Common surgical training program: standardization of learning quality

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ABSTRACT

Introduction. The various surgical specialties in our center have used the simulation and experimental surgery resources available for their training tasks in minimally invasive surgery (MIS) in an individualized manner. With this learning model, a great dispersion of effort and expense was observed, so it was decided to create a unified program based on the following: shared learning, synergy among specialties, moderation of the economic cost, and rational use of the facilities.

Objective. To describe and assess our consensually designed training program in order to consolidate a shared learning strategy that will enable our residents to acquire and perfect surgical skills in MIS.

Materials and methods. The program consists of various increasingly complex phases implemented on a continuous basis throughout the period of specialized training in the virtual laboratory and experimental operating room. The assessment methods were based on quantifiable criteria: percentage of efficiency and completion time of the "McGill Inanimate System for Training and Evaluation of Laparoscopic Skills" (MISTELS) exercises at the beginning and end of the program. An economic study was also conducted.

Results. 20 residents have completed the program. Mean times show a significant reduction in each of the exercises. The efficiency percentages at the end of the program were higher than at the beginning ($p < 0.001$). The cost of the program represented a saving of 67.89%.

Conclusion. The new MIS training program improved the quality of learning in a safe environment, establishing common criteria among the different specialties and an improved use of resources.

KEY WORDS: Training; Standardize; Training program; Simulation; Experimental surgery.

PROGRAMA DE FORMACIÓN QUIRÚRGICA COMÚN: UNIFORMIDAD EN LA CALIDAD DEL APRENDIZAJE

RESUMEN

Introducción. Las diferentes especialidades quirúrgicas de nuestro centro han usado los recursos de simulación y cirugía experimental para sus tareas de formación en cirugía mínimamente invasiva (CMI) de manera individualizada. Con este modelo de aprendizaje se detectó una gran dispersión de esfuerzos y gasto, por lo que se decidió crear un programa unificado basado en: aprendizaje compartido, sinergia entre especialidades, moderación del coste económico y uso racional de las instalaciones.

Objetivo. Describir y evaluar nuestro programa de entrenamiento diseñado por consenso de cara a la consolidación de una estrategia de aprendizaje compartido que permita a nuestros residentes adquirir y perfeccionar habilidades quirúrgicas en CMI.

Material y métodos. El programa consta de diferentes fases con complejidad creciente desarrolladas durante todo el periodo de formación especializada de forma continuada en laboratorio virtual y quirófano experimental. Los criterios de evaluación se basaron en criterios cuantificables: porcentaje de eficiencia y tiempo de realización de los ejercicios de *McGill Inanimate System for Training and Evaluation of Laparoscopic Skills* (MISTELS) al inicio y final del programa. Se realizó también el estudio económico.

Resultados. Han completado el programa 20 residentes. Los tiempos medios demuestran una reducción significativa en cada uno de los ejercicios. Los porcentajes de eficiencia al final fueron mayores que al inicio del programa ($p < 0,001$). El coste del programa supuso un ahorro del 67,89%.

Conclusión. El nuevo programa de entrenamiento en CMI mejoró la calidad de aprendizaje en un entorno seguro, estableciendo criterios comunes entre las diferentes especialidades y un mayor aprovechamiento de los recursos.

PALABRAS CLAVE: Formación; Unificar; Programa de entrenamiento; Simulación; Cirugía experimental.

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INTRODUCTION

Nowadays, minimally invasive surgery (MIS) has become a key procedure in most surgical specialties, including pediatric surgery. Therefore, the acquisition of these skills is of utmost importance in the training of our residents.

Thanks to technological advances, since the 1990s, virtual and experimental surgical training has been progressively introduced to our center, where the different surgical specialty programs have used simulation and experimental surgery resources to carry out MIS training tasks on an individualized basis. A great dispersion of efforts and excessive expense was observed in this training model, so it was decided to establish common criteria for the development of a standardized surgical training program based on the following: shared learning, synergy among specialties, moderation of economic cost, and rational use of the facilities. To this end, during the 2010/2011 academic year, one of the strategic objectives of our center became the creation of a common training model in MIS - more specifically in laparoscopic surgery (LS) - for the various surgical specialties, combining theoretical teaching and practical training both in the virtual laboratory and in the experimental operating room.

