Improvement of surgical skills after a three-day practical course for laparoscopic surgery

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Summary

Objectives: Currently, skills labs are becoming increasingly important in the field of medical education. This study aims to objectively assess psychomotor skills acquisition of residents attending a three-day laparoscopic course.

Materials and methods: 44 participants (test group) of the sixth practical course for Visceral Surgery of German surgical societies (Deutsche Gesellschaft für Chirurgie; DGCH and Berufsverband Deutscher Chirurgen; BDC) in Warnemuende with various degree of experience in laparoscopic surgery (18 advanced residents performing more than 50 laparoscopic operations and 26 novices performing less than 10 laparoscopic operations) and 6 consultants attending as tutors of the course (gold standard) were recruited as subjects. 20 medical students in their final year (camera holder) were chosen as a second control group (naive). Both control groups had no training during the practical course. The virtual reality simulator LapSim® was used to assess laparoscopic skills of participants before and after the course. Time to complete the tasks, error score, and economy of motion parameters (path length and angular path) were analysed.

Results: After the practical course the advanced participants of the test group completed the task significantly faster ($p = 0.019$), with smaller error score ($p = 0.023$), and more economy of motion [path length ($p = 0.014$) and angular path ($p = 0.049$)] than before the course. The novices of the test group and both control groups showed no significant improvement of their performance parameters ($p > 0.05$).

Conclusion: A three-day practical course for laparoscopic surgery improved laparoscopic skills of residents. However, advanced residents benefit most from the course.

Key words: virtual reality; computer simulator; laparoscopy; minimally invasive surgery; surgical training

Introduction

Patient safety is becoming increasingly important in the medical field and may be improved. This takes in account that adequate performance depends not only on psychomotor skills, but also on higher cognitive skills and non-cognitive factors such as team-integration, communication and decision making.

The technical skills in the field of surgery have been commonly taught using the apprenticeship model. It is well known that different types of operations need to be performed 15–100 times before reaching a low plateau of complications [1–3]. Medical educators know that such performance curves are longer for laparoscopic surgery compared to open surgery [4]. Additionally, residents commonly cite factors associated with their emotional distress like insufficient knowledge and poor learning environments [5]. For such purpose several laparoscopic training courses have been set up to improve the performance curve before the operating room. One of the well-established courses in Germany is the annual Warnemuende visceral surgery skills course organised in cooperation with the DGCH and the BDC, the main German surgical societies.

However, it has not been proven that such laparoscopic courses lasting only a few days are effective in improving laparoscopic skills of residents. It is not known in which stage of apprenticeship the most benefit could be achieved through such a practical course. The answers of these two questions are important for educators because they

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should become more involved in a structured residency program as previously suggested [6].

The advent of minimally invasive surgery expanded the scope of computer simulation as a training tool. Such simulations make it possible to offer a wide range of repeatable surgical situations, and thus to make assessments based on direct observation of the performance [7, 8].

The current study was designed to determine if a three-day laparoscopic skills course can improve laparoscopic skills of residents measured by a virtual reality laparoscopy-simulator (LapSim®). Another aim of this study was to investigate existing laparoscopic experience and its effect to enable the highest benefit from a hands-on laparoscopic course.

Methods

Skills course curriculum

The study was carried out during the sixth surgical skills course in Warnemuende, June 12–18 2004. This is a seven-day practical course of the German Societies of Surgery (DGCH and BDC). The three-day laparoscopic course consisted of exercises for groups of six residents trained by an experienced laparoscopic surgeon. Two participants formed a team using one laparoscopic device. Following a video demonstration and short lectures concerning operative strategies, practical exercises were performed at several animated models in a Trainer-Box®. The tasks varied from basic laparoscopic skills, such as simple grasping, placing of objects and cutting picture from a paper, in the box to more complicated procedures including simulation of Appendectomy using sponge and intraoperative cholangiography using glove. Furthermore, laparoscopic knot tying, suturing, fundoplication, laparoscopic cholecystectomy and laparoscopic intestinal anastomoses were performed using animal models (alcohol fixed as well as fresh liver with gallbladder).

The simulation model

The simulator used in this study (LapSim®, Surgical Science Ltd., Goteborg/Sweden) creates a virtual laparoscopic system using a computer (Windows XP®), a video monitor and laparoscopic interface containing two pistol-grip instruments and a diathermy pedal without haptic feedback. The LapSim® software contains the basic modules referred to as "clip-and-cut task", in which the level of complexity and difficulty can be adjusted as previously described [7, 9]. The clip-and-cut modules in the LapSim® skills set represent a surgical procedure during laparoscopic operations. Each of the skills may be adjusted to different levels of procedural complexity by increasing the level of difficulty to accomplish the task.

