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ORIGINAL RESEARCH

"Self-Designed Simulation-Based Laparoscopic Training Program for Urology Residents: Results After 6 Years of Experience"

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Introduction: Learning laparoscopy (LAP) is challenging and requires different skills to conventional open surgery. There is a recognized need for a standardized laparoscopic training framework within urology to overcome these difficulties and to shift learning curve from patient to skills laboratory. Simulation-based training has been widely commented, but implementation in real day practice is lacking. We present our "LAP training program for residents".

Material: Between 2017 and 2022, 11 residents participated in our self-designed program: Theoretical: (Moodle platform) basic knowledge and multimedia content for initiation into LAP. Evaluated through online exam. Practical: exercises for LAP skills acquisition were proposed and encouraged residents' practice in a box trainer available and experimental surgery sessions on a porcine model. On-site E-BLUS (European Basic Laparoscopic Urologic Skills) examination was performed annually. Feedback was obtained through an anonymous online survey.

Results: All residents positively evaluated the program. Theoretical: 82% passed the online exam. The most valued topics: LAP in special clinical situations, complications, instruments, and configuration of the operating room (OR). Practical: all residents increased dry-lab box practices. A total of 23 experimental surgical sessions were carried out. For 64%, simulation in the experimental OR was a necessary complement to achieve laparoscopic skills and allowed them to feel more confident. Forty-five percent considered it essential to improve their surgical technique. E-BLUS evaluation was valued as a means to achieve dexterity and safer surgery by 90%. Reduction in time and errors were observed through time, although only 2 passed the E-BLUS.

Conclusion: Our program for learning LAP includes the acquisition of knowledge, training of basic skills and surgical technique in a safe environment, as well as an objective evaluation. Encouraged practice of basic skills and surgical technique simulation and improved objective evaluation. It is structured, reproducible, systematic and has been positively valued, although it requires commitment for success.

Keywords: training, laparoscopy, resident, urology

Introduction

Today minimally invasive surgery using laparoscopic approach is a standard procedure in urology, which residents must learn during their training. Acquiring knowledge and skills to master laparoscopy (LAP) is challenging for those beginning their training.

The introduction of minimally invasive surgery as a tool for patients' treatment represented a revolution. Urologic surgery suffered a radical change, since LAP blasted at our operating room (OR) in early 90s. It also brought a shift in the way future surgeons were taught and acquired surgical skills. Training moved from the OR to the simulation laboratory.[1,2] Simulation-based training helps to acquire technical skills in a safe, controlled, and stress-free manner, although there is no universally accepted method for its application or evaluation.

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In Spain, the allocation process of specialist training position is widely known as "MIR" ("Médico Interno Residente") and literally means "Resident Medical Intern". Organized and regulated by the National Ministry of Health,[3] it is a one-sided sequential allocation mechanism where doctors choose their preferred training hospital according to their position in a pre-established ranking, for the full five-year formative period. Accredited hospital specialties play a passive role in selecting MIRs', notwithstanding must guarantee residents acquire full competency during their training period. MIRs' regulatory framework does not include or provide the method to achieve this process, since it only refers to the theoretical content and procedures that residents must learn, without mentioning the method to obtain surgical expertise.[3] The current training program is based on the traditional "master-apprentice", which consists in imitating the skills and behaviors of tutors and consultants.[4] Surgical opportunities and evaluation are conditioned by subjective criteria, creating variability between different centers and granting a passive role to residents.[5] Therefore, there is a gap in the way residents acquire skills and learn procedures that are required at the end of their official training.

It is necessary to find a structured model of surgical teaching in LAP, which includes basic knowledge, acquisition and evaluation of skills, as well as training in surgical techniques outside the OR.

Material and Methods

We present Fundación Jiménez Díaz University Hospital (FJDUH) "LAP Training Program for Residents" (R2-R5) and our results after 6 years of experience, 2017–2022 (11 residents). A self-designed proposal to standardize LAP training for our residents, providing theoretical knowledge and facilitating basic LAP skills acquisition in a safe and structured environment.

Starts from year two (R2), when MIRs join the service. It begins with a theoretical introductory course, through our own "Moodle" platform; "Aula Jiménez Díaz" (Table 1): a multimedia tour, created by the author of this article, with basic knowledge, reference bibliography, photos and videos for initiation in LAP. At the end, an online test exam of 40 questions is taken, in which 80% correct answers are required to pass the evaluation. Passing the theoretical course is mandatory before progressing to practical simulation.

