Construction and employment of a low cost laparoscopic simulator

Test on General Surgery residents

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INTRODUCTION: *Based on studies that confirm the usefulness of simulators in laparoscopic surgical training, we designed and tested a cost-effective solution to improve the skills of surgeons training in the operating room. The goal was to exercise the basic gestures of laparoscopic surgery.*
MATERIALS AND METHODS: *The initial budget of € 500 was sufficient for this project. We spent only € 360 on the majority of the components, which included buying a laptop. The project was performed with material that was readily available online, and the assembly did not require special tools. The goal was to make the product easily replicable. The test was performed using a simulator on 9 doctors in specialist training in general surgery at the University Hospital of Parmadistributed, who were equally distributed among the six years of school in general surgery.*
RESULTS: *The first exercise, which was the simplest, had as its objective the acquisition of familiarity with the vision monocular feature of VL and coordination between the two hands. We observed statistically significant improvement between the first and second (2.52 to 2.17 min, p = 0.006) tests and between the first and third (from 2.52 to 1.57 min, p = 0.001) tests with a non-significant correlation between the time of year and the achieved specialty. In the second exercise, there was a statistically significant improvement due to the excessive excursion of the confidence intervals (remarkable variability with overlap of the same features). This exercise, which consisted of two parts, explored the ability to use two hands independently.*
The third and final exercise involved the packaging of a laparoscopic ligation and was the most complex because it required skill in the use of instruments with both hands as well as considerable coordination. The t-test for paired data showed a significant improvement in all tests with p = 0.0008 between the average time for the first and second tests, p = 0.001 between the second and third tests, and p = 0.01 between the first and third tests (from 10.09 min to 3.52 min).
CONCLUSIONS: *The simulator that we constructed will never replace the experience gained in the operating room, and it was not our intention to replace the normal process of learning for young surgeons. Instead, we aimed to provide an inexpensive tool for refining the basic skills of laparoscopic surgery, such as the use of instruments in monocular vision, coordination between two hands and ambidexterity.*

KEY WORDS: Laparoscopic simulator, Laparoscopy, Surgical training

Laparoscopy is a rapidly increasing surgical technique; an increasing number of operations can now be performed with this method. However, the learning curve for these operations is longer than for traditional surgery. The Videolaparoscopy (VL) should play a central role in the education of young surgeons in laparoscopic simulators, and specialized training should become a key instrument for this goal [1-3].

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Several studies have suggested that laparoscopic simulators improve technical capabilities [4,5] and are therefore recommended for the learning of surgical techniques [6]. Even the use of certain interactive video games can improve a surgeon's skills [7].
Some manufacturers have developed and tested [8], with excellent results, both virtual laparoscopic simulators and "traditional" techniques with costs ranging from a minimum of $ 2,000 to over $ 30,000 [9]. We decided to evaluate a low-cost simulator.
We preferred to focus on traditional simulators for economic reasons as well as because these types of simulators are more functional than those in surgical training in virtual reality [10].

Materials and Methods

The following six components were identified in our laparoscopic simulator: a box serving as the abdominal cavity, an optical light source, a video interface, surgical instrumentation and types of exercises.
The simulator was named SI.RIO.

A) *Body*
To simulate the abdominal cavity, we used a box model "Samlah" (http://www.ikea.com/it/it/catalog/categories/departments/secondary_storage/series/125 53/), which was purchased at IKEA ®; it was black and had dimensions of 57x39x28 cm as well as a volume of 45 L.

B) *Optical*
To display images, we used a model Logitech ® B910 HD Webcam (http://www.logitech.com/it-it/product/b910-hd-webcam) for its compact size, excellent video quality, and affordable price. The video recording was performed with the software that was included with the webcam (Logitech webcam software).
Below are the specs:
– Video resolution 720x1280 (HD ready 720p) at 30 frames per second;
– Glass lens Carl Zeiss®;
– System auto focus;
– Sensor 5 MP HD native;
– Wide-Angle 78 degrees;
– USB 2.0 high speed 1.5 m

C) *Light*
A Headlamp ONnight 200 (http / / www.decathlon.it/ lampada-frontale-onnight-200-id_ 8231572.html) was amended accordingly. The output of 30 lumens was generated by an OSRAM LED 4 (with an average life of 12,000 to 15,000 hours). LEDs provided bright white light and allowed for a uniform representation of the color tone that is as close as possible to reality and very similar to that used in operating rooms. Three 3 AAA batteries, with an average duration of 16 hours, supplied the power.