The acquisition and improvement of MIS skills can be measured objectively using standardized systems validated in the literature. From among these published training systems, we decided to focus on the McGill University MISTELS ("McGill Inanimate System for Training and Evaluation of Laparoscopic Skills") system, since it has proven to be valid in all the surgical specialties included in our program: pediatric surgery, general and digestive surgery, urology, and gynecology. Proof of this is the use of this system in the certification models of several important training programs such as the "Fundamental Laparoscopic Skills" (FLS) program of the Society of American Gastrointestinal and Endoscopic Surgeons, the "European Basic Laparoscopic Urological Skills" (E-BLUS) program of the European Association of Urology, or the "Gynaecological Endoscopy Skills of the European Associations" (GESEA) program of the European Society for Gynaecological Endoscopy.

This laparoscopic training system consists of easily reproducible elements, which makes it possible to extrapolate it to any training center that can provide a training box or "pelvitrainer," a camera, laparoscopic instruments, and a monitor. The model is designed to simulate the essential technical skills for MIS, such as hand-eye coordination, motor coordination of both hands, depth perception, and the adaptation of three-dimensional vision to two dimensions, all synthesized in 5 exercises: pin transfer, pattern cutting, preformed sliding loop placement, extracorporeal knot suturing and intracorporeal knot suturing.

Our main aim in this article was to describe and assess our surgical skills training program for LS, designed by consensus among the various specialties, with objectifiable levels of surgical skill of gradually increasing complexity, with a view to consolidating a shared learning strategy that will enable our residents to acquire and perfect surgical skills and habits in MIS.

In addition, since progress in MIS skills can be objectively measured according to the quantifiable MISTELS criteria, we present the results of the efficacy obtained following program implementation.

MATERIALS AND METHODS

Our training program was created according to the following principles:

- Detailed planning and programming by considering objectives, contents, activities, scenarios, and levels of complexity.
- Availability of a multidisciplinary teaching team made up of members from the four surgical specialties and complemented with specialized medical teaching staff and a research unit.
- Availability of the necessary equipment.
- Assessment of the effectiveness and economic cost of the program.

The program consists of various phases of increasing complexity, since it is conducted throughout the training period as a resident physician or MIR (Spanish initials for "resident physician") from MIR2 to MIR5 in the case of pediatric surgery, general and digestive surgery, and urology; and from MIR2 to MIR4 in the case of gynecology and obstetrics, since the training period for the latter medical-surgical specialty is four years. A single common learning scenario was established and shared between residents and teachers of the various specialties, using appropriate facilities: virtual laboratory and experimental operating room (Fig. 1).

The program schedule (Fig. 2) was designed in such a way that the first year of training, MIR2, is carried out in a virtual laboratory with tutored face-to-face sessions and self-study sessions. This arrangement continues in the following year of training, MIR3, but training in the experimental operating room is gradually introduced, as the basic skills and concepts have already been successfully acquired at this level. Finally, it was decided that, during the final years of training, MIR4 and MIR5, priority should be given to training in the experimental operating room, given its greater similarity to clinical practice and the need to acquire more complex LS skills. Table I shows the total hours of the course and their distribution at each level.

In our program, it was decided that the teachers of a particular specialty would teach trainess in their own specialty as well as those from other specialties, with the aim of offering our residents the most varied and diverse training possible, regardless of their specialty.

Figure 1. A) Experimental operating room. B) Virtual laboratory.

