Reduced Cost Training Program in Minimally Invasive Surgery

A. H. Hermini, I. M. U. Monteiro, L. O. Z. Sarian, and J. C. C. Torres

Abstract

Minimally Invasive Surgery (MIS) procedures are now considered mainstay practice in the best hospitals word-wide. Despite its benefits, high costs and increased hazards appear as disadvantages for this technology. Suboptimal surgeon performance is a major hazard in many centers and can be overcome by an adequate training program. This work describes a reduced cost Training Program (TP) composed of three levels of theory and practice activities to improve the skills of the surgeons in MIS. The basic level is composed by 1 h of lessons on the videosurgery setup, optics and instruments, and a practice lessons composed of eight exercises in inanimate models. The intermediary level consists of 1 h of theory with 6 h of practice exercises in electrosurgery (chicken leg) and 4 h of laparoscopic suture in Neoderma simulation pieces. The third (advanced) level, consists of a hysterectomy in a living animal (pig). The investment in permanent assets for the basic and intermediary levels is roughly US$ 12,000,00; and for the advanced level, US$ 180,00 are needed per procedure. This TP has been applied in a multidisciplinary program involving medicine and clinical engineering areas in a University Woman´s Hospital. Twenty-one medical residents started the program and 10 completed all levels.

Keywords

Training program • Surgeon skill • Laparoscopy

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1 Introduction

Since the first laparoscopic hysterectomy (LH) performed by Reich [1], this procedure has grown in hospitals worldwide. LH has obvious advantages over open hysterectomy, e.g. reduced postoperative pain, reduced convalescence and small portholes leading to improved cosmetic outcomes (sometimes the great advantage in patient's perception). However, considerable adverse events have been reported [2]. One of the major factors associated with unsuccessful LH is suboptimal surgeon performance. The steep "learning curve" for laparoscopy procedures in general and LH in special has been pointed as chief among the disadvantages of laparoscopy [3]. Some methodologies have been developed to increase the surgeon skills in laparoscopy (very often named Fundamentals of Laparoscopic Surgery—FLS); most commonly, the trainee surgeon learns from performing surgery under the supervision of a more experienced fellow (supervised learning). Endotrainer box simulation and virtual simulation are often cited as adjuvant learning tools [4, 5]. However, it remains unknown which training model yields the best surgeon performance improvement, or are firmly defined the parameters used to define "surgeon performance". In addition, supervised learning poses risks, since the participation of untrained personnel in surgical procedures may be associated with extended surgical times, and additional complications. Virtual Reality Simulators, on the other hand, and currently beyond the financial possibilities of most public hospitals in Brazil, including our institution. Thus, we decided to develop a low-cost training problem to improve our professional´s laparoscopy skills.

This paper describes a reduced cost training program to improve the surgeon skills according the University Hospital needs. Our training program starts addressing perception and fine motor control, through training in inanimate models, and culminates with actual surgical procedures in living animals.

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2 Methods

Using the concepts of the MISTELS model [4, 5], we used endotrainer box constructed with opaque fiber, 10 flexible trocars ports, allowing to simulate different accesses for training and practice. The simulated cavity image is captured by a HD webcam and visualized by a computer video monitor, as shown in the Fig. 1

The training program encompasses three levels of progressive skill acquisition, simulating conditions faced by surgeons during real-life procedures. By the end of the program, students are expected to be able to perform complex activities, including perform surgery in a living animal, which in turn will make their further supervised training in human patients more efficient and safer.

The three levels of training are named: Basic, Intermediate and Advanced, and their contents are described below:

Basic: The basic level consists of theory classes and practice lessons. The objective is to give the trainees fine motor coordination and 3D-in-2D perception. The theory classes deals with videosurgery setup and gaining familiarity with equipment. The classes address the components of the Image Chain, starting with the patient (Abdominal cavity is considered the first component of the system), presenting the Electromedical Equipments (camera, light source, insuflator, …), the optical devices (endoscope, light cable,…), the surgical instruments (scissors, grasps, trocars,…) and reaching the video monitor, where the patient cavity is visualized by the surgeon as shown in Fig. 2.