D) *Interface Video*
A video interface device for recording and archiving the exercises was run on a laptop ASUS eeePC 1011 CX (http://www.asus.com/Notebooks_Ultrabooks/Eee_PC_1011CX/)
Below are the specs:
– Operating System: Windows 7 Starter 32 bit;
– Screen: 10.1 "LED Backlight WSVGA (1024x600) Screen;
– CPU: Intel ® Atom ™ N2600 (Dual Core, 1.6GHz) Processor;
– Chipset: Intel ® NM10 Express;
– RAM: DDR3, 1 x SO-DIMM 1GB;
– HD: SATA 500GB HDD;
– Dimensions: 262 x 178 x 23.6 ~ 36.4 mm (WxDxH)

The computer in question is convenient because of its small size, but the CPU and RAM were insufficient for making pictures "full screen" at high resolution (720 p), which was allowed by the webcam without compromising f E) Laparoscopic Instruments
The following were provided:
– 1 clamp diameter of 5 mm and length of 35 cm.;
– 1 needle holder "crocodile" of 5 mm and length of 33 cm

Construction

The first issue that we addressed was the placement of the instruments; after several attempts, we decided to drill holes in the box Samlah (used upside down on the paino work) with an 8 mm drill bit and drilled to a 9 mm round file. The finished margins were positioned inside the black seal round rubber with an internal diameter of 6 mm, allowing for great and fluid flow instrument laparoscopy (5 mm). It is preferred to use this method of real trocar 5 mm for a simple construction as well as to reduce the costs despite a small decrease in the performance.
To facilitate access, we made holes on the corners of the box at a height of 12 cm from the bottom to obtain a working angle of approximately 75 degrees.
We then included the optics in a central position on the shorter side of the box to 11 cm from the bottom. To attach the webcam, we used two rods of aluminum (20 cm) anchored to the casing with 4 mm screws.
The camera was then positioned between the two metal supports and secured using special rubber seals, which were obtained from the door of an old car. The gaskets were cleaned and could suitably be cut for positioning on the rods of aluminum. The hole for the camera was made with a large drill bit and then finished by hand with a circular file up to a diameter of 185 mm.
We tried to accommodate the light as close as possible to the optics so that it would be similar to the situation in which the camera and light source coexist in a unique and sophisticated tool.

The lamp was deprived of the elastic band from the head and secured to the box 5 cm above the hole of the camera with two screws (4 mm). The support characteristic of this model allows for tilting the light 45 degrees downward with direct light illuminating the field of work.
Finally, the tables were constructed (Fig. 1); for convenience, we used a wooden board (36x29 cm) attached to the cover, the bottom base of the box, with strips of Velcro on the four corners, allowing for easy removal and turning.
On the above tablet, we fixed the eyelets of iron used for exercise number 3 on one side. Even in this case, we placed more than one eyelet to determine the best position for carrying out the exercise. We chose a more centrally located position that was equidistant from the access holes in the tools and oriented in the frontal plane. On the opposite side, we placed a rigid plastic with four tips for the first year. The support is a spacer (product-cap) used for storing pickled vegetables that are appropriately colored black to avoid light reflection.
Later, the support is fixed with glue and 2 screws in a vertical position in the wood trims, which were practiced to the extreme two holes with a diameter of 12 mm used for the second year.

F) *Exercises*
To test the usefulness of the simulator, the participants performed three exercises with increasing difficulty, allowing the operator to practice different tasks.

Exercise one (Fig. 2)
We provided a rigid support that was fixed inside the simulator with four truncated tips that were conically arranged at the vertices of an imaginary square with a diagonal of 30 mm. The data also include findings for three colored, circular bands (diameter of approximately 40 mm) with different thicknesses so that they were more or less extensible. The operator must collect all of the elastics with pliers, bring them inside of the box and place them on the simulator's support at four points with the help of the contralateral hand, which manipulated the other instrument. This procedure was performed three times; the elastics must be removed one at a time and brought outside of the box.
The following parameters were evaluated in this exercise:
– Duration in minutes;
– Use of both instruments in an active way (right hand and left hand).
Points 1 to 2 for elastic (3-6)
– Accuracy in positioning the elastic (overlap and the use of all four media).
Steps 1 through 4 for elastic (4-12)
– Removal of the bands
Points 1 to 2 for elastic (3-6)

Exercise two (Fig. 3)
A yellow rubber cylinder (12 mm in diameter and 20 mm in length) was placed in the left visual field. The operator must grasp the cylinder with forceps and pass it to the right caliper without dropping it. Then, the

Fig. 1: The wooden board.

