Conventional box model training improves laparoscopic skills during salpingectomy on LapSim: a randomized trial

Geleneksel kutu tipi eğitim modeli ve laparoskopik becerilerin geliştirilmesi: Randomize çalışma

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Abstract

Objective: Box model trainers have been used for many years to facilitate the improvement of laparoscopic skills. However, there are limited data available on box trainers and their impact on skill acquisition, assessed by virtual reality systems.

Material and Methods: Twenty-two Postgraduate Year 1 gynecology residents with no laparoscopic experience were randomly divided into one group that received structured box model training and a control group. All residents performed a salpingectomy on LapSim before and after the training. Performances before and after the training were assessed using LapSim and were recorded using objective parameters, registered by a computer system (time, damage, and economy of motion scores).

Results: There were initially no differences between the two groups. The box trainer group showed significantly greater improvement in time (p=0.01) and economy of motion scores (p=0.001) compared with the control group post-training.

Conclusion: The present study confirmed the positive effect of low cost box model training on laparoscopic skill acquisition as assessed using LapSim. Novice surgeons should obtain practice on box trainers and teaching centers should make efforts to establish training laboratories. (J Turkish-German Gynecol Assoc 2013; 14: 157-62)

Key words: Laparoscopy, skill, box trainer, LapSim

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Özet

Amaç: Geleneksel kutu tipi laparoskopi eğitim modelleri yıllardır laparoskopik beceri gelişimini kolaylaştırmak amacıyla kullanılmaktadırlar. Fakat kutu tipi eğitim modelleri ve bunların laparoskopik beceri kazanılması üzerine etkilerinin sanal gerçeklik sistemler ile değerlendirilmesi konusunda sınırlı bilgi mevcuttur.

Gereç ve Yöntemler: Laparoskopik deneyimi olmayan 22 birinci yıl jinekoloji asistanı gruplardan birincisi kutu tipi eğitim modelinde yapılandırılmış eğitim alacaklar ve ikincisi kontrol grubu oluşturacak şekilde iki gruba randomize edilmiştir. Tüm asistanlar eğitim öncesinde ve sonrasında LapSim de salpenjektomi gerçekleştirmiştir. Eğitim öncesi ve sonrası performansları LapSim'in bilgisayar sistemi sayesinde elde edilen objektif parametreler kullanılarak (zaman skoru, hasar oranı, hareket ekonomisi skoru) değerlendirildi.

Bulgular: Başlangıçta iki grup arasında her hangi bir fark saptanmadı. Eğitim sonrasında, kutu modelde eğitim alan grup kontrol grubuna göre, zaman (p=0.01) ve hareket ekonomisi skorlarında (p=0.001) anlamlı olarak daha fazla gelişme göstermişlerdir.

Sonuç: Bu çalışma, düşük maliyetli kutu tipi laparoskopi eğitim modelinin laparoskopik beceri kazanımı üzerine olumlu etkisinin bulunduğu LapSim kullanılarak konfirme edilmiştir. Laparoskopi konusunda tecrübesiz cerrahlar kutu tipi eğitim modelinde egzersiz yapmalıdırlar. Ayrıca eğitim hastaneleri laparoskopi eğitim laboratuarlarına sahip olmak için gerekli çabayı göstermelidirler.
(J Turkish-German Gynecol Assoc 2013; 14: 157-62)

Anahtar kelimeler: Laparoskopi, beceri, kutu tipi eğitim modeli, LapSim

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Introduction

Reduced mortality, faster postoperative recovery, shorter hospital stays, and better cosmetic results are the main advantages of laparoscopic surgery and thus it has become a standard approach for many conditions in most surgical fields (1, 2). On the other hand, it is obvious that laparoscopic surgery is associated with a longer operation time and a higher surgical complication rate during the learning curve of the laparoscopic technique, which requires novel and unique psychomotor skills, such as the transfer to 2-D from 3-D, long instruments that amplify tremor, reduced tactile feedback, and the fulcrum effect (3, 4). Additionally, laparoscopic skills are fundamentally different from those used for traditional open surgery, leading to a prolonged learning curve. Moreover, these skills cannot be acquired exclusively via the old apprenticeship model of observing and assisting (5).