For the purpose of this study, the clip-and-cut task was adjusted to a hard level as "baseline" before training in the practical course to determine the existing laparoscopic skills and as "endpoint" after training in the practical course to determine the improvement of laparoscopic skills. This task in a hard level was chosen for multiple reasons. First, it is likely to be one of the most essential stages of the laparoscopic cholecystectomy procedure that must be performed safely to avoid possible damage to the common bile duct. Second, by selective assessment of the clip-and-cut scenery, technical skills can be assessed quite independently of other factors influencing outcome variation. Third, it is likely to be a good predictor of overall performance [10]. Finally, to exclude a fast learning curve on the simulator after few repetitions we used the hard level of the clip application because difficult tasks need much more repetitions to show a clear learning curve. For each individual, as well as for the entire group the following parameters were calculated as previously described [11]: time needed to complete the task (min); error score [blood loss (dl); dropped clips (n); badly placed clips (n); incomplete target areas (n)] as well as economy of motion [instrument path length (m) and angular path (°)].

The study groups

44 surgical residents who attended the Warnemuende laparoscopic skills course (test group) were divided into two groups:

Advanced participants: 18 residents, who had performed more than 50 laparoscopic operations;

Novices: 26 residents, who had performed less than 10 laparoscopic operations.

All participants of the practical course had paid course fees and judged the practical course a compulsory requirement for them; consequently, it was impossible to randomise the residents to groups taking or not taking the course.

In order to ascertain whether any learning effect was associated with the use of the LapSim, a further control group of medical students in their final year (n = 20) with limited laparoscopic experience (camera holder rule) and no formal training were assessed at the time points equivalent to the subject group.

The second control group recruited in this study comprised of surgical consultants (n = 6) attending the practical course as tutors (gold standard control group). Both control groups had no training during the practical course. All participants of the study were without any previous experience with a virtual reality simulator. All participants were briefly instructed regarding the virtual reality technique of the clip application. The use of the laparoscopy simulator was demonstrated and the participants were given time to practice until they felt comfortable.

At the beginning, participants received familiarisation on the simulator, introducing them to the clip application task. Participants followed a step-by-step teaching schedule for this task through the author. The VR clip-and-cut procedure, incorporates, a colour-guided teaching approach showing the exact area and preferred sequence for the placement of the clips on the virtual vessel, specific instruction on what is regarded as common faults and/or resulting problems. When subjects strongly stretched the vessel its colour will change from brown into red signalling imminent rupture. Only after supervised instruction, during which each subject practised a run of the clip application task on the LapSim and instruction on how to handle the system, another identical unsupervised run was performed.

Then all groups performed the clip application task before and after the practical course at the same level. The laparoscopy simulator was used only to assess the psychomotor skills, and not as a part of the training course. In addition to participant demographics and previous surgical laparoscopic experience, questions concerning the experience with the laparoscopic simulator as well as computer games were asked.

Statistics

The data were transported directly by the computer of the simulator into an MS Excel® table worksheet. With the help of the statistic program (SPSS®, version 12.0) the data were descriptively analysed. The differences of the parameters of performance between the groups were analysed by the nonparametric Mann-Whitney and Kruskal-Wallis tests. The comparison of means was carried out using the two-independent t-test. The level for statistical significance was set at p <0.05.

Results

Subjects' characteristics

The test group comprised 10 women and 34 men with a median age of 34 years (range 26–50). The naive control group comprised 10 women and 10 men, with a median age of 25 years (range 23–31). The experts control group comprised 6 men, with a median age of 42 years (range 39–62). All 70 participants completed the study as described previously.

Comparison of performance of the Test-group before and after the practical course

The advanced participants in the test group displayed a faster improvement in their performance assessed by the simulator after the practical laparoscopic course. In the statistical analysis using the Mann-Whitney test, they completed the task significantly faster (p = 0.019), with smaller error score (p = 0.023), and more economy of motion [path length (p = 0.014) and angular path (p = 0.04)] than before the course.

For the novices in the test group, there was a trend after the course only for reducing the error score (t-Test; p = 0.08) (table 1; figure 1–2).

Comparison of performance of the control groups before and after the practical course

There was a trend after the course only for shortening the time for the experts test group (t-test; p = 0.1). The change of the other parameters was inconsistent. After the course the naive control group showed a minimal reduction of time and error scores without statistical significance, whereas the economy of motion parameters got worse (table 1; figure 1–2).