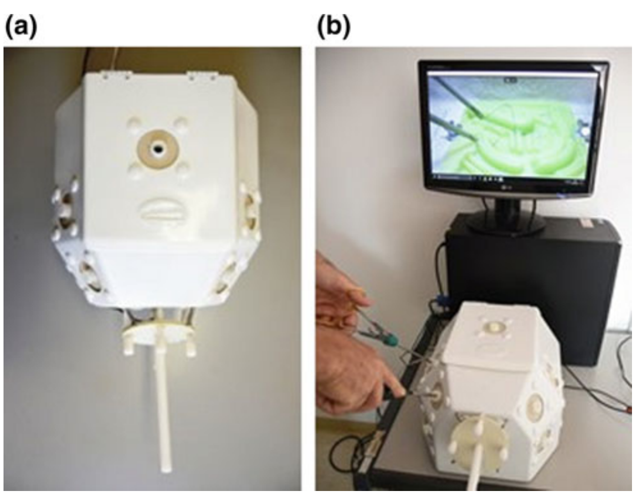


Fig. 1 **a** Endotrainer box; **b** Simulator system

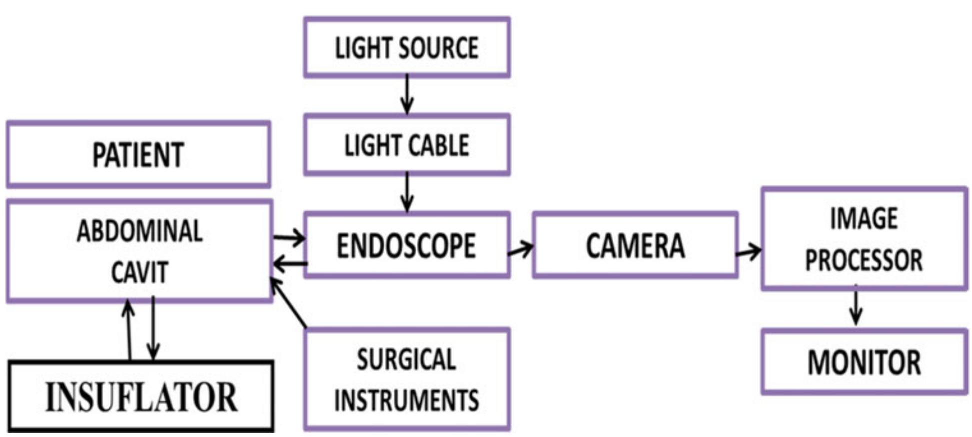
We consider important that the surgeon understands the image chain as a system and acquires fundamentals of operation of each component, becoming able to solve minor problems that could occur during the surgical procedure or to give more specific explanation for the clinical engineering team about the problems, optimizing its solution.

Next, the practical activity of this level is composed of 8 (eight) exercises, as presented below. Before starting with the exercises, a brief explanation is given. It is emphasized that all exercises should be performed using both hands ('two-hands surgery') and that all instruments must be kept in the field of vision. The 'two hands ability' is trained by forcing students into performing each exercise at least once with each hand.

The first exercise, named Pick and Place, was developed to give to the trainee the 2D x 3D perception and the haptic or kinesthetic sensation related to the endoscopic instruments, as grasps, scissors and needle holders, as presented in Fig. 3. Three rounds of each exercise, for each hand, are performed. During the entire session, the instrument held by the hand contralateral to that performing the exercise must be kept in the field of vision, as mentioned above.

Next, the trainee is exposed to perception and control skills, by being asked to put four training plastic pieces inside of a plastic vessel with 50 mm (2") diameter. The goal is to place the pieces inside the vessel without touching vessel walls. The simulated operating field is small and full of structures that cannot be touched, always keeping the