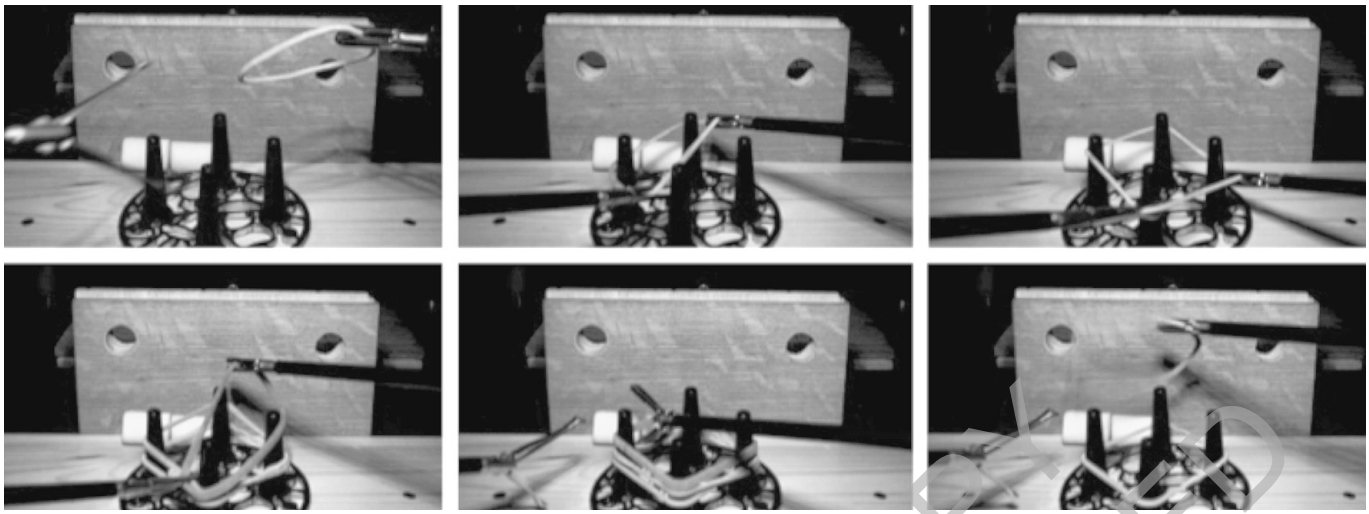


Fig. 2: Exercise one in progress.