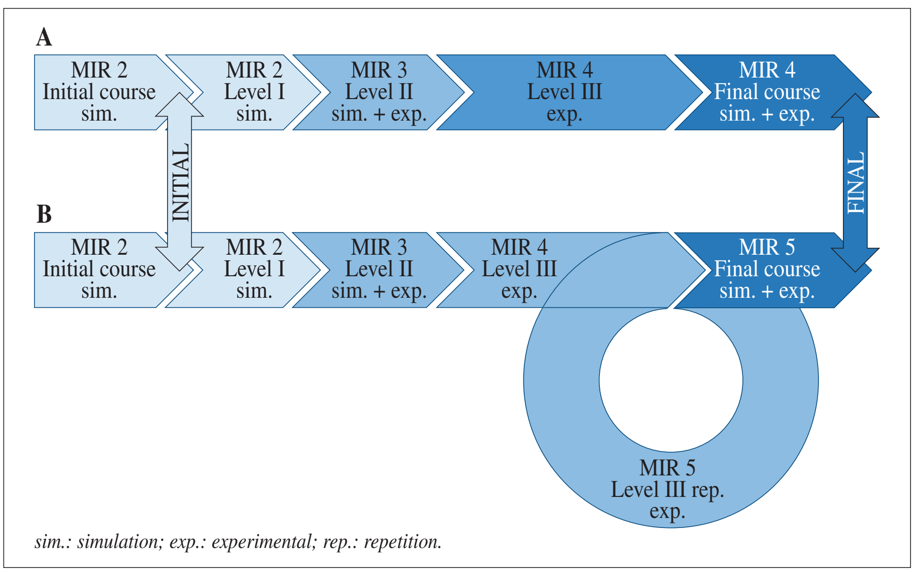


Figure 2. Training program schedule. Efficiency measurements at the beginning and the end of the program are represented as vertical arrows in the diagram. A) Schedule followed by specialties with 4 years of training (gynecology and obstetrics). B) Schedule followed by specialties with 5 years of training (pediatric surgery, general and digestive surgery, and urology).

The program's efficacy study was conducted between January 2016 and May 2021, after being assessed by the Teaching Commission of the Ezkerraldea-Enkarterri-Cruces Integrated Healthcare Organization (OSI-EEE) in 2015, subsequently approved by the Medical Directorate, and authorized by the Management Directorate of our center. The 5-exercise MISTELS system was used to measure surgical skills, taking measurements at the beginning and the end of the program. The MISTELS exercises and their respective reference times were as follows: peg transfer (reference time, 300 s.), pattern cutting (reference time, 300 s.), endoloop (reference time, 180 s.), extracorporeal knot (reference time, 420 s.), and intracorporeal knot (reference time, 600 s.). In our case, in order to adapt to the available resources, it was necessary to modify one of the MISTELS exercises, replacing the endoloop placement exercise with a similar exercise involving the placement of a fixed stitch with an external Roeder sliding knot, thus also adapting the reference time (reference time, 420 s.) (Fig. 3). These exercises are carried out in training boxes or "pelvi-trainers", which in our case were designed and developed by the teaching team specifically for the program, meeting all the criteria of the American FLS certification (Fig. 4).

In the Initial Course (MIR2) and Final Course (MIR4-MIR5), time measurements were taken for each exercise and compared with the MISTELS reference times, adding time penalties of 5 seconds for each error committed, to calculate the percentage efficiency of each trainee according to the equation:

$$\text{Efficiency } \% = \frac{(RT - ST) \times 100}{RT} - (n^{o} \times 5)$$

RT: MISTELS reference time for the exercise; ST: time in which the trainee has performed the exercise; nº: number of errors made.

Table I. Distribution of program hours by levels.

Program phase	*Type of teaching*	*Tutored face-to-face Hours (sessions)*	*Distance learning online*	*Self-study*	*Total hours*
Initial course	Theory/Videos	2	7	–	
Simulation	*Pelvitrainer*	16 (4)	–	–	25
(MIR-2)	Animal model	–	–	–	
Level I	Theory/Videos	–	–	–	
(MIR-2)	*Pelvitrainer*	4 (1)	–	36 (9)	40
	Animal model	–	–	–	
Level II	Theory/Videos	–	–	–	
(MIR-3)	*Pelvitrainer*	4 (2)	–	16 (4)	25
	Animal model	5 (1)	–	–	
Level III	Theory/Videos	–	–	–	
(MIR-4)	*Pelvitrainer*	–	–	–	15
1st cycle	Animal model	15 (3)	–	–	
Level III	Theory/Videos	–	–	–	
(MIR-5[a])	*Pelvitrainer*	–	–	–	15[a]
2nd cycle	Animal model	15 (3)[a]	–	–	
Final course	Theory/Videos	2	3	–	
Experimental	*Pelvitrainer*	5 (1)	–	–	15
(MIR-4[b] and -5[a])	Animal model	5 (1)	–	–	
				Total hours MIR-5[a]	**135**
				Total hours MIR-4[b]	**120**

[a]: only 5-year specialties: pediatric surgery, general and digestive surgery, and urology; [b]: 4-year specialty: gynecology and obstetrics.