Fig. 2 Laparoscopy Image Chain



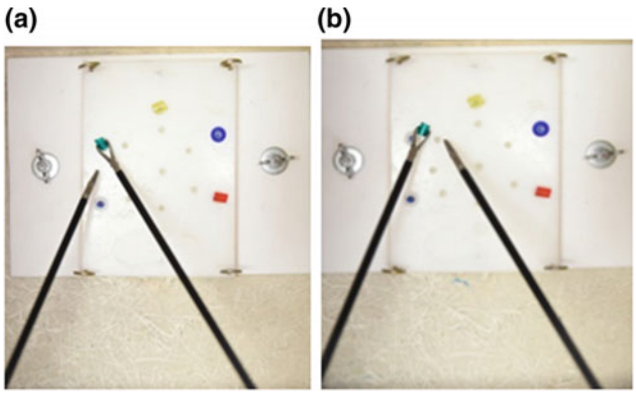


Fig. 3 Pick and place exercise **a** right; **b** left

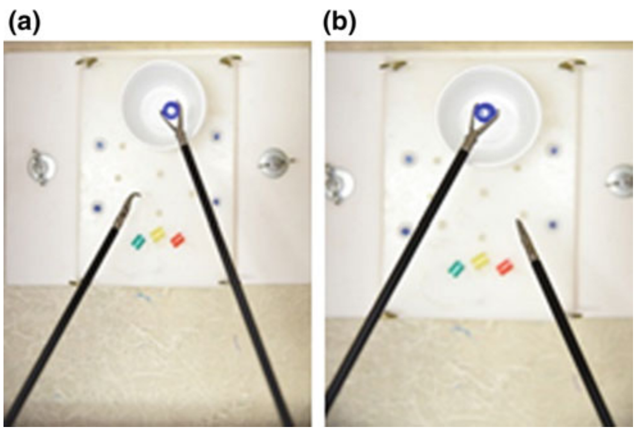


Fig. 4 Depth perception and control **a** right; **b** left

instrument held by the opposite hand inside the field of vision, as presented below (Fig. 4).

After training depth perception and control, students are asked to place different shape rings with 4 mm internal diameter in a 2 mm pin, to train delicate movements and fine 3D control (Fig. 5).

Next, we simulate Endobag use. During this activity, both hands are used. The trainee is asked to place four plastic pieces inside the bag, similar to surgical procedures where it is necessary to place biopsy specimens inside the endobags (Fig. 6).

Traction and force control. During laparoscopic procedure, surgeons need to traction tissues in order to cut and move. Thus, they use force that must be controlled, that is, insufficient force may result in loss of traction and excessive forces may result in tissue damage. The fifth exercise in the series consists of pulling four office elastics, to train traction forces and control, as presented in Fig. 7.

Cutting tissue is inherent to the surgical procedure, meaning that damage to the tissue is a necessary part of the surgical intervention. However, the aphorism “don’t cause greater damage than necessary” is valid, and students must