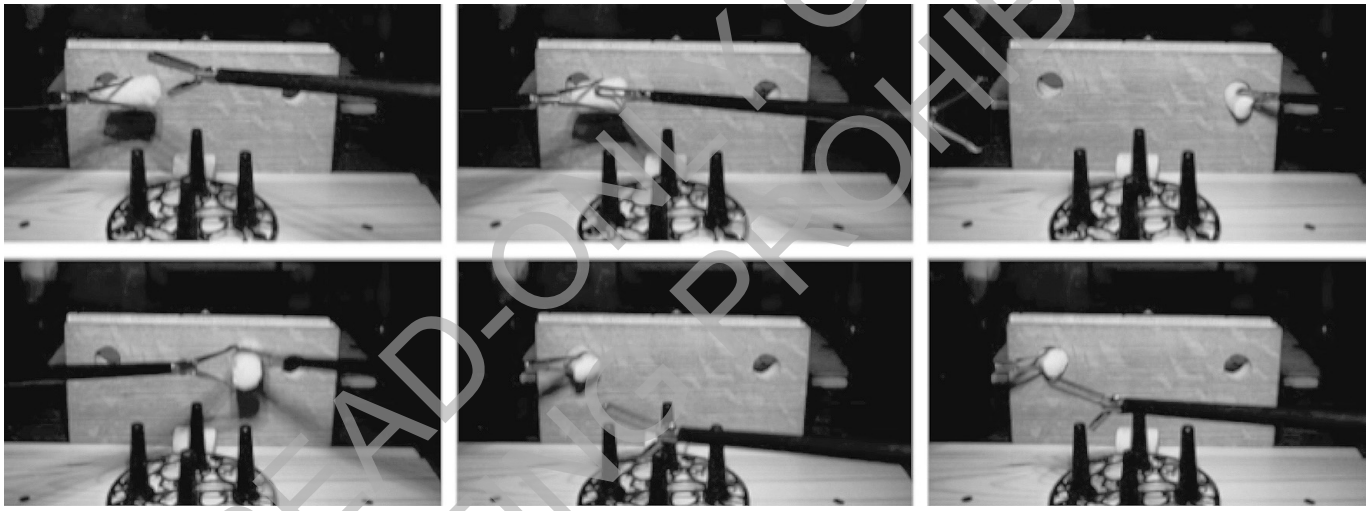


Fig. 3: Exercise two.

cylinder must be placed in the center of the visual field with the right caliper, shot with the left caliper and passed back to the right, inserting the grommet in a hole, with a diameter of 12 mm, that is localized in the frontal plane to the right of the visual field. The rubber is left in place for a few seconds, and then the procedure is resumed with the right caliper; the rubber is always deposited at the bottom right visual field where there is a special black dot.

The previously described operations should be repeated in a mirror image, starting with the right hand and then finishing with the left, which allows for the insertion of the grommet into a similar hole in the frontal plane that is always to the left of the field of vision.

If the grommet falls outside the field of view, it may not be recoverable with the tongs; in these cases, the subjects were provided with a second gasket to complete the exercise. If the second grommet was lost, the exercise was considered to be concluded.

The parameters evaluated in this exercise were the following:

– Duration (in minutes);

– Number of falls grommet.

Less a point to fall

– Completion of both parties (right and left hands)

Points from 1 to 10 on each side (2-20)

eg. 10-point Perfect Exercise

9-point positioning is not accurate

8-point jump of a passage

5 points completed by mid-year

1 point operation not performed

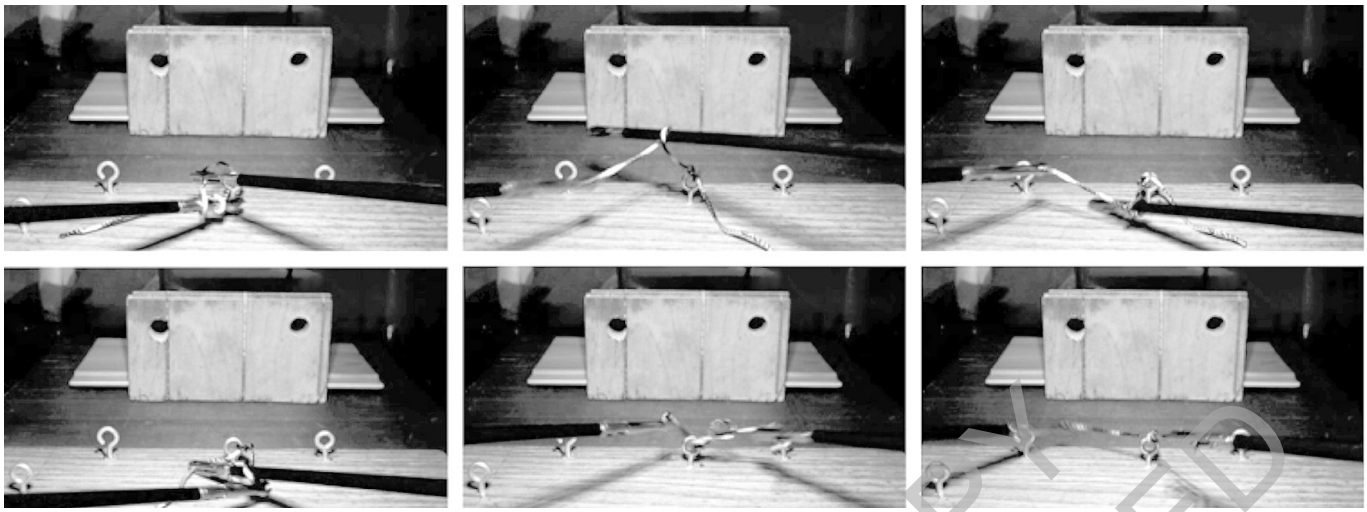


Fig. 4: exercise three

EXERCISE THREE (Fig. 4)
The device is equipped with a lanyard (diameter of 1 mm and length of 200 mm) and a loop of iron (5 mm diameter), mounted on a base in the center of the field of view, 30 cm from the entrance of the instruments. The exercise consists of inserting the lanyard eyelet and running two nodes.
For this exercise, given the greater complexity, we set an upper limit of 20 minutes.
The parameters evaluated for this exercise were the following:
– Duration in minutes
– Number of nodes executed (max2)
5 points per node (5-10)
– Number of loops per node (max2)
5 points per loop (5-20)
– Execution of the nodes with both hands
Points 10

Results

This section is divided into two main topics: costs and outcomes exercises.