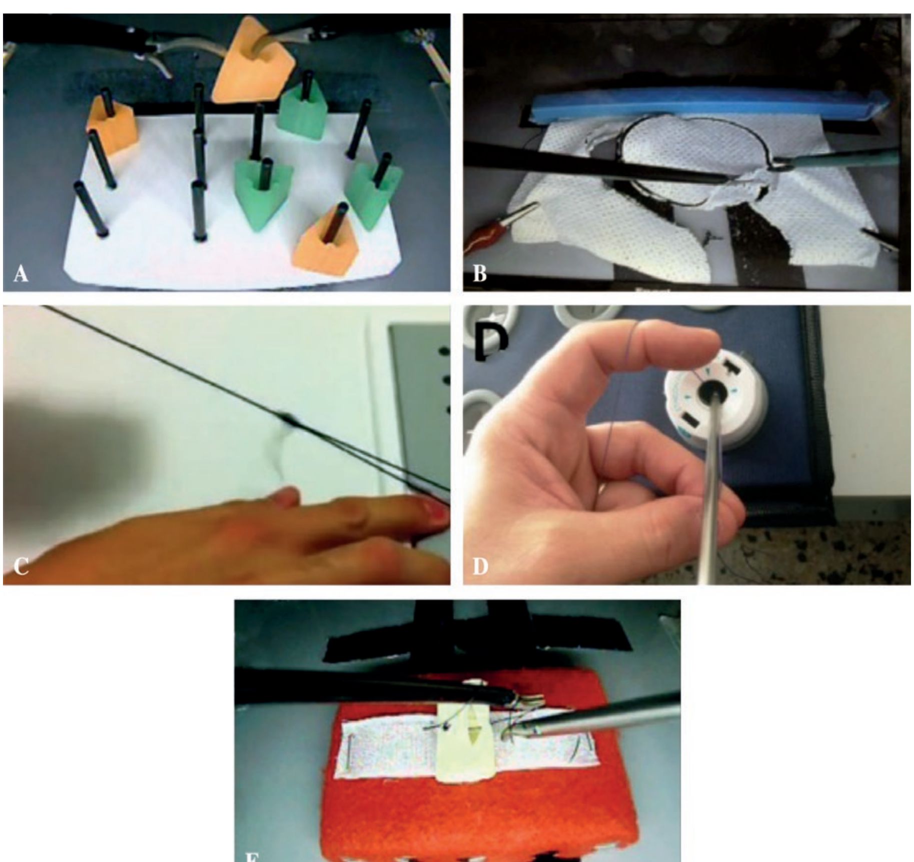


Figure 3. MISTELS exercises with modification of 1 exercise. A) Transfer exercise: transfer of different elements from one side of the template to the other using both hands (reference time: 300 s). B) Cutting exercise: a 5 cm template is cut out and checked for accuracy (reference time: 300 s). C) Modified Roeder loop exercise: a stitch is made and fixed with an external Roeder slip knot (reference time: 420 s). D) Extracorporeal knotting exercise: a stitch is made and fixed with 3 simple knots positioned with a knot pusher (reference time: 420 s). E) Intracorporeal knotting exercise: a stitch is made, and a double knot is conducted with intracorporeal knotting and a simple fixing knot, lowering the square ends (reference time: 600 s).