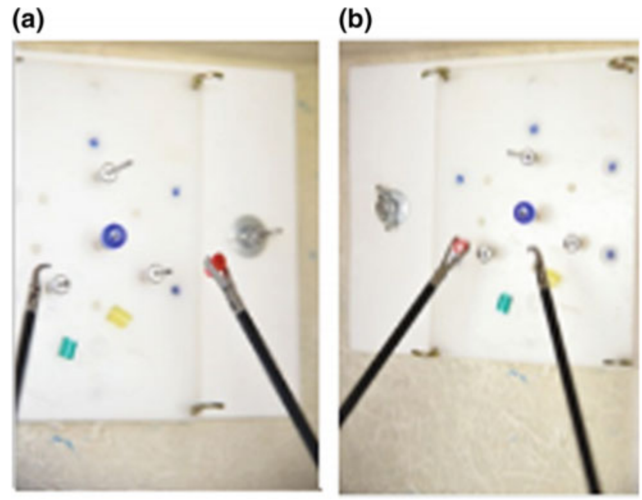


Fig. 5 3D fine perception and control **a** right; **b** left

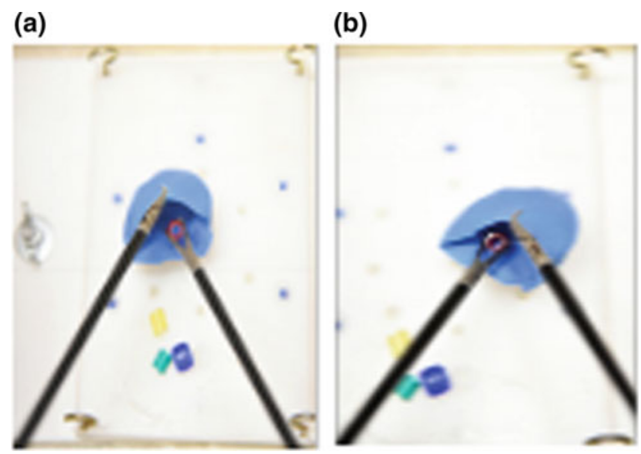


Fig. 6 Endobag simulation **a** right; **b** left

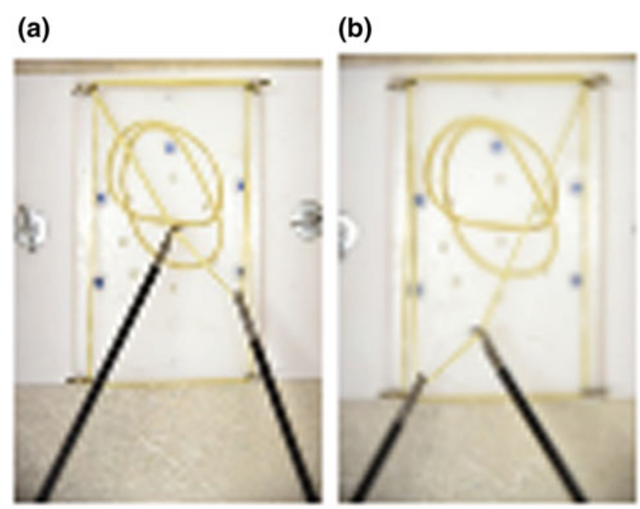


Fig. 7 Training traction and control **a** right; **b** left

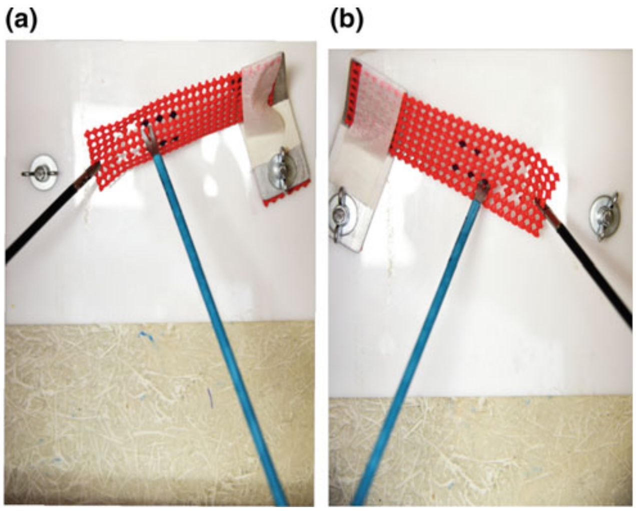


Fig. 8 Scissors cut training **a** right; **b** left

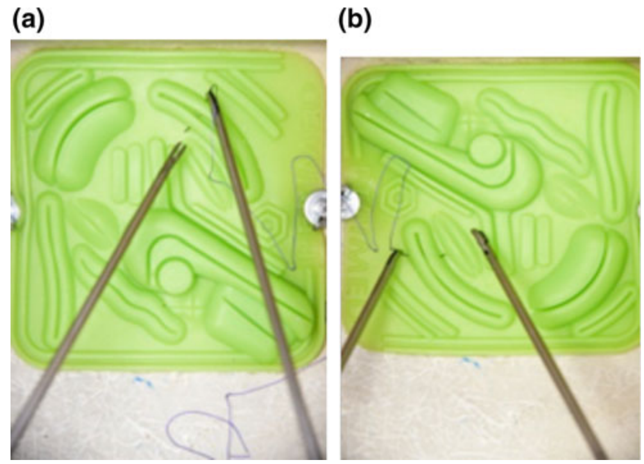


Fig. 10 Silicon model **a** right; **b** left

be trained to cut no longer or deeper than necessary. Due to optical magnification of the instruments, surgeons must learn to adjust range of motion. To train safe tissue dissection, we used an EVA 3 mm mash (piece and space) marked alternately, as shown in Fig. 8. Using laparoscopic scissors and clamps, the trainee was asked to hold and to cut inked tops without damaging the adjacent markings.

The final stage of the Basic Level is dedicated to preparing trainees to perform sutures. The first movement to be trained is ‘pick and position’ needles using the needle holder. We used foam to simulate and train deepness perception. The exercise consisted of the needle being passed through the peak of the foam piece, three times with each hand (Fig. 9).

When the students develop the ability to position and hold the needle, they repeat the exercise passing it through a silicon model that simulates the hardness of the tissue, as presented below (Fig. 10).