COSTS

There are many laparoscopic simulators on the market, with costs ranging from tens to hundreds of thousands of Euros (4). The aim of this project was to construct an affordable, useful tool for training young surgeons .The total cost was € 359.49, and the cost decreased to € 109.74 if the group already had a laptop. The detailed costs are described below.

Computer € 249.75
Webcam € 79.99
Box € 2.90
Lamp € 10.95
Rubber Seals (No. 20) 5.00 €
Velcro (1 m) € 2.40
Aluminum bar 5x30x1000 millimeters € 5.00
Plastic spacer € 0.50
Screws, bolts and screws with eyelet € 1.00
Wood € 2.00

Nine trainees participated in the trial at the University Hospital of Parma in general surgery, and they were divided into three groups according to their year in training.

Group I: 3 in the first postgraduate year (RM1, CC1, and BE1)
Group II: 2 in the second postgraduate year (BE2 and LE2)
1 trainee in the third year (MF3)
Group III: specializing 1 of the fifth year (NC5)
2 trainees of the sixth year (VL6 and DB6)

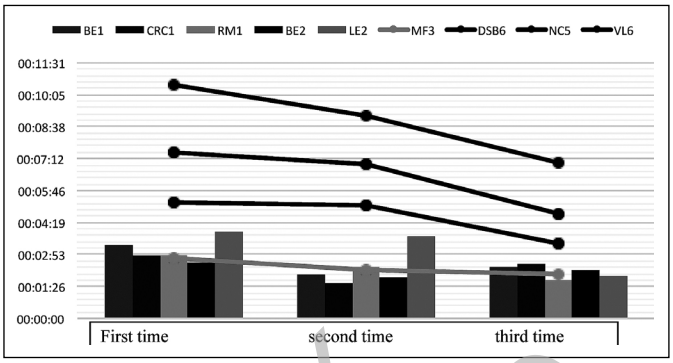
Trainees participated in 3 tests in a period of approximately two months, during which time they performed the exercises. Each trial consisted of the performance of the three exercises in sequence without the possibility of exercising or practicing before or after.
Each trainee was filmed during the course of participation in the study; as a result, we collected three movies for each of the three tests, resulting in a total of 81 videos that were examined and cut to standardize the duration. For example, the time count in the first period started when the trainee introduced the elastic in the simulator and continued to the removal of the last of

Table I - 1) *Use of both hands: point from 1 to 2 for every movement (min 3- max 6);* 2) *Precision during the movement: point from 1 to 4 every exercise (min 4 – max 12);* 3) *Take off the body: points from 1 to 2 every body.(min 3 – max 6)*