Laparoscopic simulators, such as box model trainers and virtual reality simulators (VR) have been used for many years to facilitate the acquisition of skills needed for laparo-

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scopic surgery. The former, which incorporates conventional laparoscopic equipment, is a relatively inexpensive and highly versatile device that enables training on animal parts as well as synthetic inanimate models (6). The latter shows a great potential for both training and assessment purposes. VR replicates laparoscopic instruments as surgeons navigate through and interact with the environment using their natural senses and skills. Now, laparoscopic VR software can replicate procedure-specific tasks such as salpingectomy, tubatomy, myomectomy, and even hysterectomy. It can also be used more easily as an objective tool for assessing laparoscopic skills than the box trainer (5, 7).

The aim of the current study was to evaluate the effectiveness of training on the box trainer with regards to salpingectomy training using the LapSim (LapSim®, Surgical Science, Gothenburg, Sweden) VR simulator.

Material and Methods

The study was conducted as a prospective, randomized, controlled trial. Twenty-two Postgraduate Year 1 gynecology residents with no laparoscopic experience were randomly assigned to either a box trainer group or a control group using the sealed envelope technique. All residents completed a questionnaire regarding demographics, handedness, and any previous experiences with laparoscopic surgery, the box trainer, the LapSim simulator, or video games.

The aim of the study was explained to all the subjects, and informed consent was obtained prior to participation in the trial. The training was spread over a period of 5 weeks. During the first week, all residents were given didactics about the LapSim and each of them performed a salpingectomy on the ectopic pregnancy module of the LapSim as an initial test. Thereafter, during the subsequent four weeks (one hour weekly), the box group received a structured box model training curriculum and the control group did not receive any training. One week after the training period had finished, both groups performed another salpingectomy on the LapSim as a post-training test (Figure 1).

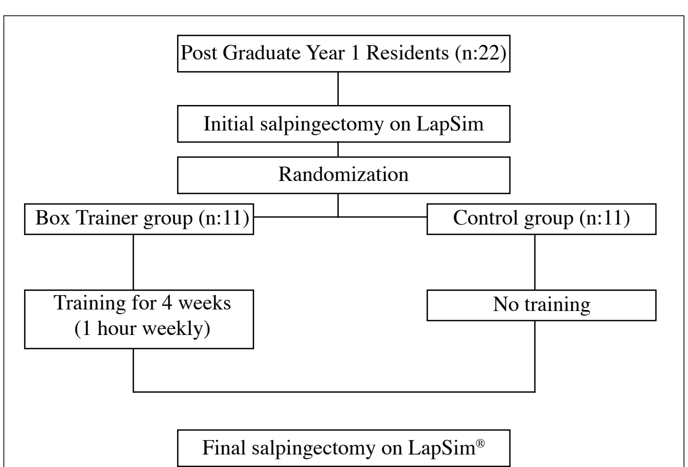

Figure 1. Experimental design

Each participant performed four sessions of a salpingectomy on the LapSim during both the initial and post-training tests. Since it was previously shown that there is a familiarization curve with the LapSim, the first three sessions were used for this purpose (8).

Performance before and after training was assessed and based on objective parameters registered by the computer system (time, damage, and economy of motion scores).

Equipment

LapSim® (Gothenburg, Sweden) is a PC-based VR system that consists of a 19 inch monitor and a laparoscopic interface module with two instruments and a foot-switch. The software is run on a dual-processor Pentium D 3 GHz computer with 1 GB RAM and GeForce 6800 graphics card using Windows XP Professional. The LapSim® has been extensively validated as a relevant tool for training of laparoscopic skills (Figure 2).

The ectopic pregnancy module of the LapSim provides a realistic image of the procedure with which subjects can interact to perform a salpingectomy (Figure 3). The difficulty level of the module can be altered from level 1 (easy) to level 3 (difficult); this was set to level 1 for the present study. The subject interacts with the simulator through a virtual laparoscopic interface. This is a frame holding two standard laparoscopic instruments in an appropriate position. The nature of the instrument is changed virtually and thus a laparoscopic grasper, bipolar grasper, diathermy scissors, suction and bag are available for use. A pedal, which