Comparison of performance of the test and control groups before the practical course

The students group performed the task faster and with better economy of motion than the course participants and the gold standard. However, they made more errors compared to the participants of the course and the gold standard. In the statistical analysis using the Kruskall-Wallis test, the students have significantly more incomplete areas than the course participants and the gold standard (p = 0.009). The other parameters showed no significant difference between the four groups (table 1; figure 1–2).

Table 1

Means and 95% confidence intervals (95% CI) of the performance parameters of the test and control groups.

Group		Before the practical course						After the practical course					
		Badly placed clips (n)	Incomplette target areas (n)	Dropped clips (n)	Blood loss (dl)	Angular path (°)	Path length (cm)	Badly placed clips (n)	Incomplette target areas (n)	Dropped clips (n)	Blood loss (dl)	Angular path (°)	Path length (cm)
Naïve control group	mean	0.35	1.93	1.05	8.30	528	249	0.25	1.80	1.08	6.27	536	265
	95% CI	0.15–0.55	1.81–2.04	0.58–1.52	5.86–10.3	455–600	220–278	0.08–0.42	1.67–1.93	0.72–1.43	4.23–8.32	460–612	230–300
	p	–	–	–	–	–	–	0.346	0.132	0.718	0.080	0.872	0.920
Novices test group	mean	0.21	1.37	0.83	6.98	637	304	0.50	1.44	1.06	5.09	632	300
	95% CI	0.06–0.36	1.16–1.57	0.51–1.14	5.11–8.85	554–721	270–337	0.24–0.76	1.25–1.64	0.75–1.36	3.68–6.49	512–752	264–337
	p	–	–	–	–	–	–	0.078	0.528	0.215	0.094	0.579	0.913
Advanced test group	mean	0.42	1.64	0.92	7.34	698	295	0.53	1.64	0.81	4.69	548	252
	95% CI	0.20–0.64	1.46–1.82	0.51–1.32	5.08–9.59	598–799	262–329	0.22–0.84	1.41–1.87	0.48–1.13	2.74–6.64	448–648	212–293
	p	–	–	–	–	–	–	0.479	0.922	0.742	0.001*	0.040*	0.019*
Gold-standard control group	mean	0.08	1.58	1.17	5.2	685	287	0.67	1.67	0.67	6.73	603	259
	95% CI	–0.1–2.7	1.16–2.01	0.23–2.1	1.93–8.40	516–854	224–350	–2.5–1.58	1.25–2.08	–2.5–1.58	2.37–11.0	436–770	195–322
	p	–	–	–	–	–	–	0.102	0.739	0.236	0.632	0.308	0.480

* p = 0.019; – p = 0.023; # p = 0.04; ? p = 0.019 in the before-after-comparison of the advanced test group.

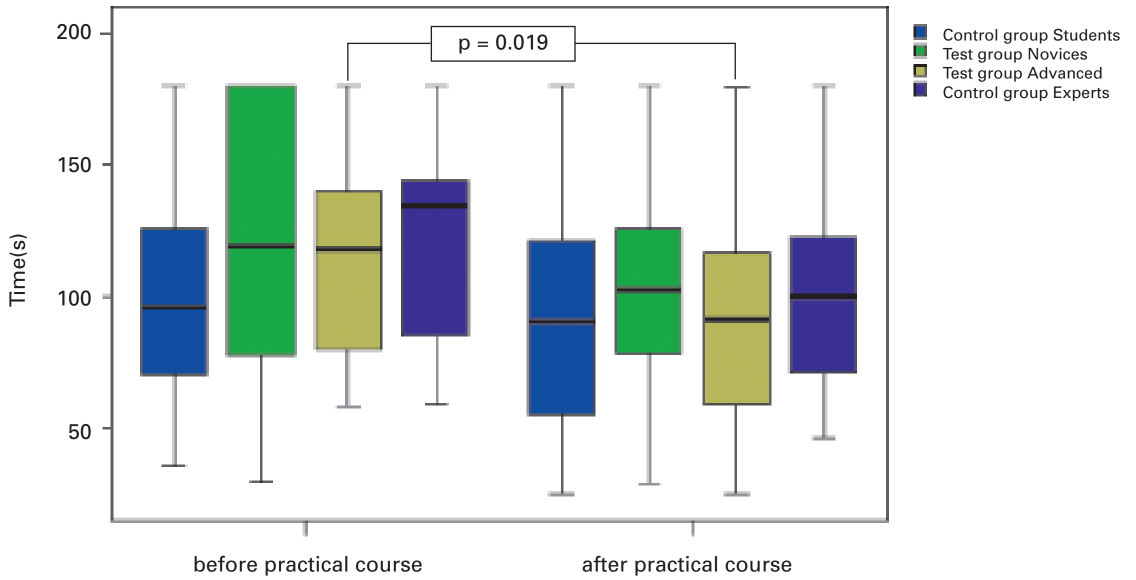

Figure 1

Box plots show mean and standard deviation of the time in seconds needed for completion of the clip application on the LapSim for the test and the control groups. Only advanced residents in the test group became significantly faster after the practical course (Kruskall-Wallis test; p = 0.019).

