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RESEARCH ARTICLE

BASIC LAPAROSCOPIC SKILLS RETENTION AND TRANSFER AFTER HIGH FIDELITY SIMULATION TRAINING: A PROSPECTIVE COMPARATIVE STUDY

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ABSTRACT

Background: Simulation in laparoscopic training has gained wide acceptance but long-term retention after basic skills training for novices has seldom been explored, and transfer to more complex surgical interventions remains controversial. **Objective:** To assess (i) skills retention at more than six months after initial training and (ii) skills transfer to a simulated surgical procedure. **Methods:** Prospective comparative study of simulated surgical training. Nine six-year medical students had two training sessions on the Simbionix LAP Mentor™'s "basic skills". They completed a 4-task workshop six months later as well as a cholecystectomy module. For the latter, their results were compared to those of another group of 9 participants who had never trained on laparoscopic simulation. Evaluation was assessed by the Objective Structured Assessment of Technical Skills (OSATS) global rating scale and by LAP Mentor™'s metrics. **Results:** For basic skills training, the median OSATS score improved from 17 (10-21) during the first session to 25 (2-27) in the second one (p=0.009), remaining at 24 (19-26) in the third session 6 months later. These results were consistent with metrics scores such as total time and path length of instruments. As regards completion of the cholecystectomy, median OSATS scores were comparable between trained and novice participants (21 vs. 23), and LAP Mentor™'s metrics even showed a tendency towards better performance for novices. **Conclusions:** Laparoscopic high fidelity simulation seems efficient for long-term retention even after short training, but has not proved to be effective on skills transfer to more complex surgical procedures for non-experienced students.

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INTRODUCTION

Laparoscopic surgery has gained wide acceptance due to its numerous benefits for patients, but it has challenged traditional surgical apprenticeship in the operating theatre (Kuper *et al*., 2014 and Gallagher *et al*., 2001). Hence, for 15 years, the learning of basic motor skills required to perform laparoscopic interventions has been progressively transferred to simulation centres where numerous low and high fidelity simulator devices have been developed and validated for laparoscopic skills training and assessment (Gallagher *et al*., 2001; Stunt, 2014; Woodrum *et al*., 2006 and Ayodeji *et al*., 2007). Many studies have addressed the topics of skills retention and transferability in the operating theatre (Stefanidis *et al*., 2005; Buckley *et al*., 2014 and Dawe *et al*., 2014), but almost all of them offered intensive, proficiency-based training before post-test assessment, which remains time consuming for supervisors in an era of work time reduction and staff cuts, and thus seems difficult to apply in the routine surgical curriculum. Another constraint comes from the frequent problem of integrating simulation-based skills training in the clinical duties of surgical residents. This suggests that some training might begin as soon as the end of medical studies for incoming surgical residents (Singh *et al*., 2015 and De Win *et al*., 2012). Hence, the aim of this study was (i) to assess the retention of basic skills more than six months after a short laparoscopic training course offered to fifth-year medical students, and (ii) to compare their ability to complete a simulated cholecystectomy to that of future residents in surgery, at the end of their 6th year of medical study, thus assessing the transferability of skills to complex procedural interventions.

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MATERIAL AND METHODS

All the experiments were registered by the CNIL (Commission Nationale Informatiqueet Liberté) without need of ethical approval, as legally required in France at the time of

completion, and took place in the simulation centre All Sims of the university hospital of Angers (France). The participants were six-year medical students. They were recruited on a voluntary basis after receiving information about the study and they had all signed an informed consent form. The only exclusion criterion was the prior implementation of a cholecystectomy in the operating theatre or on a high fidelity laparoscopic trainer. Beforehand, a minimum number of 6 participants per group was statistically assessed using the Biosta TGV online calculator (Biosta TGV, Jussieu, France), with an expected difference of 5 points on the evaluation scale between the two comparative groups and on iterative evaluation within the training group, and statistical risks set at $\alpha = 0.05$ and $\beta = 0.80$. As considered to be equivalent to a prospective comparative study, STROCSS guidelines[11] were carefully followed.