All residents (R2 to R5) were invited to join the program and encouraged to perform practical exercises to stimulate the acquisition of basic skills (dry-lab box simulation). There are two box-trainers at our Urology Department with basic

Table 1 Index of Theoretical Contents of the On-Line Course

Title	Contents
1. Introduction	Historical development of laparoscopy in surgery and in Urology. • Milestones in laparoscopic surgery in Urology Difficulties in learning laparoscopy. New learning model base on simulation.
2. The operating room in laparoscopic surgery	General basic organization of the operating room to perform laparoscopic surgery. Ergonomics in laparoscopy. Basic instruments and complementary materials in laparoscopy.
3. Starting surgery.	Patient positioning for laparoscopic surgery. Initiating pneumoperitoneum: • Veress needle. • Hasson's technique. • Hand-assisted laparoscopy.
4. Pathophysiology of pneumoperitoneum	Effects on physiology: • Ventilatory • Hemodynamics • Perfusion of abdominal organs • Intracranial pressure • Hormonal, metabolic and immune system effects

(*Continued*)

Table 1 (Continued).

Title	Contents
5. Laparoscopy in special situations	Performing laparoscopy in: • Morbid obesity • Previous abdominal surgery • Pelvic fibrosis • Visceromegaly • Ascites • Pregnancy • Hernias • Aneurysms
6. Complications in laparoscopic surgery	Potential complications and their resolution: • Creation of pneumoperitoneum • Insufflation and pneumoperitoneum • Of the surgical procedure itself • In the removal of the trocars
7. Bibliography	Reference and must-read articles

instruments for practice. Surgical technique training is scheduled at the FJDUH experimental OR on a porcine model. At the experimental OR MIRs' have to fulfill basic, intermediate and advanced exercises depending in their year of residency and expertise.

As a means for encouraging practice, evaluate progress and provide feedback on their evolution, yearly a "home" European Basic Laparoscopic Urologic Skills (E-BLUS) exam[6,7] was performed to all residents every year (5 exercises: "peg transfer", "circle cut", "simple knot", "clip & cut" and "needle guidance") (Figure 1). The E-BLUS program organized by the ESU (European School of Urology) section of the EAU (European Association of Urology), as the first step of a study plan offered to residents and urologists who want to improve their expertise in LAP.[8] Includes an on-line theoretical course and "hands-on training" taught by expert tutors on a set of exercises performed in a dry-lab box and finally, a standardized exam for the evaluation and certification of competencies.[9]

Evaluation, feedback and feedforward report was performed every year, during the study period, by the authors of this paper RC, GBS and AHA. We evaluated resident progress yearly and collect participant's opinions through an anonymous online survey.

As a control group, we included four R5 residents (n = 4) that visited our hospital as observers for at least 2 months during the study period. None of them had anything similar at their hometown hospital nor previously contacted our LAP training program. All did the theoretical introductory course and the E-BLUS examination at the end of their visit to our service.

Results

All residents took the introductory theoretical course in their R2 year. Spending from 6 to 8 hours on the course and its on-line evaluation. Eighty-two percent passed the evaluation (>80% correct) on first attempt (9/11). The most valued topics were "The OR in laparoscopic surgery" and "LAP in special clinical situations" for 90% (10/11), followed by "Complications of laparoscopic surgery" for 82% (9/11).

Practical exercises were carried out by 100% of the residents. Regarding dry-lab box practice, 100% (11/11) acknowledged increase their simulation hours, either throughout the year (54.5%, 6/11), when the practical exam approached (27.2%, 3/11) or irregularly (18.1%, 2/11), respectively (45%, 5/11), reported exercising between 0–5 and 5–10h/month, while 9% (1/11) reported simulating very irregularly.

Only 2 residents (18.2%, 2/11) passed the home-made E-BLUS, full 5 exercises evaluated by the author of this article, with no disqualifying errors and on time, both were R5. However, even if the exam was not passed, a reduction in execution time and errors was observed in subsequent years (Figure 2). All R5s' visitors participated in the study, 100% passed the online theorical evaluation (>80%), and none the E-BLUS practical evaluation (Figure 3).