Group I		First time	Second time	Third time
BE1	Date	22 ott.	29 ott.	15 nov.
	Time	3.17 min	2.00 min	2.19 min
	1	2+2+2	2+2+2	2+2+2
	2	4+4+4	4+4+4	4+4+4
	3	2+2+2	2+2+2	2+2+2
	Total	24/24	24/24	24/24
CRC1	Date	23 ott.	30 ott.	15 nov.
	Time	2.50 min	1.35 min	2.25 min
	1	2+2+2	2+2+2	2+2+2
	2	4+4+4	4+4+4	4+4+4
	3	2+2+2	2+1+2	2+2+2
	Total	24/24	23/24	24/24
RM1	Date	21 ott.	15 nov.	19 nov.
	Time	2.49 min	2.17 min	1.44 min
	1	2+1+2	2+2+2	2+2+2
	2	4+4+4	4+4+4	4+4+4
	3	2+2+2	2+2+2	2+2+2
	Total	23/24	24/24	24/24
Group II		**First time**	**Second time**	**Third time**
BE2	Date	5 nov.	19 nov.	5 dic.
	Time	2.30 min	1.53 min	2.09 min
	1	2+2+2	2+2+2	2+2+2
	2	4+4+4	4+4+4	4+4+4
	3	2+2+2	2+1+1	2+1+1
	Total	24/24	22/24	22/24
LE2	Date	23 ott.	4 nov.	20 nov.
	Time	3.56 min	3.44 min	1.55 min
	1	1+1+1	2+2+2	1+2+2
	2	4+4+4	4+4+4	4+4+4
	3	2+2+2	2+2+2	2+2+2
	Total	21/24	24/24	23/24
MF3	Date	22 ott.	4 nov.	26 nov.
	Time	2.42 min	2.09 min	2.00 min
	1	2+2+1	1+1+1	2+1+1
	2	4+4+4	4+4+4	4+4+4
	3	2+1+2	1+2+2	2+2+2
	Total	22/24	20/24	22/24
Group III		**First time**	**Second time**	**Third time**
DSB6	Date	23 ott.	29 ott.	19 nov.
	Time	2.33 min	2.55 min	1.22 min
	1	2+2+2	2+2+2	2+2+2
	2	4+4+4	3+4+4	4+4+4
	3	2+2+2	2+2+2	2+2+2
	Total	24/24	23/24	24/24
NC5	Date	22 ott.	13 nov.	26 nov.
	Time	2.12 min	1.54 min	1.21 min
	1	2+2+2	2+2+2	2+2+2
	2	4+4+4	4+4+4	4+4+4
	3	2+2+2	2+2+2	2+2+2
	Total	24/24	24/24	24/24
VL6	Date	22 ott.	4 nov.	13 nov.
	Time	3.03 min	2.08 min	2.17 min
	1	2+2+2	2+1+2	2+2+2
	2	4+4+4	4+4+4	4+4+4
	3	2+2+2	2+2+2	1+2+2
	Total	24/24	23/24	23/24

the elastic supports. Table I summarizes the data obtained from the first exercise according to the time (Table II); there was a decrease in the duration of the exercise from

Table II - *Mean time for every time*



the first to the third test. The statistical analysis of the data was performed with the Student's t-test for paired data with averages and 95% confidence intervals. There was a statistically significant improvement between the first and the second tests ($p = 0.006$) from an average time of 2.52 min to 2.17 min. Comparing the second and third tests, there was improvement (from 2.17 to 1.57 min), but it was not significant. However, the improvement between the first and the third tests was significant ($p = 0.001$) with a change from 2.52 to 1.57 min.

The correlation between the time of year and achieved specialty was not significant because of the variation in the scores. Virtually all interns performed the exercise correctly with a few, insignificant errors.

The second exercise, the data for which are summarized in Table III, was not statistically reliable in terms of the time for the scores which is due to the excessive excursion of the confidence intervals.However, the specific characteristics of this test allow for separate analysis of the performance of the right and left hands, developing a parameter of "brain dominance", i.e. a score that is completely left-handed = 10 and right-handed = -10. There was a significant correlation ($p = 0.05$) between the times for the third test and score with the best of times, which was in proportion to the degree of left-handedness.

In the last year (Table IV), the t-test for paired data showed significant improvement in all tests,. A p-value of 0.0008 was obtained when comparing the average time for the first and second tests; in addition, $p = 0.001$ between the second and third tests and $p = 0.01$ between the first and third tests (from 10.09 min to 3.52 min). We have registered the reduction in the time and the increase in the scores with each subsequent test.

Discussion

The first exercise, which is the simplest of the three, trains the user in the typical view of VL; the hand-eye coordination for working with an indirect view of the

Table III - *Number of downfall rubber (evrye downfall -1). Complete use of both hands (from 1 to 10 points every hand)*