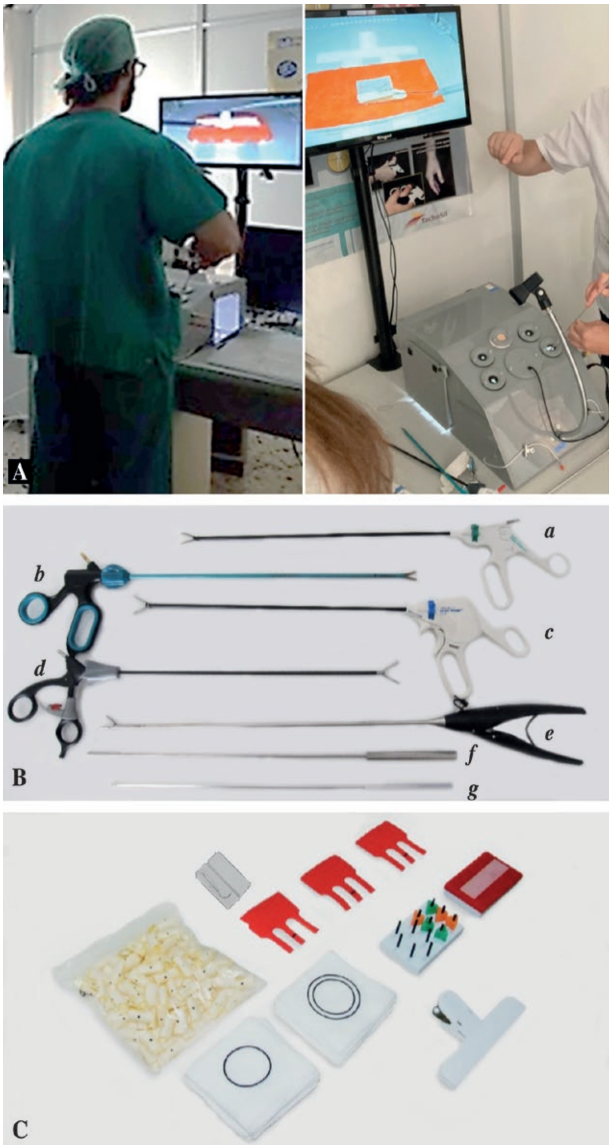


Figure 4. Equipment used for exercise training. A) Laparoscopic training box designed and assembled by the program staff. B) Laparoscopic instruments required: (a) dissector, (b) endoscopic scissors, (c) atraumatic forceps, (d) grasping forceps, (e) needle holder, (f) closed knot pusher, and (g) open knot pusher. C) MISTELS templates and single-use material required to perform the exercises.

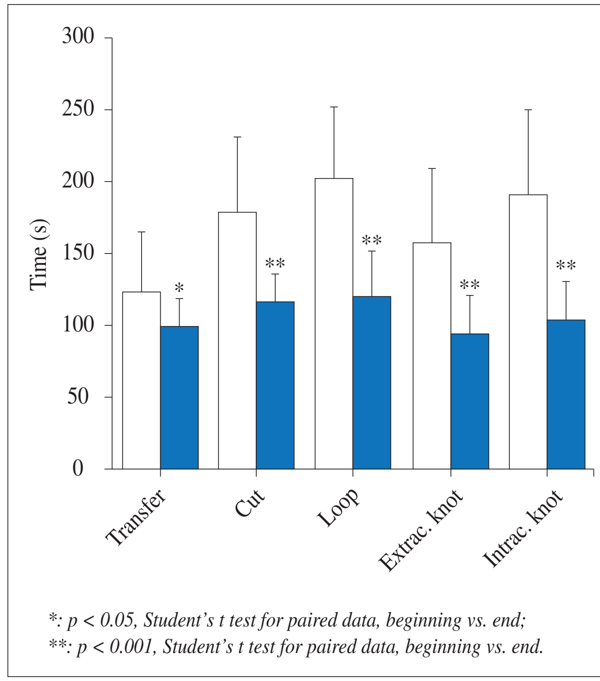


Figure 5. Times recorded at the beginning (white bar) and the end (blue bar) of the training program.

Data are presented as mean, standard deviation, and [range]. The normal distribution of the variables measured for each exercise was checked for both the initial and final intervals using the Shapiro-Wilks test. The results (initial vs. final) were compared by Student's t test for paired data.

The annual cost of the standardized program (2016/2017 period) is presented in table II together with the annual cost of the individualized programs for each specialty before the standardized program (2010/2011 period).

