgery* 2000; 128:613-22.
8. Renznick, Regehr G, MacRae H, et al. Testing technical skills via an innovative 'bench station' examination. *Am J Surg* 1997; 173: 226-30.
9. Grantcharov TP, Kristiansen VB, Bendix J, et al. Randomized clinical trial of virtual reality simulation for laparoscopic skills training. *Br J Surgery* 2004; 91: 146-50.
10. Watson DI, Baigrie RJ, Jamieson GG. A learning curve for lap fundoplication definable, avoidable, is a waste of time? *Ann Surgery* 1996; 224: 98-203.
11. Mac Fadyen BV, Vecchio R, Recardo, Mathis CR. Bile duct injury after laparoscopic cholecystectomy. The US experience. *Surg Endosc* 1998;12:315-21.
12. Teodor P, Grantcharov, Linda Bardram . Learning curves and impact of previous operative experience on performance on a virtual reality simulator to test laparoscopic surgical skills. *Am J of Surgery* 2003; 185: 146-9.

13. Kurt E Roberts, Robert L Bell, Andrew J Duffy. Evolution of surgical skills training. *World J Gastroenterol* 2006; 12 : 3219-24.
14. Fried GM, Feldman LS, Vassiliou MC, Fraser SA, Stanbridge D, Ghitulescu G. Proving value of simulation in laparoscopic surgery. *Ann Surg* 2004; 240:518-28.
15. Ahlberg G, Heikkinen T, Iselius, et al. Does training in VR simulator improve surgical performance. *Surg Endosc* 2002; 16: 126-9.
16. Van Sickle KR, Ritter EM, Smith CD. The pre trained novice: using simulation-based training to improve learning in the operating room. *Surg Innov* 2006; 13:198-204.
17. Stefanidis D, Acker C, Heniford BT. Proficiency-based laparoscopic simulator training leads to improved operating room skill that is resistant to decay. *Surg Innov* 2008; 15 : 69-73.
18. Shamsunder SC, Manivannan M. Haptic guided laparoscopy simulation improves learning curve. *Stud Health Technol Inform* 2008; 132:454-6.
19. Banks EH, Chudnoff S, Karmin I, Wang C, Pardanani S. Does a surgical simulator improve resident operative performance of laparoscopic tubal ligation? *Am J Obstet Gynecol* 2007; 197:541.
20. Bholat OS, Haluck RS, Murray WB, Gorman PJ, Krummel TM. Tactile feedback is present during minimally invasive surgery. *J Am Coll Surg* 1999; 189:349-55.
21. WA, Cooper CS, Fisher RJ. Predictors of laparoscopic complications after formal training in laparoscopic surgery. *JAMA* 1993; 270:2689-92.
22. Hruby GW, Sprenkle PC, Abdelshehid C, Clayman RV, McDougall EM, Landman J. The EZ Trainer: validation of a portable and inexpensive simulator for training basic laparoscopic skills. *J Urol* 2008 ; 179 : 662-6.
23. Kirby TO, Numnum TM, Kilgore LC, Straughn JM. A prospective evaluation of a simulator-based laparoscopic training program for gynecology residents. *J Am Coll Surg* 2008; 206 :343-8.

JOURNAL INFORMATION

The journal is indexed/abstracted by IndMED, ExtraMED, Index Medicus of Southeast Asia, International Abstracts of Biological Sciences, Abstracts of World Medicine, Hygiene and Tropical Disease Abstracts and EMBASE.

The IndMED database is accessible on internet at the website <http://indmed.nic.in>

Bibliographic details of the journal are available on website <http://indmed.nic.in>

At present you will find full text articles from the year 2000 at <http://medind.nic.in>

From IndMED site you can access, MJAFI directly by typing in the search box **jid-maa**. If specific articles published in MJAFI are to be searched e.g. articles pertaining to malaria, type in the search box "**malaria and jid-maa**".

Articles can also be accessed directly at website www.google.com by feeding in keywords/author's name/title of the article.

Instructions to Authors appear in January issue every year.

Authors Index, Subject Index and contents of the volume appear in October issue every year