Group I		First time	Second time	Third time
BE1	Date	22 ott.	29 ott.	15 nov.
	Time	1.34 min	2.01 min	2.06 min
	1	1	3	2
	2	9+10	9+5	10+10
	Total	18/20	11/20	18/20
CRC1	Date	23 ott.	30 ott.	15 nov.
	Time	2.01 min	1.42 min	1.48 min
	1	0	0	0
	2	10+10	9+10	9+10
	Total	20/20	19/20	19/20
RM1	Date	21 ott	15 nov	19 nov
	Time	01.55 min	01.50 min	01.39 min
	1	1	0	1
	2	8+9	10+10	10+10
	Total	16/20	20/20	19/20
Group II		**First time**	**Second time**	**Third time**
BE2	Date	5 nov.	19 nov.	5 dic.
	Time	3.53 min	3.13 min	3.40 min
	1	2	1	7
	2	5+1	10+10	10+5
	Total	4/20	19/20	8/20
LE2	Date	23 ott.	4 nov.	20 nov.
	Time	3.36 min	3.27 min	1.51 min
	1	4	2	0
	2	10+5	10+9	9+10
	Total	11/20	17/20	19/20
MF3	Date	22 ott.	4 nov.	26 nov.
	Time	2.00 min	2.07 min	1.27 min
	1	0	2	0
	2	9+10	9+9	10+10
	Total	19/20	16/20	20/20
Group III		**First time**	**Second time**	**Third time**
DSB6	Date	23 ott.	29 ott.	19 nov.
	Time	3.03 min	1.47 min	1.31 min
	1	3	3	1
	2	9+9	10+5	10+10
	Total	15/20	12/20	19/20
NC5	Date	22 ott.	13 nov.	26 nov.
	Time	1.55 min	2.26 min	1.23 min
	1	0	1	0
	2	10+10	10+10	10+10
	Total	20/20	19/20	20/20
VL6	Date	22 ott.	4 nov.	13 nov.
	Time	5.39 min	1.46 min	1.13 min
	1	6	0	0
	2	9+9	9+9	10+10
	Total	12/20	18/20	20/20

Table IV - *1) number of ligature (max 2), 5 points every ligature (5-20) 2)Number of loop every ligature (max 2), 5 points every loop (5-20) 3)Ligature made with both ligature (10 points)*

Group I		First time	Second Time	Third time
BE1	Date	22 ott.	29 ott.	15 nov.
	Time	9.38 min	8.40 min	5.15 min
	1	5+5	5+5	5+5
	2	5+5	5+5	5+5
	3	10	0	10
	Total	30/40	20/40	30/40
CRC1	Date	23 ott.	30 ott.	15 nov.
	Time	8.09 min	5.54 min	3.35 min
	1	5+0	5+5	5+5
	2	5+0	5+10	10+10
	3	0	0	0
	Total	10/40	25/40	30/40
RM1	Date	21 ott	15 nov	19 nov
	Time	08.27 min	02.17 min	01.44 min
	1	5+5	5+5	5+5
	2	5+5	10+5	5+10
	3	0	0	10
	Total	20/40	25/40	35/40
Group II		**First time**	**Second Time**	**Third time**
BE2	Date	5 nov.	19 nov.	5 dic.
	Time	3.47 min	5.01 min	7.32 min
	1	5+5	5+5	5+5
	2	10+5	5+5	10+
	3	0	0	0
	Total	25/40	20/40	25/40
LE2	Date	23 ott.	4 nov.	20 nov.
	Time	11.56 min	6.12 min	7.00 min
	1	5+5	5+5	5+5
	2	5+5	10+5	10+10
	3	0	0	0
	Total	20/40	25/40	30/40
MF3	Date	22 ott.	21 nov.	26 nov.
	Time	11.51 min	13.45 min	1.58 min
	1	5+5	5+5	5+5
	2	5+5	5+5	5+5
	3	10	0	0
	Total	30/40	20/40	20/40
Group III		**First time**	**Second Time**	**Third time**
DSB6	Date	23 ott.	29 ott.	19 nov
	Time	17.13 min	4.22 min	1.53 min
	1	5+5	5+5	5+5
	2	5+5	5+5	5+5
	3	10	0	10
	Total	30/40	20/40	30/40
NC5	Date	22 ott.	13 nov.	26 nov.
	time	13.04 min	2.09 min	1.46 min
	1	5+5	5+5	5+5
	2	5+5	5+5	5+5
	3	0	0	0
	Total	20/40	20/40	20/40
VL6	Date	22 ott.	4 nov.	13 nov.
	Time	7.11 min	9.55 min	5.08 min
	1	5+5	5+5	5+5
	2	5+5	5+5	10+5
	3	0	0	0
	Total	20/40	20/40	25/40

field is altered and the coordination between the two is necessary for using both hands to position elastic media. The results indicate that the interns were able to successfully complete the exercise in all trials, which is most likely because of its simplicity. Nevertheless, there was a progressive and statistically significant improvement in the execution time.