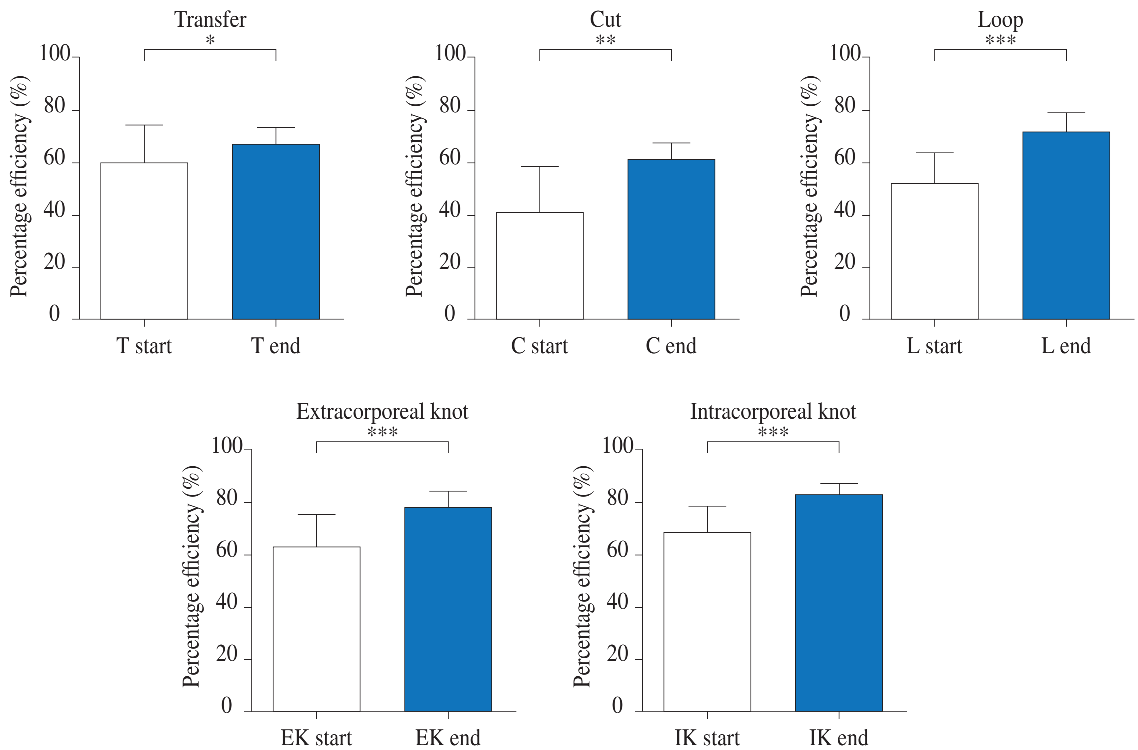
RESULTS

Since the start of the program in 2016, 48 residents have participated in the training activities. 20 of them have completed the training program, with initial and final time measurements being taken in the 5 MISTELS exercises. Of the remaining 28, data from 7 trainees were lost due to the interruption of face-to-face training as a result of the COVID-19 pandemic, which prevented final assessment from being carried out. 21 residents are still in the training phase and therefore pending final assessment.

Mean times of the 20 trainees who completed the program, without penalties for errors (Fig. 5), show a significant reduction in the mean time for each of the exercises. Moreover, the efficiency percentages at the end of the training were higher than at the beginning ($p < 0.001$) (Fig. 6).

By resident, the overall percentage of improvement, comparing the initial and final efficiency percentages, was 72 ± 4% [62-77].

Table II shows the individualized costs of the programs for each specialty (2010/2011 period) and the cost of the standardized program (2016/2017 period). The sum of the four training programs for the four surgical specialties totaled 181,162.50 € for the training of about 30 residents. The total cost of the standardized program for virtually the same number of trainees was 58,160.10 €, a saving of 67.89%.



**: $p < 0.05$, Student's t test for paired data, beginning vs. end; **: $p < 0.01$, Student's t test for paired data, beginning vs. end; ***: $p < 0.001$, Student's t test for paired data, beginning vs. end.*

Figure 6. Mean efficiency percentage at the beginning (white bar) and the end (blue bar) of the program in relation to MISTELS reference times.

DISCUSSION

Technological advances in recent decades have enabled us to give our residents more specialized MIS training through the use of virtual and experimental models. This type of training provides trainees with a safe environment free from the stress of clinical practice in order for them to develop their surgical skills to the fullest.

In our center, as in many others, each specialty organized their LS training programs based on the resources provided to them on an individual basis. Low efficiency was observed in this independent planning by specialty, which is why our center decided to provide uniformity in the quality of MIS teaching with a common LS program as part of the training plan for residents in the various specialties, as well as seeking to limit excess expenditure.

Our program was designed by consensus in 2015, establishing increasingly complex levels of learning throughout the residency period. During the first year of the program, MIR2, the training is carried out only in the virtual laboratory, based on the MISTELS training program, which, in addition, enables us to conduct an initial assessment of the trainees using objective and quantifiable criteria. During the second year, MIR3, training in the virtual laboratory is combined with sessions in the experimental operating room. In the final years, MIR4-MIR 5, training is almost exclusively carried out in the experimental operating room, except in the final year of the program, when the trainees' assessments are again carried out in the virtual laboratory.

Since the program began, 20 students have completed it, which has enabled us to compare the overall assessments of these residents at the beginning and the end of the training, both in terms of time and efficiency percentage in each MISTELS exercise. In both cases, statistically significant differences were found, which demonstrates that the residents have considerably improved their basic surgical skills, quantifiable using the MISTELS scale, in terms of hand coordination, pattern cutting, and the execution of both intra and extracorporeal loops and knots. This notable, objectively quantified improvement in surgical skills endorses and supports the efficacy of the program.