The students in the first group (group T - training -) were offered 3 training sessions on the Simbionix LAP Mentor™ (Twin Medical, Angers, France) high fidelity laparoscopic simulator (HFLS) in pairs, under the supervision of a senior surgeon (expert supervisor). The second session took place about 4 weeks after the first one during their 5th-year medical studies, and the 3rd session occurred more than 6 months thereafter as they were six-year medical students. During each of these sessions, every participant completed a workshop comprising 4 tasks selected from the "Basic skills" and "Essential tasks" of the HFLS, to deal with camera manipulation, transfer of objects using both hands, cutting and clipping or performing electrocautery. During the 3rd session, they also each completed the "Lap Chole Case 1" procedural module. The students in the second group (group N - novices -) did not have special training and were future surgical residents. They were invited to perform the "Lap Chole Case 1" module after they had briefly trained on basic skills modules to familiarise themselves with the use of the HFLS. Before they performed the cholecystectomy, both groups were given a description of the different steps required for this intervention by the supervisor, supported by HFLS video tutorials. The participants' performance was assessed by the OSATS (Objective Structured Assessment of Technical Skills) global rating scale (Martin *et al*., 1997), scored by the actor student, the observer student and the expert supervisor out of 35 points for the basic skills workshops, and out of 40 points for the cholecystectomy module. The "use of an assistant" item was relevant only in this last case. Data collected by the HFLS were also analysed, including the total operating time, the path length and average speed of movements, and various efficacy and safety parameters. Statistical analysis was performed using GraphPad Prism 5.04 for Windows (GraphPad Software, San Diego, USA). Quantitative data were expressed as median values with ranges, and qualitative data as percentages. Quantitative data were compared using the two-tailed Wilcoxon matched-pairs signed rank test for retention parameters, and the Mann-Whitney test for transfer parameters. Qualitative comparisons were made using Fisher's exact test, and correlation analysis using Pearson's test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Description of the populations: Nine students completed the three training sessions on the laparoscopic basic skills (group T). The median age was 24 (23-25) years and all but two of the students were considering a surgical career. The median interval between the first and the second training sessions was 26 (19 – 37) days, and 6.8 (6.3 - 8.1) months between the second and the third sessions. In group N, all of the participants were future surgeons who were about one year older than the group T participants (25 (24-27), ns: not significant) and their previous experience on laparoscopy did not differ from that of group T (Table 1).

Retention of laparoscopic basic skills (group T)

The median OSATS score, as assessed by the expert supervisor, was 17 (10 – 21) during the first (S1) session, increasing by 55% in the 2nd session (S2) to reach 25 (22 – 27) ($p = 0.009$). This value remained balanced in the third (S3) session with a median OSATS score of 24 (19 – 26), which was 5% lower than that recorded during the S2 session (ns), but 46% higher than the S1 session score ($p = 0.009$). Even if median S1 values differed between the expert supervisor's evaluation and self- and peer-grading ($p<0.0001$), changes in the laparoscopic skills pattern remained the same, with a significant increase in S2 and S3 sessions compared to S1, and stable OSATS scores between S2 and S3 sessions (Figure 1a), thus confirming that improvement in laparoscopic skills was maintained over more than 6 months. The number of participants completing workshops 1 or 2 was inadequate to highlight any difference between the three training sessions for each HFLS metrics. Nevertheless, a pooled evaluation on the three metrics recorded in all exercises, namely "total time", "average instrument speed" and "total path length", showed results consistent with OSATS scores (Figure 1b). For example, the total time taken to complete all 4 workshops' tasks decreased from 16.5 (13.2 - 36.7) minutes during session S1 to 12.3 (11.2 – 18.0) minutes in session S2 ($p = 0.004$), remaining stable in session S3 (12.6 (9.4 - 17.0) minutes, ns). Indeed, there was no direct linear correlation between OSATS scores and HFLS metrics.

Transfer of laparoscopic skills to procedural interventions

The second part of this study aimed to explore the impact of basic laparoscopic skills apprenticeship on transfer to a simulated surgical procedure. The previous group of trained medical students (group T) thus had to perform a cholecystectomy on the simulator, and surgical performance was compared to that of a group of 9 novices (group N), who had never completed a cholecystectomy nor trained on a laparoscopic simulator. Both groups were comparable in terms of surgical experience at the time of completion of the cholecystectomy (Table 1). An assessment of the OSATS score by the supervisor (Figure 2a) resulted in a median score of 21 (16 – 29) in group T compared to 23 (13 – 26) in group N (ns). Self- and peer-grading did not reveal any differences between group T and N results, and sub-scoring of manual skills items or knowledge and procedural items of the OSATS rating scale did not highlight any difference between the groups either (Figure 2b). Analysis of HFLS metrics did not confirm any statistically significant difference in terms of group performance, except for the metrics "path length" and "path length of right instrument" (Table 2). Indeed, group N made fewer instrument displacements than the trained participants, mainly with the right hand, but there might be a bias because 3 out of 9 participants in group T were left-handed, whereas all participants in group N were right-handed.