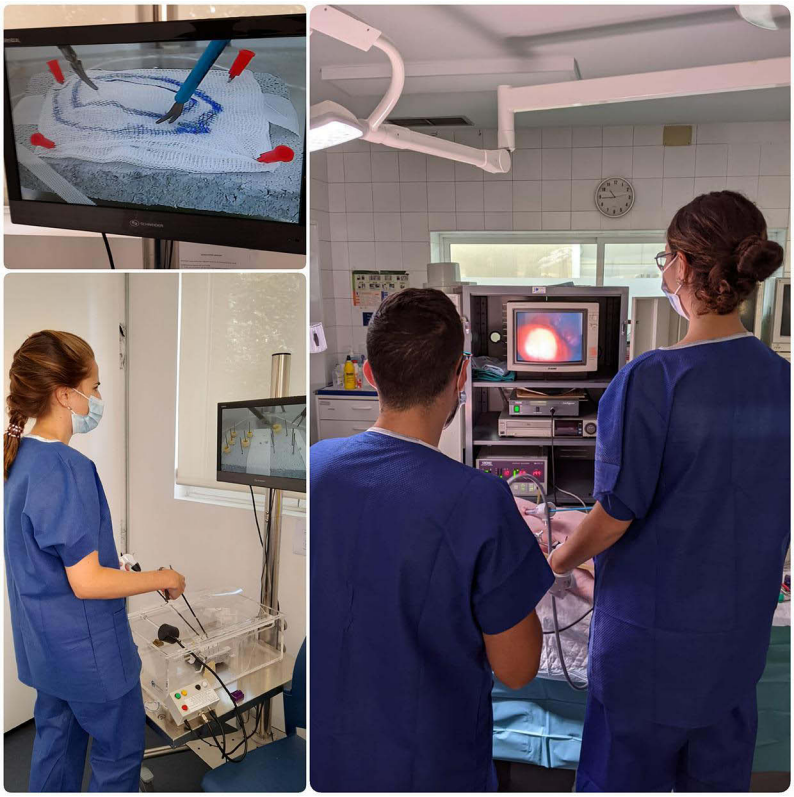

Figure 1 Residents participating in the FJDUH laparoscopic training program.Top right: E-BLUS "circle cut" exercise. Bottom right: practice on the E-BLUS "peg transfer" exercise on a pelvic trainer. Left: surgical simulation day on a porcine model in the FJDUH experimental operating room. Residents have given authorization to publish the pictures.

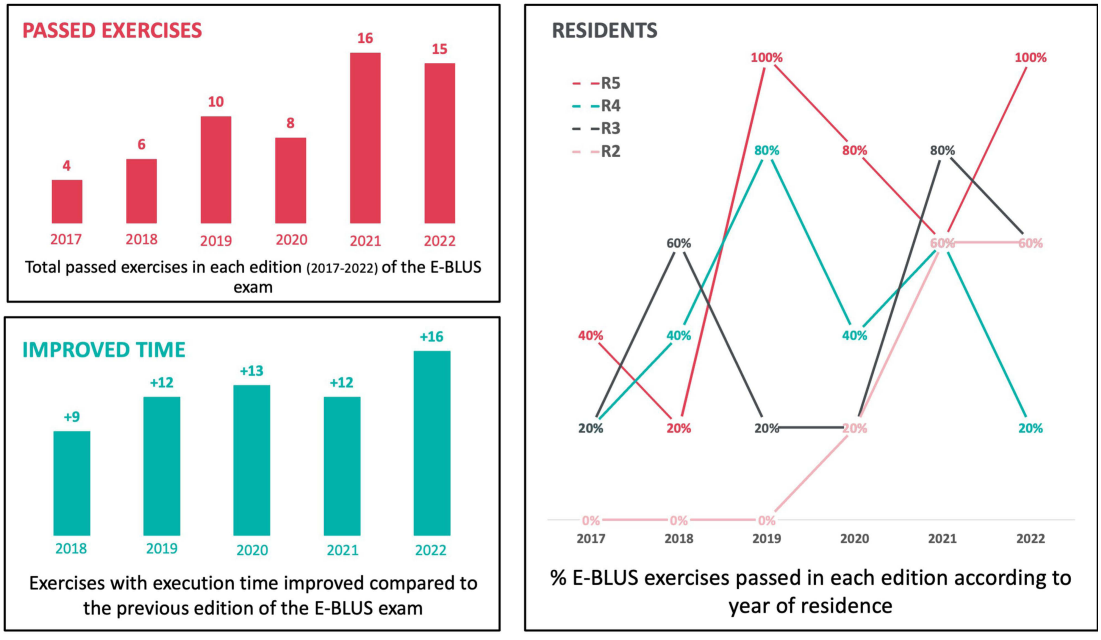

Figure 2 Total exercises in each edition of the E-BLUS exam. Exercises passed in each edition according to year of residency. Exercises in which execution time is improved compared to the previous edition.

