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Original article

Does the incorporation of a virtual simulator improve abilities in endoscopic surgery acquired with an inanimate simulator?☆

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Introduction: The carrying out of training courses in surgical endoscopy for surgeons in training centres, is becoming more common. In addition to adequately planning activities, simulation systems are used to improve learning and monitor progression. Inanimate models and virtual reality programs increase psychomotor skills and assessment of performance.

In this work we tried to improve our training program, basically in training boxes by introducing a virtual simulator.

Material and method: Seventeen surgical residents, with a basic training were chosen as the control group. Two additional groups were established, group A: with 6 hours of training with inanimate simulator. Group B: the same training system plus 4 hours of practice with LapSim. Exercises in the endotrainer and virtual simulator with moving-replacing objects, cutting and suturing-knotting were planned. End-point was time (mean with 95% confidence interval) in every exercise in box trainer, before and after the training period. **Results:** Movement exercises: time in control group was 223.6 s, A: 103.7 s, and B: 89.9 s (control vs A, $P < .05$). Cutting exercises: time in control group was 317.7 s, group A: 232.8 s, and in the B: 163.6 s, (control vs B, $P < .05$). In the suture/knot exercise everyone was able to carry out a stitch after the training period. Time in control group was 518.4 s, in group A: 309.4 s, $P < .05$, and in B: 189.5 s (control vs A, $P < .05$).

Conclusions: Training in inanimate boxes was able to improve the skills of students, particularly for moving and suture/knots. The incorporation of a virtual simulator increased the learning capabilities, mainly in cutting exercises.

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¿Mejora la incorporación de un simulador virtual las capacidades en cirugía endoscópica adquiridas con simuladores inanimados?

R E S U M E N

Palabras clave:

Formación
Simulación
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Simulador virtual
Capacidades laparoscópicas

Introducción: Se ha generalizado la realización de cursos y programas de formación en cirugía endoscópica en centros de entrenamiento. Además de una adecuada planificación de las actividades, se deben introducir sistemas de simulación para el aprendizaje y monitorizar la progresión.

Se valoró la mejor adquisición de capacidades en un programa de formación en cirugía endoscópica al incorporar un simulador virtual a la práctica con cajas de entrenamiento.

Material y método: Se incluyó a 17 médicos residentes con un registro basal: grupo control. Se constituyeron 2 grupos: el grupo A, con 6 h de entrenamiento con simulador inanimado, y el grupo B, con lo mismo más 4 h de prácticas con LapSim. Se planificaron ejercicios de movilización-desplazamiento de objetos, corte y sutura-anudado en el simulador simple y en el virtual. Se evaluó el tiempo (medias e intervalos de confianza del 95%) empleado en cada ejercicio sobre el simulador inanimado, antes y después del entrenamiento.

Resultados: Ejercicio de movilización: el tiempo del grupo control fue de 223,6 s, el del grupo A fue de 103,7 s y el del grupo B fue de 89,9 s (grupo control frente al grupo A, $p < 0,05$). Ejercicio de corte: el tiempo del grupo control fue de 317,72 s, el del grupo A fue de 232,8 s y el del grupo B fue de 163,6 s, (grupo control frente al grupo B, $p < 0,05$). En el ejercicio de sutura todos consiguen dar un punto tras el entrenamiento. El tiempo del grupo control fue de 518,4 s, el de A fue de 309,4 s y el de B fue de 189,5 s (grupo control frente al grupo A, $p < 0,05$).

Conclusiones: El entrenamiento con simulador inanimado consiguió mejorar tanto el tiempo de movilización como el de sutura-anudado con respecto al grupo control. La incorporación del simulador virtual ha logrado superar los resultados obtenidos, sobre todo en el corte.

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Introduction

The degree of implementation, development, and learning peculiarities of minimally invasive procedures has led to the creation of specific training programmes for endoscopic surgery. In addition to proper planning of teaching activities, one of the most significant advances in training has been incorporating different simulation systems: inanimate simulators (training boxes), virtual simulators, laboratory animals, and even human cadavers. At the same time, evaluation techniques have been developed that enable us to monitor student progress.¹⁻³

We are now beginning to understand the true role that different simulation and organisation possibilities play in attaining the necessary degree of competence, as well as the manner of guaranteeing safe transfer of knowledge and acquired skills to the area of patient treatment. However, we need a better understanding of the topic if we are to definitively introduce such practices into official training programmes for specialists.

This study was designed to evaluate whether incorporating a virtual simulator in an endoscopic surgery training programme that uses inanimate simulators would further the acquisition of basic skills, or if it would merely complicate the process.

Material and method

We included 17 internal medicine residents (IMR) in their second or third year of residency with different surgical specialties (General and Digestive Tract Surgery, Paediatric Surgery, Urology, and Gynaecology). All had participated in the minimally invasive surgery training programs at the Centre for Surgical Training and Technological Transfer (CEQTt in Spanish) during 2007 and 2008. None of them had prior experience with laparoscopic surgery. Data collected at the beginning of the activity were considered to be control group data. Following that step, 2 randomly-assigned groups were created: group A (7 IMR) with 6 hours of training using an inanimate simulator in 2- and 4-hour sessions over 2 days with a week of unstructured forceps practice between the 2 days, and group B (10 IMR) with the same programme plus 4 hours of practice with a virtual simulator.

The traditional training boxes preventing direct view of the procedure were used as inanimate simulators. These were provided with a camera with a 0° angle of view, a light source and a video monitor, as well as a dissector, scissors and a laparoscopic needle holder. The virtual simulator used was the non-haptic LapSim version 3.0 (SurgicalScience Ltd. Gothenburg, Sweden).