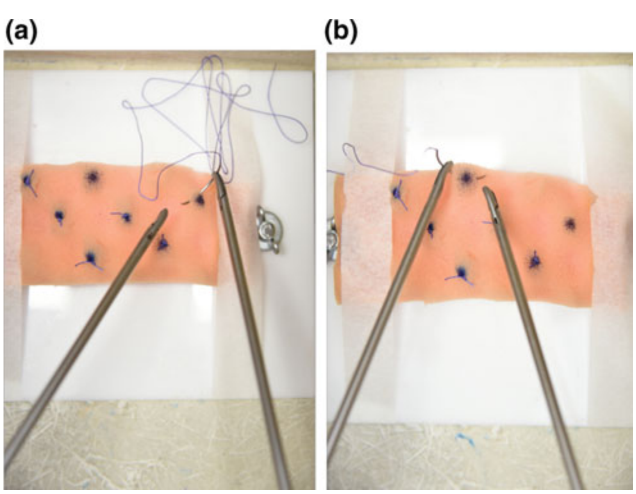


Fig. 9 Needle control foam model **a** right; **b** left

Students are scored according to the time spent to perform each exercise series.

Intermediary level: The intermediary level is aimed at developing students´ electrosurgical and suture skills. This levels comprise theory classes (1 h) about the principles, risks and injury prevention, and 4 h of laparoscopic suture in Silicon model. After training using the model, the resident physician performs 6 h of practice in monopolar electrosurgical dissection and cut in chicken leg, as shown in Fig. 11a and b. Next, they will have the opportunity to rehearse bipolar hemostasis, as shown in Fig. 11c. After cutting the chicken leg, the incision is sutured, as presented in Fig. 11d. The score of the electrosurgical procedures is obtained evaluating if the tissue was dissected and if the incision was done. Points are subtracted if adjacent tissue was burned. Sutures are considered optimal if sufficient to tie the edges of the tissues together and hold them firmly together. When the trainees develop fine movements and perception in the 2D-in-3D view, they are deemed ready to advance to the next level.

Advanced level: The last, the advanced level, consists of a hysterectomy in a living animal (pig), using the ethical and animal protection procedure, approved by Internal Ethics Committee on the Use of Living Animals.

Trainees are supposed to excise anatomical structures indicated by the Fellow, and to log injuries. Importantly, approval depends on the animal being still alive by the end of the procedure. Figure 12 shows the external and internal views of the procedure.

Experimentally, we evaluated the trainee laparoscopic surgical skills prior to the TP measuring time and quality of three types suture: open suture (Fig. 13a), laparoscopic suture with direct view (Fig. 13b) and laparoscopic suture with camera view (Fig. 13c) comparing it with the values and levels obtained by a trained surgeon.