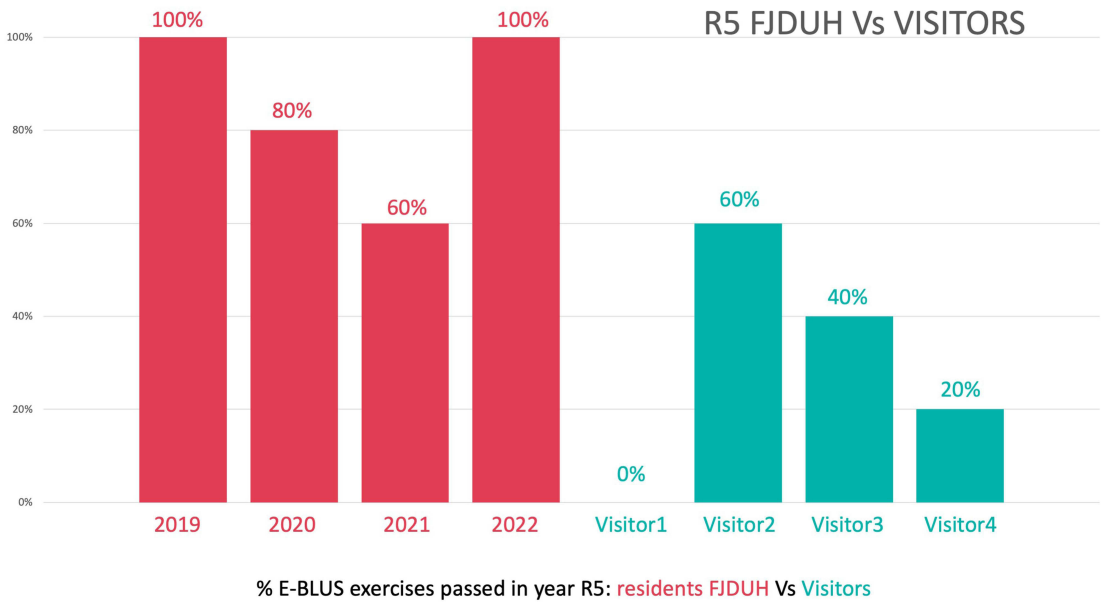

Figure 3 Total exercises passed in the E-BLUS examination (5 exercises evaluated): FJDUH (left side) Vs last year residents from hospitals without standardized LAP training program visiting our service during the study period (right side).

A total of 23 experimental surgical sessions were carried out. The surgical team was organized with a R5-R4 and a R2-R3 for each of these days of surgical practice. The exercises performed at basic level (23 creation of pneumoperitoneum and trocar placement), intermediate (30 nephrectomies, 6 cystorrhaphys) and advanced (20 partial nephrectomies, 6 pyeloplasties, 2 urethro-vesical anastomoses) were recorded.

In the anonymous evaluation survey (Table 2), 100% of FJDUH residents (11/11) evaluated positively the program. All of them claimed to improve their bimanual dexterity, 81% (9/11) their suturing technique and 72% (8/11) their hand-eye coordination and spatial orientation. For 90% (10/11), the E-BLUS evaluation is a means to achieve skills and safer surgery.

For 64% (7/11), experimental surgery is a necessary complement to achieve LAP skills in a close to clinical scenario and declared that they felt more confident when facing surgery. Some felt that it was essential to improve their surgical technique (45% (5/11)).

Table 2 Survey: Anonymous Online Evaluation Questionary Fulfilled by All Residents' Participants

Question	Contents					
1. General evaluation of the program	0	1	2	3	4	5
2. General evaluation theoretical contents of the course	0	1	2	3	4	5
3. Theoretical course: Evaluate the most valuable chapters	Enumerate					
4. Did the program made you increase your practices at the box-trainer?	• No • Yes, but just when the exam was close • Yes, but irregularly • Yes, all year through					
5. Which of these basic skills you improved the most?	• Eye-hand coordination • Bi-manual coordination • Suture technique • 3D orientation • Clipping and cutting technique					

(*Continued*)

Table 2 (Continued).