Similar exercises were carried out using both the training boxes and the virtual simulator (Table 1). For the first

option, disposable forceps and scissors were used, as well as slides and other standard simulation tools. LapSim was only used for equivalent, pre-established basic exercises. For either method, students practiced no more than 30 minutes followed by a rest period of at least 5 minutes, and those students with access to the virtual simulator alternated inanimate and virtual simulator exercises.

The time spent on each exercise was considered to be an evaluation indicator and the concrete goal was completion of the exercise while reducing possibilities of wrong movements, particularly when cutting, as much as possible. In the cutting exercise, students were evaluated in a preliminary study according to the Likert psychometric scale assessing the edge quality as 0 = very irregular, 1 = regular, and 2 = very close to the line, without obtaining acceptable data regarding the reliability of the measurement.

The time spent on each exercise (means and 95% confidence intervals) in the inanimate simulator was measured before and after training in the two different groups. Values of $P < .05$ were considered significant.

Results

The mean elapsed time to complete the displacing exercise before training (control group) was longer than that of group

A, and group B's time was the shortest; there were significant differences between the times for control group and group A. For the cutting exercise, times for both groups A and B were shorter than the control group's, but the difference was only significant between the control group and group B. For the suturing exercise, all IMRs managed to place a suture following training, although four had been unable to do so initially. There were significant differences between group A and the control group, but there were no significant differences between groups A and B (Table 2).

Discussion

It is currently proven and accepted that training with both inanimate simulators and virtual simulators can be used to achieve skills in laparoscopic surgery.⁴⁻⁶ At present there is a wide range of simple devices that can be used as inanimate simulator and several virtual simulators whose effectiveness has been demonstrated.^{7,8}

Nevertheless, we must consider what the advantages and limitations are for each one. While inanimate simulators are cheaper, more realistic, provide haptic feedback and permit unlimited manoeuvring, their main drawbacks are the need for qualified monitors and manual collection of evaluation data. On the contrary, virtual simulators lend more independence to the student by automatically collecting data, but they are more expensive, generally less realistic, have occasional haptic limitations, and the manoeuvres that can be simulated depend on the available software.

This study used simple training boxes with indirect view and the same instruments used in surgery. Subjects performed three exercises that were equivalent to those found in the Fundamentals of Laparoscopic Surgery (FLS) programme introduced by the Society of American Gastrointestinal Endoscopic Surgery (SAGES) in 2004. Out of the possibilities that LapSim proposes, subjects only practiced the exercises most closely related to those named above, on a basic level. We verified how the dexterity that was initially developed under the control and supervision of an expert monitor was improved using partially independent training. With training boxes alone, 100% of the students completed the minimum requirements for obtaining the FLS programme certificate⁹ after 9.7 (2.4) hours (ranging, 6-14 hours).

Knowing how much time passed while completing each exercise enabled students to improve their performance, while receiving instructions on how to do the task better did not make a substantial difference to end results, at least in the case of the suture exercise.¹⁰

Table 1 – Description of the exercises evaluated in the inanimate simulator

Exercise	Description
Moving-displacing	8 plastic cylinders are grasped with a dissector and placed upon a swivel stand in such a way as to make a 3×3 square in the shortest possible time
Cutting	Cutting out a circle drawn on a sheet of thin sponge (euro coin diameter size), holding the grasper with the non-dominant hand and cutting with shears held in the dominant hand
Suturing	A line is drawn along the sheet; the student must cut along the indicated segment, and place a suture on each side with an intracorporeal knot between 2 sutures on opposite sides of the line

Table 2 – Time required by each group for each exercise, 95% confidence interval

Group/time, s	Control group	Group A	Group B	P
Moving-displacing	223.6 ^a (181.4–265.6)	103.7 ^a (76.1–131.3)	89.9 (66.5–113.3)	^a <.05
Cutting	317.7 ^a (261.7–373.7)	232.8 (181.2–284.4)	163.3 ^a (124.5–202.7)	^a <.05
Suturing	518.4 ^a (405.8–631)	309.4 ^a (250.6–368.2)	189.5 (110.8–268.2)	^a <.05

^aGroups being compared with statistically significant differences.

Virtual simulation can be a substitute for standard laparoscopic surgery training.¹¹⁻¹³ The results obtained in this study also indicate that virtual simulation also improves the capabilities that are acquired using the inanimate simulator. Therefore, it may be considered a useful resource for independent study and a way of simultaneously receiving data on how the acquired abilities have been maintained or improved. Other studies have demonstrated differences having to do with the separate aspects being improved, according to the type of simulation being used: virtual simulator training improves overall precision, whereas inanimate simulator training improves grasper use speed.¹⁴ For this reason, the authors also suggest that the appropriate combination of the two methods could be favourable.

An ideal programme for attaining sufficient competence in laparoscopic surgery that reduces the safety deficit and the time consumed in learning curves has not yet been established. National programmes such as the FLS or other smaller-scale programmes may introduce virtual simulators that simulate complex procedures, laboratory animals or cadavers in order to develop beyond basic capabilities to reach advanced capabilities that require specially prepared equipment, locations and personnel with specialised training if their objectives are to be met.¹⁵⁻¹⁷ Recently, initiatives with support from major institutions, such as the National Programme in Laparoscopic Colorectal Surgery, advocate improving the low substitution index of laparotomy for laparoscopy in colorectal surgery (about 15%) by means of initial participation of 11 training centres in Great Britain and Ireland.¹⁸

In conclusion, we can state that training with an inanimate simulator manages to lower both the procedure time and suture-tying time compared with the baseline situation. The incorporation of the virtual simulator has managed to improve results obtained using the inanimate simulator, and these improvements are significant for precision-related aspects such as cutting.

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