Figure 2. The LapSim

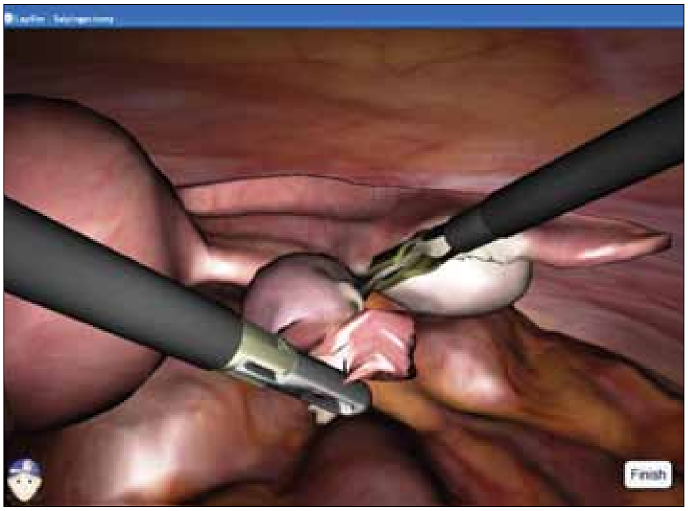

Figure 3. A demonstration of a simulated salpingectomy

Results for: Salpingectomy

Overall Score: 42%

Parameter	Value	Graph	Min	Max	Passed	Score
Total Time (s)	964.8		0	360	Failed	0%
Blood Loss (mL)	100.92		0	500	Passed	100%
Bleeding (mL/s)	0		0	1	Passed	100%
Pool volume (mL)	0.87		0	10	Passed	100%
Ovary Diathermy Damage (s)	0.54		0	10	Passed	100%
Tube Cut: Ulterus Distance (mm)	0		0	50	Passed	100%
Bleeding vessel cut (max 1)	1		0	1	Passed	0%
Evacuation from the body	0		1	1	Failed	0%
Left Instrument Path Length (m)	14.43		0	3	Failed	0%
Left Instrument Angular Path (dengrees)	2402.33		0	720	Failed	0%
Right Instrument Path Length (m)	17.36		0	5	Failed	0%
Right Instrument Angular Path (dengrees)	2642.33		0	1080	Failed	0%

Figure 4. Summary metrics of LapSim

is operated by the subject, doubles as a diathermy or suction device depending on which instrument has been selected.

The aim of the task is to perform a right-sided salpingectomy using the left hand grasper to identify the mesosalpinx and the right hand bipolar grasper to cauterize the mesosalpinx, followed by the right hand diathermy scissors. Once the salpingectomy has been fully completed, the tube should be placed in a virtual bag and any residual bleeding should be controlled. When the subject is satisfied that the task is completed, the simulation ends. Summary metrics include total time taken to complete each task (seconds), path length of each hand (meters), angular path length of each hand (degrees), total blood loss (milliliters), ovarian diathermy damage (seconds), residual bleeding rate (milliliters/seconds) and amount of un-removed dissected tissue (if any). These are subsequently recorded using the computer and can be downloaded into a spreadsheet format (Figure 4).

The box trainer was constructed using dark plastic in the shape of a rectangular prism (size 45×30×25 cm). Five holes were cut out for the camera and trocars. The right side of the box trainer was left open in order to put the training tools inside (Figure 5).