Question	Contents
6. Did the program facilitate your basic LAP skills acquisition?	• Yes, definitely as much I practiced more I improved • Yes, my skills improved, but it was due to the combination of practice, other courses and everyday surgical practice • No, I did not feel any modification on my learning curve • No, in any way.
7. Estimate hours/month (h/m) of box practice during your residency	• 0–5 h/m • 5–10 h/m • 10–15 h/m • >15 h/m • Variable through the year
8. What is your opinion about EBLUS exercises and exam?	• EBLUS is a goal. It should be mandatory before acquiring Urologist certification, no matter your area of expertise. • EBLUS is a goal. Warranties that you have the skills for LAP surgery. • EBLUS is the way to stimulate practice and acquire skills for a save LAP procedure. But that does not mean that you know how to perform LAP surgery. • EBLUS is useless
9. Experimental surgery practices: express your opinion	• Are a complement for skills acquisition in a near to clinical scenario. • Are expendable but are interesting to do • I feel more confident if I have done a certain procedure on the experimental OR before I try it with a patient. • It is an essential tool to improve my surgical technique • Not interesting at all • I prefer doing experimental OR practices outside my hospital

Discussion

Urology training in the 21st century takes the resident into an exciting five-year period, in which he or she faces an avalanche of theoretical knowledge that must be combined with the acquisition of abilities to master surgical procedures in a highly technological specialty. General training in Urology is heterogeneous and asymmetrical in our country and within Europe, and LAP is no exception.[4,10–12] Despite progressive establishment of modular training programs in LAP, implementation is far from being generalized.[13] Some countries include some kind of LAP training in their curricula to provide surgical skills prior to completing residency, although there is wide variation between different agendas.[10] Even within the same country there are important differences between academic hospitals. In Europe, only 58% of residents acknowledge having been trained in LAP, and only 44% of teaching hospitals have simulation centers.[11] Meanwhile, in our country, only 50% residents are trained in hospitals with an experimental surgery department, which use less than 20%.[12] Compared with other specialties, Urology residents who finish training have low confidence in undertaking LAP surgery as a main surgeon (26.9%), similar to Gynecology (28.8%) but unlike General Surgery (52.2%).[14] The majority claim greater exposure to LAP during their residence.[10]

Currently, in Spain, the resident training schedule of the Ministry of Health for Urology does not include the method, nor does it require any proof of knowledge or validation of surgical skills at the end of the residency.[3] In recent years, the "Asociación Española de Urología" (AEU) (Spanish Association of Urology) has proposed some skills validation models, which have not been ultimately put into practice.[5,15] We cannot blame on the lack of infrastructure, there are centers in Spain with great experience and excellent facilities where skills training as well as surgical technique simulation can be carried out. These institutions offer courses, conferences, masters and surgical training simulation

stays.[16] Unfortunately, we must consider them as a complement and not as the way to learn and acquire skills, since it is very difficult to obtain funding for courses, and they are far from everyday practice. Our program seeks to complement our resident traineeship, providing a solution to this problem.

We include our R2 in the agenda, and they must begin their training as soon as possible.[1] If a trainee has been trained in LAP during residency, it is more likely to perform laparoscopic procedures in the early days as urologist.[17] In addition, all our residents participate in the daily LAP surgical activity of the service, according to the formation timetable and year of residency. They will acquire a progressive role in surgery, carrying the camera, as assistant surgeon or main surgeon according to their evolution at the discretion of the consultant responsible for surgery.

To get started in LAP it is necessary to know the basic and peculiar theoretical fundamentals of this surgical approach. Theoretical content, available through the "Aula Jiménez Díaz", was designed in an attractive multimedia environment, to provide essential knowledge (Table 1). Reviews the history of LAP, milestones in the specialty and difficulties in performing procedures on a 2D or 3D screen, with less tactile sensitivity, depending on instruments and imaging media.[18] Teaches how OR should be organized for LAP surgery, both specific and complementary materials. It covers principles of safe patient positioning and the different techniques for initiating pneumoperitoneum. An essential section is patients' pathophysiological response of different organs and systems under LAP. Peculiar clinical situations are presented in which performing LAP requires special consideration, and alerts are given to main complications that may arise in an LAP procedure, as well as how to resolve them. Finally, reference bibliography is presented. To ensure the acquisition of knowledge, students are subjected to a test exam at the end of it.