The second- and third-year ambidexterity and coordination were examined with the operator packing a node or switching the rubber from one instrument to another and performing mirror movements. In the second exercise, the results did not show a tendency for improvement between successive tests, but the right and left hands could have different scores. We could distinguish the candidates on the basis of the dominant cerebral

hemisphere, and those who had higher scores with their left hands performed worse, in training, than those with higher scores in the right hand. A left-handed person may be more accustomed to using the non-dominant hand compared to a right-handed person; then, left-handers have a greater degree of ambidexterity than those who are right-handed. In the third year, instead of significant improvement, there was a sharp drop in the execution time compared to the first test. The residents in this exercise ventured into a new practice or exercised (run a node in laparoscopic vision), which has a negative impact on the timing of the first test for which they had to figure out the correct technique that could then be applied in the subsequent tests.

There are two types of simulators for the VL: the traditional and virtual reality. In our case, the simulator is traditional, wherein the operator sees, on a monitor, the real instruments with which he or she is moving his or her hands. Tactile sensations (friction, heavy tools, etc.) are therefore as close to reality as the visual sensations (especially lighting and anatomical aspects) and have profound differences in the operating room performance. In contrast, a virtual reality simulator software more faithfully reproduces the anatomical structures that are seen in the video, but the operator is not holding true surgical instruments; instead, the operator uses joysticks that record and send movements of the hands to the software.

The economic component is a very important part of this project; the budget of € 500 was deliberately limited to achieve an economical and, therefore, reproducible solution. Already, in other situations [11], this approach was undertaken to develop excellent products [9,11]. Therefore, the positive results of our study indicate that our simulator is satisfactory.

In addition, based on the work performed in other situations [2], the improvement achieved by the practice on the simulator is transferable to the operating room during a laparoscopic video.

We therefore believe that the features of this and other simulators [12] for VL surgery can affordably improve specialist doctors' training.

The simulator should not replace the practice performed in the operating room, but this method can improve surgeons' skills through offering additional, quality training. It has specifically been observed [12] that the repetition of a movement and the level of exercise positively affect a surgeon's ability. Because it is often not possible to repeat the surgical procedure in the operating room for purely educational purposes, the simulators have become a fundamental tool for training surgeons.

Riassunto

INTRODUZIONE: Abbiamo creato e testato, in base a pregresse esperienze che dimostravano come i simulatori laparoscopici fossero di aiuto nel training chirurgico, una soluzione ottimale in termini costo beneficio per migliorare lo skill del chirurgo in sala operatoria. Il fine era quello di potersi esercitare sui gesti chirurgici laparoscopici base.

MATERIALI E METODI: Il budget iniziale era di 500 euro. Abbiamo speso 360 euro per la maggior parte dei componenti incluso il laptop. Il progetto è stato portato avanti con materiale acquistabile on line e il suo assemblaggio non richiede particolare esperienza. Il fine era stato quello di poter creare uno strumento di facile uso e replicabile. Il test è stato condotto su 9 medici in formazione specialistica in chirurgia generale presso l'Università di Parma,suddivisi in base agli anni di specialità.

RISULTATI: Il primo esercizio, il più semplice, aveva come obiettivo la acquisizione della familiarità con la visione laparoscopica e la coordinazione tra le due mani. Noi osservammo come statisticamente significativo il miglioramento del tempo tra il primo ed il secondo test (2,52 vs 2,17 min., p=0.006) e tra il primo ed il terzo test (2.52 vs 1.57 min.,p=0.001).senza una significativa correlazione con gli anni di specialità.Il secondo esercizio presentava una statisticamente significativa escursione dell'intervallo di confidenza. Questo esercizio, che consisteva di due parti, esplorava l'abilità all'uso delle due mani indipendentemente.Il terzo esercizio riguardava la capacità di legare ed era più complesso poiché richiedeva l'uso di strumenti con entrambe le mani ed una notevole coordinazione.Il t test per dati appiati dimostrava un significativo miglioramento in tutti i tests con p=0.0008 tra il tempo medio per il primo ed il secondo test; p=0.001 tra il secondo ed il terzo test;p=0.01 tra il primo ed il terzo test (da 10.9 min. a 3.52 min.).

CONCLUSIONI: Il simulatore che abbiamo costruito non potrà sostituiure l'esperienza in sala operatoria e non era nostro intento sostituire il processo di apprendimento per il giovane chirurgo. Il nostro scopo è stato quello di sviluppare un sistema economico, per migliorare i gesti base della laparoscopia, l'uso degli strumenti sotto visione, l'ambidestria.

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