Figure 5. The Box Trainer

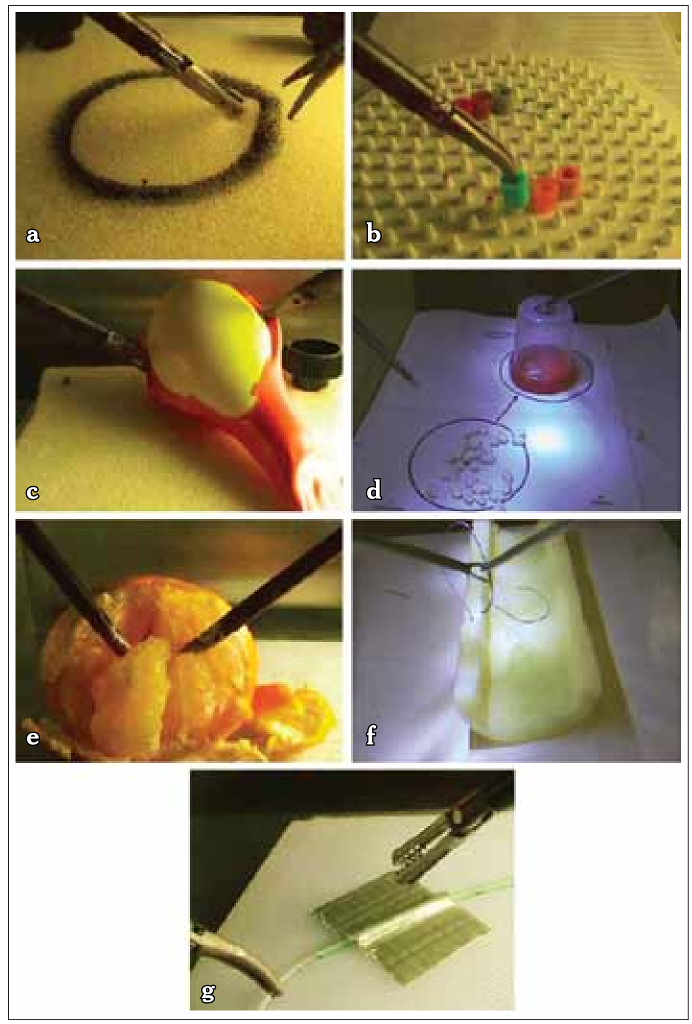

Figure 6. Box trainer exercises. Cutting out a drawn circle (a). Moving pegs on a board (b). Cutting out the inner balloon to simulate enucleating an ovarian cyst (c). Grasping and dropping beans into a small box (d). Peeling a mandarin (e). Suturing and knot tying (f). Tubulation (g)

Task description (Figure 6)

Task 1: Cutting out a drawn circle with a diameter of 4 cm from a thin sponge directly on the drawn line. The sponge material is fixed to the base of the box trainer.

Task 2: Moving pegs on a board. Ten small plastic pegs are moved to predefined spots.

Task 3: Cutting out the inner balloon of two balloons to simulate enucleating an ovarian cyst, without rupturing the inner balloon. The inner balloon is filled with ultrasound gel.
Task 4: Grasping and dropping beans into a small box.
Task 5: Peeling a mandarin.
Task 6: Suturing a sponge and tying a knot. The sponge is fixed onto a board.
Task 7: Introducing an epidural catheter into a piece of intravenous infusion tube. The piece of tube is fixed onto a board. The epidural catheter is initially placed beside the tube.

Evaluation of performance
Evaluation of performance was based on time, economy of motion score (left and right instrument path length and angular path) and damage score (bleeding, ovarian thermal damage).

Statistics
Data was analyzed using the SPSS 15.0 software package. The normality of the data was assessed using the Shapiro-Wilk test. Because the data were non-parametric, Mann-Whitney's U test was used to assess the differences between the two groups regarding all performance parameters. The Wilcoxon signed rank test for related data was used to assess differences in performance of all of the parameters. Significance was set at $p<0.05$. Post hoc power analysis was performed using NCSS-pass 2000 software package. Group sample sizes of 11 and 11 achieved 93%, 94% and 97% power to detect a difference between two groups for the time, instrument path length and instrument angular path scores, respectively, with a significance level (alpha) of 0.05 using a two-sided Mann-Whitney test.

Results

All 22 participants assigned to take part in the study completed it (Table 1). Analysis of the initial performance data showed no significant differences between the two groups in all parameters. In comparison with the control group, the box trainer group performed significantly better regarding the time and economy of motion scores in the post-training data, but there were no differences in damage scores (Table 2, 3).
Analysis of pre- and post-training performance data of the box trainer group showed a significant improvement in the time and economy of motion scores, but there were no differences in damage scores (Table 4).

Table 1. Demographics of the participants

Group Demographics	Box Trainer Group (n:11)	Control Group (n:11)
Age (year)	28.2±1.7	27.8±2.0
Female/male	6/5	6/5
Dominant hand (R:L)	10/1	10/1
Previous laparoscopic experience	None	None
Previous LapSim experience	None	None
Previous Box trainer experience	None	None
Video game play experience		
None	5	4
Occasionally	2	2
Formerly	1	3
Often	3	2

Table 2. Pre-training test performance. Better performance is represented by a lower score

	Box Trainer Group Median / IR	Control Group Median / IR	p
Time (sec)	321 (107)	325 (73)	0.818
Damage Score			
Ovarian diathermy damage (sec)	0.28 (0.41)	0.55 (0.47)	0.308
Bleeding (mL)	5.36 (12.24)	14.17 (12.37)	0.139
Economy of Motion			
Instrument path length (m)	7.35 (5.10)	8.52 (2.57)	0.412
Instrument angular path (degrees)	1264.34 (671.10)	1508.93 (600)	0.094