Table 1. Description of the two groups of participants on completing the cholecystectomy module

	Group T	Group N	p=
Age (y)	24 [23-25]	25 [24-27]	0.09
Sex ratio (M/F)	3/6	6/3	0.35
Future trainee surgeon (%)	78	100	0.50
Median number of laparoscopies observed	10 [0-40]	10 [0-20]	0.96
Median number of laparoscopies performed	0	0	1
Sessions on laparoscopic simulators (n=)	3	1	NA

Students in group T had trained on basic LAP Mentor™ skills before completing thecholecystectomy, whereas group N were novice students. NA: not applicable.

Table 2. Results of high fidelity simulator metrics for the cholecystectomy module

Global metrics	Group N	Group T	p=
Total time (sec)	841 (616-1521)	1122 (804-1593)	0.39
Time to extract the gallbladder (sec)	794 (565-1462)	1067 (758-1549)	0.39
Total path length (cm)	1621 (872-2367)	2155 (1095-2590)	0.04
Total path length of right instrument (cm)	1123 (615-1524)	1394 (755-1654)	0.05
Total path length of left instrument (cm)	448 (257-843)	593 (340-1114)	0.09
Average speed of right instrument ($cm.s^{-1}$)	1.92 (1.73-4.85)	2.03 (1.59-5.23)	0.86
Average speed of left instrument ($cm.s^{-1}$)	1.67 (1.12-5.25)	2.04 (1.53-3.81)	0.26
Cautery			
Total cautery time (sec)	46.4 (26.6-115.8)	61.5 (35.4-12.1)	0.26
Time cautery is applied without appropriate contact with adhesions (sec)	16.7 (4.9-75.7)	31.0 (11.7-53.8)	0.19
Efficiency of cautery (%)	63.9 (34.7-81.5)	49.5 (42.5-76.1)	0.34
Safe cautery (%)	80.1 (57.0-89.9)	75.0 (54.0-87.2)	0.3
Time cautery is applied less than 15mm from the clip (sec)	6.7 (0.3-13.7)	8.3 (6.4-21.8)	0.14
Time cautery is applied less than 5mm from the duct (sec)	5.8 (1.6-14.7)	6.7 (0-29.8)	0.73
Clipping			
Total number of applied clips	6 (5-7)	6 (6-8)	0.07
Number of lost clips	0 (0-2)	1 (0-2)	0.73
Safe clipping - distance between the clips (mm)	8.7 (2.2-12.6)	7.0 (4.0-12.7)	0.8
Safe clipping - distance between the distal clip and the infundibulum (mm)	8.4 (5.5-11.5)	8.7 (5.7-12.8)	0.93
Cutting			
Safe cutting - distance from the clip (mm)	1.8 (0.2-5.2)	2.3 (1.0-5.5)	0.60
Safe cutting (%)	44.4	33.3	1
Safety parameters			
Occurrence of organ perforation (%)	66.6	77.8	1
Number of perforations	2 (0-12)	6 (0-17)	0.28
Number of non-cauterized bleeds	0 (0-0)	0 (0-3)	0.17
Perforated organs	L:5; S:1	L:6, S:1; D:1	

Results are expressed as median numbers with extremes. Abbreviations: L = liver, S = stomach, D = duct bill.