Simulation aims to approach the same situation several times, to understand it, apply different strategies to solve it, evaluate all the pros and cons, select a preferred approach and improve it safely. It is widely used in various fields not related to medicine or surgery.[13] Acquiring expertness with a simulator requires dedication and discipline but is more effective than the traditional training method and promotes transferring skills to real surgical environment in a safer way.[19] The main target in simulating LAP skills is practicing simple abilities, such as camera handling, grip, pull-against-pull, cut and knotting. These basic competencies are common to any laparoscopic procedure, and as they can be acquired in a dry-lab box, in a suitable environment, without stress nor harming the patient on whom are practiced; therefore, a novice surgeon should never learn on a patient.[1,20] The development of the psychomotor domain is achieved through repetition until it reaches automation; surgical simulation has changed the way we learn surgery.[15] A further step is to achieve surgical competence, as it includes the knowledge, skills and attitudes to carry out a procedure, and implies the surgeon's ability to perform a certain task. Unfortunately, there is no universally accepted criterion to measure this level of competence.[15]

The material needed on which practice LAP does not have to be complex or sophisticated. There are multiple "homemade" models that have proven their worth for simulation, they are as useful as modern virtual reality simulators for learning basic skills in LAP.[1] In our program, basic LAP instruments are used to acquire skill, and it is practiced on synthetic material, avoiding the use of animals, which is an economical and easily available model. They learn in a decent simulation environment, although it is not optimal, it helps to overcome the technical and technological difficulties that often arise in the OR.

Although basic laparoscopic skills are already well documented and standardized, more complex exercises aimed at achieving intermediate levels of training are not defined or incorporated into validated programs. Intermediate training is much more specific to each specialty and should be focused on the acquisition of skills that allow complex steps and complete procedures to be carried out. At this stage, the student must link all the concepts learned along to perform the complete procedures (make mistakes and learn to improve) in a safe and simulated environment, before working on a real patient. Education must also complement the acquisition of technical expertise, decision-making and patient management.[20] Different simulation scenarios will be required for this level, as well as facing the steps of surgical procedures for which the student is prepared. Simulation sessions in the experimental OR provide an ideal setting to rehearse this intermediate level, practicing surgical techniques (basic, intermediate or advanced) on the experimental animal before facing surgery on a real patient. In the experimental environment, surgical team (junior and senior resident) assume a leading role in a scenario similar to daily clinical practice.

Initially intended as a stand-alone certification, E-BLUS is rapidly evolving into the first step in a comprehensive path, initially guiding from basic skills to performing full procedures.[20] Our program uses E-BLUS appraisal as a means of assessing learning progression, encouragement for practice, and skill acquisition.[6,7,21,22] During the program, in addition to the evaluation, progress observed is discussed with the resident, as well as areas of improvement on which work must be done. It is essential to provide feedback on practice and evolution in the acquisition of skills.[1] An individualized report during practice improves performance.[1,23]

This study has obvious limitations, like small sample size and a single-center experience, and it is not a case–control study. But when comparing performance at E-BLUS examination of our last year residents with visitors from other hospitals with no structured LAP training program, our residents did better (Figure 3). Forcefulness of these observations and real impact on LAP training and surgical learning curve need further evaluation.

Stepping forward between acquiring skills and reaching the ability to perform the complete procedure, facing the circumstances that make its execution difficult, is possibly the most challenging thing in the learning process of LAP. The proposed plan probably could be improved, but together with monitored participation in service's LAP surgical activity, it can help in this process. This is supported by the opinion collected from residents who have participated. Although we cannot forget that to achieve these objectives, commitment, perseverance, and determination of participants are essential, furthermore they must contribute with an active and self-critical role.

Conclusions

The FJDUH program for learning LAP includes the acquisition of knowledge, training of basic skills and surgical technique in a safe environment, as well as its objective evaluation. Encouraged practice of basic skills and surgical technique simulation and improved objective evaluation. It is structured, reproducible, systematic and has positively valued, although it requires commitment for success.

Ethical and Consent Statements

All authors have obtained prior to submission valid written releases from all patients whose names, photographs or other protected health information are submitted as part of the work, and all authors shall maintain such releases and inform the editors in a timely manner of any revocation by a patient of such a release. People in Figure 1 approved and had provided written informed consent for their images to be published within the article. Investigation published within this article was revised and approved by the IIS-FJD (Instituto Investigación Sanitaria Hospital Fundación Jiménez Díaz) and the Ethics Committee.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. Finally, all authors agree to take responsibility and be accountable for the contents of the article.

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