Mann Whitney U test, Numbers in the parenthesis represents the interquartile range (IR)

Table 3. Post-training test performance. Better performance is represented by a lower score

	Box Trainer Group	Control Group	
	Median / IR	Median / IR	p
Time (sec)	196 (72)	280 (67)	0.01
Damage Score			
Ovarian diathermy damage (sec)	0.11 (0.45)	0.13 (1.41)	0.261
Bleeding (ml)	7.45 (6.81)	23.7 (31.66)	0.317
Economy of Motion			
Instrument path length (m)	5.03 (0.97)	10.07 (3.86)	0.001
Instrument angular path (degrees)	693.63 (163.14)	1838.81 (664.62)	0.001

Mann Whitney U test, Numbers in the parenthesis represents the interquartile range (IR)

Table 4. Performance of the Box Trainer group pre- and post-training. Better performance is represented by a lower score

Box Trainer group			
	Pre-training	Post-training	
	Median / IR	Median / IR	p
Time (sec)	321 (107)	196 (72)	0.003
Damage score			
Ovarian diathermy damage (sec)	0.28 (0.41)	0.11 (0.45)	0.169
Bleeding (ml)	5.36 (12.24)	7.45 (6.81)	0.317
Economy of Motion			
Instrument path length (m)	7.35 (5.10)	5.03 (0.97)	0.003
Instrument angular path (degree)	1264.34 (671.60)	693.63 (163.14)	0.003

Wilcoxon's signed-rank test, Numbers in the parenthesis represents the interquartile range (IR)

Discussion

The present study shows that the use of a box trainer can improve laparoscopic skill performance (measured by VR simulator). The improvement in economy of motion scores, which have been shown to have the greatest validity in the assessment of laparoscopic technical skills (9), was found to be the greatest. Box model trainers have been used to improve laparoscopic skills. There have been several studies in the literature which indicate that box trainers can improve laparoscopic skill (2, 10). For performance assessment, these studies have generally used an experienced surgeon who observed the procedure and/or special devices. This is time consuming and expensive. As can be seen, the main drawback of the box trainer is the lack of a feasible system for performance assessment. Despite this, box trainers carry important advantages include the use of real laparoscopic instruments, tactile feedback and the opportunity to work with animal parts (2).

The LapSim virtual simulator was used in the present study and has been found to improve relevant skills for surgical performance in real operations (1, 11, 12). One of the main advantages of LapSim is having a feasible performance assessment system thanks to its software. One study in which participants completed the basic training tests before and after training on a box trainer showed that structured laparoscopic skill training on a box trainer improves time, economy of motion and damage scores, as assessed using a simple test in the LapSim system (4). Mainly, damage scores for the simple test for LapSim are quite different to those for the salpingectomy module. Tissue damage, which is strongly associated with tactile feedback, is the damage score for the simple test. On the other hand, bleeding and ovarian diathermy damage are the damage scores for salpingectomy; these are mostly associated with procedural knowledge. It is also known that procedural knowledge does not change with training using either VR or the box trainer (1, 11, 13). Similarly, in our study, damage scores were not affected by training on the box trainer.

The small sample size may be one of the limitations for the present study, yet it can be seen in the available literature that most studies have similar sample sizes. Additionally, we used some common training exercises instead of approved or certificated exercises for the box trainer. Despite all our efforts, we could not find any certified exercises. Related to this issue, there is a lack of agreement regarding which exercises are most useful and effective for skill improvement (4). This will be taken into account in further studies.

In conclusion, training on a traditional low-cost box trainer can help improve basic laparoscopic skills. All surgeons who want to improve their skills relevant to minimally invasive surgery should practice on trainers. Additionally, teaching centers should make more effort to have training laboratories which include box trainers and even VR simulators.

Ethics Committee Approval: *N/A.*

Informed Consent: *Informed consent was received from the participants of the study.*

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Author contributions: *Concept – A.A., F.Ş.; Design – A.A., A.M.E.; Supervision – F.Ş., A.Ö.Y.; Resource – A.A., A.Ö.Y.; Materials – A.A., A.M.E.; Data Collection&/or Processing – A.A., A.M.E., Analysis&/or Interpretation – A.Ö.Y.; Literature Search – A.A.; Writing – A.A.; Critical Reviews – F.Ş.*

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