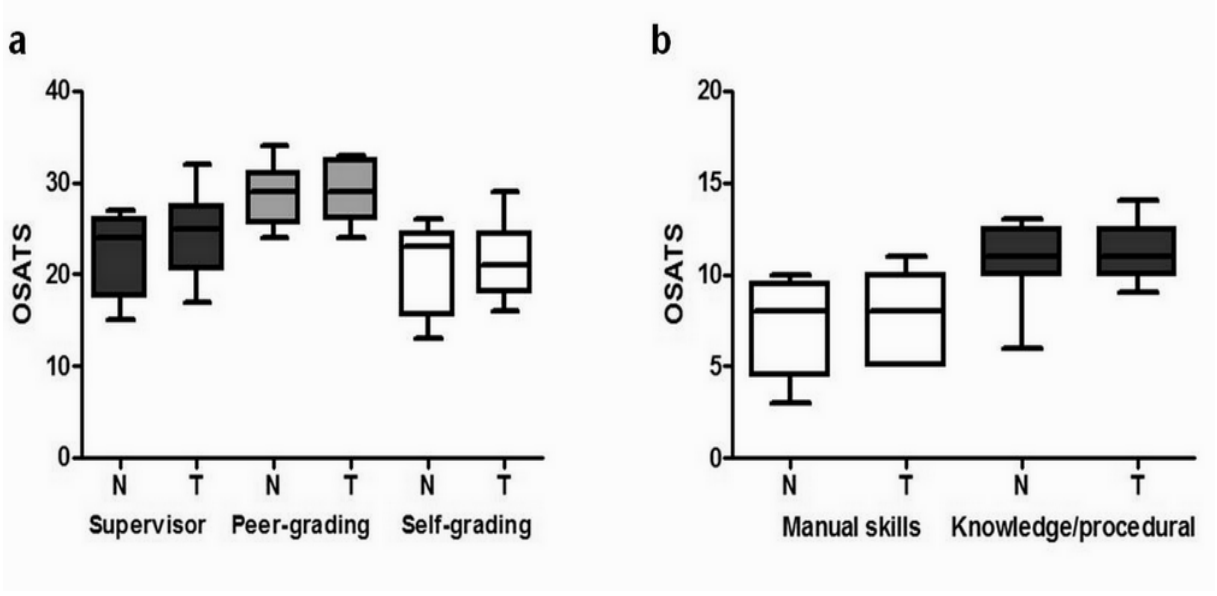

Figure 1: Basic laparoscopic skills evaluation throughout the three training sessions (S1, S2 and S3) on the Simbionix LAP Mentor™. Figure 1a: results of the OSATS global rating scale as assessed by the expert supervisor, and on self- and peer-grading. Figure 1b: pooled metrics results including total path length, average speed of the instruments and total time to complete both workshops. Statistically significant differences are represented by "*".

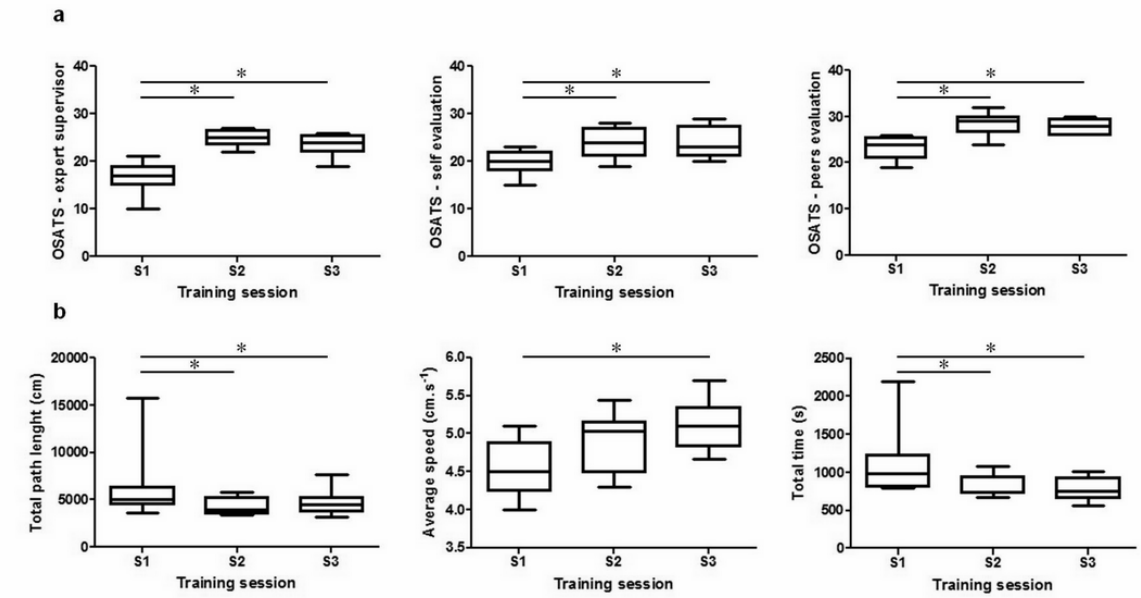

Figure 2. Evaluation of completion of a cholecystectomy on the high fidelity simulator Figure 2a: OSATS global rating scale of the novice (N) and trained (T) groups as assessed by the supervisor, and on self- and peer-grading. Figure 2b: detailed evaluation on the 3 OSATS manual skills items ('Respect for tissue', 'time and motion' and 'instrument handling') and on the 4 knowledge and procedural skills items ('Knowledge of instruments', 'use of assistants', 'flow of operation and forward planning', and 'knowledge of specific procedure')

Nevertheless, there was a global tendency towards a better performance in group N than in group T, not only in terms of efficiency parameters such as a lower completion timeor better cautery, but also with regard to safety parameters such as the positioning of clips and scissors or the number of organ perforations.