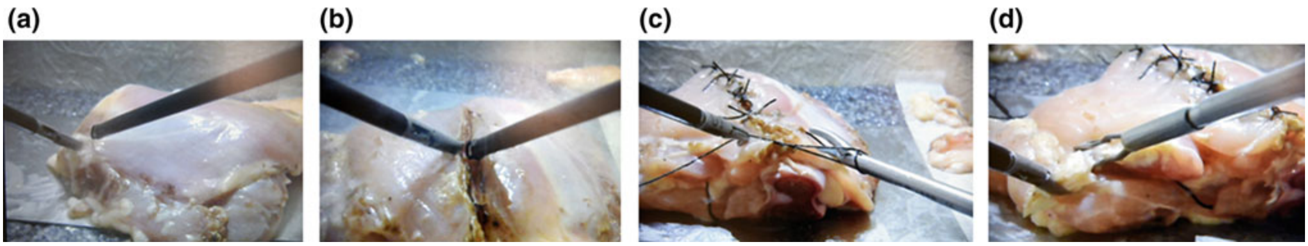


Fig. 11 Chicken leg exercises

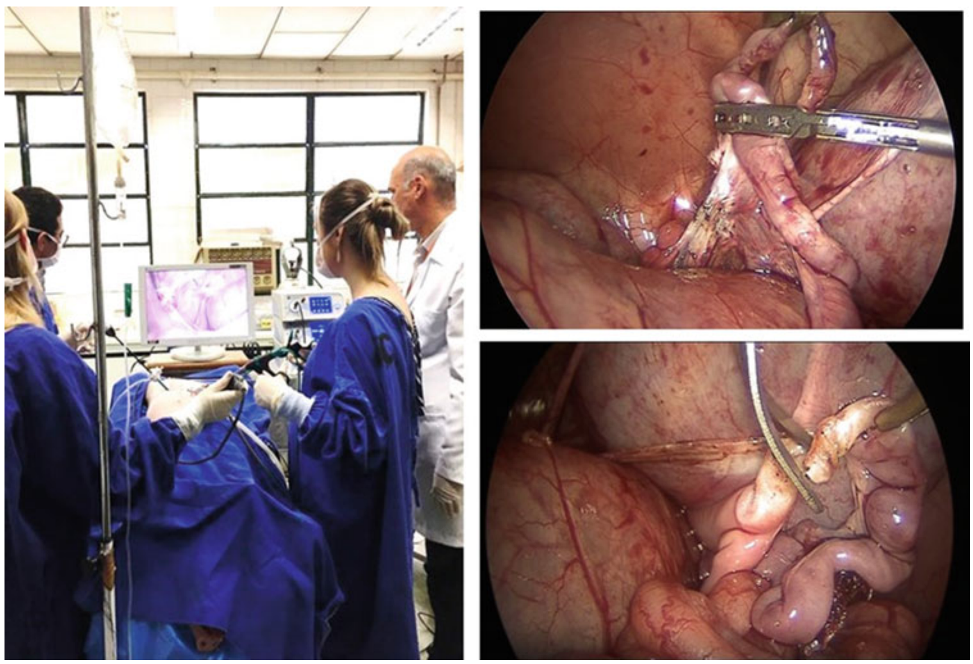


Fig. 12 Experimental living animal procedure

Fig. 13 Evaluation measuring

3 Results

During the two years of TP, a total of 21 residents participated in the program, divided into two groups, one per year. Eleven finished only the Basic Level, stating as reasons to abandon: no time to continue or showing no further interest in performing laparoscopy during their careers. Ten surgeons performed all the three levels (four residents of the first group and six of the second one), performing the living animal surgery. In the first year two surgeries were performed, each one with two residents. In the second year, two

Table 1 Activity measured time

Activity	Time	Realized
Novice open suture	00:26	3 knots OK
Novice lap suture direct view	04:44	3 knots OK
Novice laparoscopic suture camera view	05:00	Only needle pass
Trained surgeon laparoscopic suture camera view	02:50	2 Knots OK

animal surgeries were performed too, but with three residents forming each group. Four pigs were used for all procedures and all animals were still alive by the end of the procedures. In one surgery, the trainee cut a small blood vessel, which was sutured by the Fellow. After experimental surgery, the trained surgeons of the second group performed two hysterectomies, without any adverse events.

Table 1 shows the key achievements of the students and the time taken to perform.

4 Discussion and Conclusion

The initial investment was roughly U$ 8,000.00 to acquire the Endobox, the laparoscopic instruments, the models, the computer and furniture. At this moment the residents are performing some exercises of the Intermediate Level in more realistic simulators, however performed in the medical equipment manufactures plants. It was identified three new simulators and started the procurement expending U$ 4,000.00, thus enabling the University to realize full program in house.

Our low-cost laparoscopy TP resulted in adequate medical resident training in basic through advanced laparoscopy surgical skills, indicating its *cost-effectiveness viability*. The effectiveness can be assured by the successful surgery without patient injury. The cost can be figured when the expenses of our TP are compared to the expenses to make a similar training program in a private institution. In Brazil, the cost of a similar program is approximately U $ 2,500.00 per trainee. Calculating the total expenses of our TP, US$ 12,720.00 were spent (US$ 12,000.00 for investment in permanent assets [U$ 8,000.00 initial + U$ 4,000.00 new simulators] and US$ 720.00 to purchase four animals and anaesthetic drugs) to train 10 residents. Roughly US$ 25,000.00 would be spent to train the same 10 residents (US$ 2,500.00 × 10) in a similar private training program.

Conflicts of Interest The research being reported in this full paper was supported by Unicamp. The authors of this full paper are researchers and teaching member staff of Unicamp. All authors are involved in the development an innovative, low-cost Laparoscopy Training Program (FLS). The terms of this agreement were reviewed and approved by Unicamp at Campinas in accordance with its policy of objectivity in research.

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