Furthermore, the economic assessment has also shown an annual cost for the standardized training program of approximately one third of the total annual cost of the earlier individual programs.

Table II. Cost of individual programs for each specialty (2010/2011 period) and cost of the standardized program (2016/2017 period).

		Academic year 2016/2017		*Academic year 2010/2011*							
		Unified program		*Urology program*		*Gyne.&Obst. program*		*Gen. surg. program*		*Pediatric surg. prog.*	
		approx. 30 MIR/year		*approx. 8 MIR/year*		*approx. 12 MIR/year*		*approx. 8 MIR/year*		*approx. 2 MIR/year*	
Economic study	*Unit cost*	*Unit*	*Subtotal*	*Unit*	*Subtotal*	*Unit*	*Subtotal*	*Unit*	*Subtotal*	*Unit*	*Subtotal*
Laboratory animals											
Animals	300,0	28,0	8.400,0	8,0	2.400,0	8,0	2.400,0	8,0	2.400,0	2,0	600,0
Transport	225,0	14,0	3.150,0	8,0	1.800,0	4,0	900,0	8,0	1.800,0	2,0	450,0
Waste disposal	80,0	28,0	2.240,0	8,0	640,0	8,0	640,0	8,0	640,0	2,0	160,0
Surgical consumables											
Clip applicators	135,0	14,0	1.890,0	8,0	1.080,0	8,0	1.080,0	8,0	1.080,0	2,0	270,0
Endocutter terminals	605,0	14,0	8.470,0	4,0	2.420,0	4,0	2.420,0	4,0	2.420,0	1,0	605,0
Transducers	25,0	28,0	700,0	8,0	200,0	8,0	200,0	8,0	200,0	2,0	50,0
Endocutters	415,0	10,0	4.150,0	2,0	830,0	2,0	830,0	2,0	830,0	1,0	415,0
Endocutter chargers	200,0	20,0	4.000,0	4,0	800,0	4,0	800,0	4,0	800,0	2,0	400,0
Sutures											
2/0 sutures	0,6	300,0	165,0	100,0	55,0	100,0	55,0	100,0	55,0	25,0	13,8
3/0 sutures	0,6	200,0	110,0	100,0	55,0	100,0	55,0	100,0	55,0	25,0	13,8
0 sutures	0,6	24,0	15,1	0,0	0,0	24,0	15,1	0,0	0,0	0,0	0,0
Anesthesia material											
Anesthesia material	45,0	28,0	1.260,0	8,0	360,0	8,0	360,0	8,0	360,0	2,0	90,0
General material											
Gloves, gowns, shoe coverings, coverlets, bandages, etc.	60,0	28,0	1.680,0	8,0	480,0	8,0	480,0	8,0	480,0	2,0	120,0
Inventoriable material											
Laparoscopy tower (own)	0,0	2,0	0,0	1,0	0,0	0,0	0,0	1,0	0,0	1,0	0,0
Training box and instruments (own)	450,0	5,0	2.250,0	1,0	450,0	0,0	0,0	0,0	0,0	0,0	0,0
Endocutter (rented/borrowed)	2.890,0	2,0	5.780,0	1,0	2.890,0	2,0	5.780,0	1,0	2.890,0	1,0	2.890,0
Laboratory animal house	6.000,0	0,0	0,0	2,0	12.000,0	6,0	36.000,0	4,0	24.000,0	1,0	6.000,0
Laparoscopy tower (rented /borrowed)	10.000,0	0,0	0,0	1,0	10.000,0	2,0	20.000,0	1,0	10.000,0	0,0	0,0
Use of spaces											
IIS Biocruces virtual hospital and laboratory animal house	0,0	28,0	0,0	8,0	0,0	8,0	0,0	8,0	0,0	0,0	0,0
Teaching (hours)											
Tutors	50,0	194,0	9.700,0	40,0	2.000,0	50,0	2.500,0	50,0	2.500,0	10,0	500,0
Support staff	25,0	168,0	4.200,0	64,0	1.600,0	64,0	1.600,0	64,0	1.600,0	12,0	300,0
			58.160,1		**40.060,0**		**76.115,1**		**52.110,0**		**12.877,5**

Finally, we would like to state that the new standardized surgical training program improved the quality of learning in a safe environment, while establishing a common criterion among the various surgical specialties and an improving the use of resources. In addition to offering a progressive and orderly acquisition of skills, this system guarantees an ethical, fair, and efficient use of the resources available to the four specialties involved.

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