DISCUSSION

The first study objective was to assess if long-term retention of basic laparoscopic skills is feasible after a short training course comprising two non-proficiency-based learning sessions on a HFLS. Hence, we have proved that laparoscopic performance was maintained between the second training session (S2) and a third post-test session (S3) 7 months later, and was significantly higher than at baseline (S1). Previously reported training sessions ranged from 18 (De Win, 2016) to 64 hours (Edelman *et al*., 2010), and/or until a pre-defined level of performance was reached (Seymour *et al*., 2002 and Ahlberg *et al*., 2007), which represents an "ideal" in terms of surgical pedagogy with references to the Fitts and Posner model (Reznick, 2012), but may not yet be applicable within the actual surgical residency. All concluded that novices who had trained had better laparoscopic performance than controls (Al-Kadi, 2012). Although some studies have addressed the topic of long-term retention in laparoscopy with comparable delays to ours, participants in most of those studies were surgical residents with access to on-going simulation training or at least routine on-the-job training (Stefanidis, 2005; Singh *et al*., 2015; De Win *et al*., 2016; Edelman, 2010 and Mashaud *et al*., 2010). This implies that they received continuous surgical experience, helping them to maintain their performance. Conversely, participants in our study had not been exposed to laparoscopy between sessions S2 and S3, which may prove that, like other procedural medical skills (Ballouhey *et al*., 2015), laparoscopic skills can be retained for several months without further practice, even in the case of novice participants. The second topic in this study focused on the transfer of skills to a procedural intervention. For ethical reasons, we could not perform a real laparoscopic intervention on a patient as our participants were medical students without sufficient surgical experience to ensure total safety in the operating theatre. High fidelity simulators now provide training on very realistic simulated interventions. Consequently, instead of performing the cholecystectomy on animals, we preferred to use the same device as for basic task completion since participants were already used to handling it. The choice of the cholecystectomy module was based on the fact that this intervention calls for the implementation of many of the previously trained basic tasks, such as grasping with the non-dominant hand, performing electrocautery, clipping and cutting with accuracy, and has been used extensively for the same type of performance assessment (Buckley, 2014 and Dawe, 2014). Most of the published series dealing with the transfer of competences in the operating theatre have concluded that simulation training improved subsequent surgical performance on pigs (Ahlberg *et al*., 2002; Boehler *et al*., 2007), or human interventions (Seymour *et al*., 2002l Schijven, 2005; Grantcharov *et al*., 2004; Sroka *et al*., 2010 and Scott *et al*., 2000), whereas skills retention tests displayed proficiency-based training and targeted a more specialised audience, as participants were almost always surgical residents. As regards short training, this study did not show any improvement in the OSATS score for the cholecystectomy performed by the trained participants compared to the novices, and HFLS metrics even showed a tendency towards a better performance in group N, with a reduction in time and economy of motion, more accuracy and fewer errors during the intervention. Our results are concordant with those of Ahlberg *et al.* (2002), who demonstrated that training on the MIST-VR (Minimally Invasive Surgical Trainer in Virtual Reality) did not improve subsequent surgical performance on a simulated laparoscopic appendectomy in a pig.

One explanation could be that trained students may be over-confident because of the training, thus overestimating their ability to perform a simulated cholecystectomy and being less careful during the intervention. Another potential bias is that group N comprised future surgical residents, who may be psychologically more mature and more safety conscious than their counterparts. Our study has some limitations, like the small number of participants, due to the availability of volunteer participants, and, instead of other published series, did not assess surgical performance in the operating theatre. Hence the impact of pre-training on the management of various highly influential factors such as stress, limited space and constraints of working in a sterile field could not be taken into account. Nevertheless, it allowed direct comparison of basic tasks and procedural interventions on the same device, thus ensuring consistency for the participants.

Conclusion

Our study has showed that short training on simulated laparoscopy is effective for skills retention after more than six months, but transferability may require more intensive training. This has yet to be defined bearing in mind economic constraints, availability of lecturers and learners and proficiency-based requirements. It may begin at the end of medical studies for students wishing to become surgeons.

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Disclosure statement

Conflict of interest: none declared.

Bulleted key points

- Short training courses are efficient for long term retention of laparoscopic skills.
- Novices can durably improve laparoscopic basic skills after few repetitions.
- Transfer of laparoscopic basic skills to simulated procedures remains controversial.

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