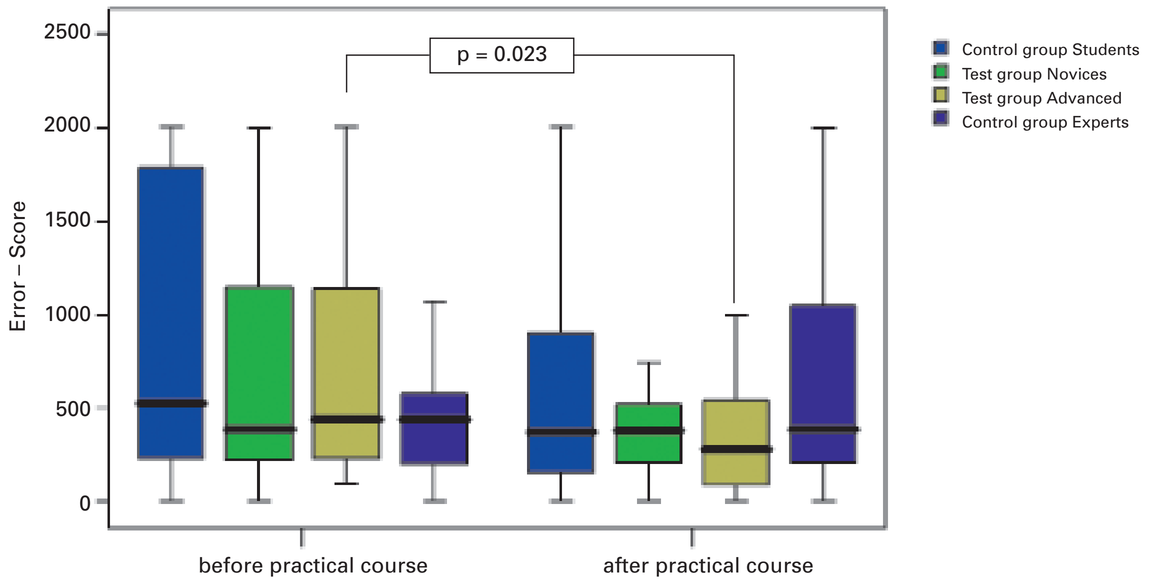

Figure 2

Box plots show mean and standard deviation of the error scores of the clip application on the LapSim for the test and the control groups. Only advanced residents in the test group reduced significantly their error score after the practical course (Kruskall-Wallis test; p = 0.023).

Comparison of performance of the test and control groups after the practical course

The students group performed the task faster and with a smaller angular path than the novices test group and the gold standard and they also performed with smaller error scores than the gold standard. The advanced test group performed the best for all parameters compared to the students, novices and gold standard. However, the difference between the four groups was not significant (table 1; figure 1–2).

Discussion

Surgeons constantly learn new techniques. Practical laparoscopic courses aim to improve laparoscopic skills of residents in surgery. These kinds of courses are needed to relocate the performance curve outside the operation theatre [12] to reduce risks for patients. Whether such practical courses are indeed able to reach this aim is still controversial.

The aim of this study was to evaluate if a three-day practical course for laparoscopic surgery can improve laparoscopic skills of residents in surgery. In addition, we were particularly interested to determine which degree of existing laparoscopic experience is required to achieve the most benefit from such a practical course in laparoscopic surgery.

In a previous study we could show, that LapSim® is able to assess the existing level of laparoscopic skills of surgeons [8]. Other groups are in line with these results [5, 9–11]. Our assessment task was designed to incorporate laparoscopic manipulation and clip-and-cut tasks, which are generic skills required to perform a laparoscopic cholecystectomy. It may be argued that the task is of too low fidelity to assess laparoscopic skills, but recent evidence has shown that a reduction in fidelity of the surgical simulation is not detrimental to technical skills training [13] and, therefore, may not be crucial for assessment. Secondly, multiple performing of the task may lead to improvement in performance simply from learning on the model. However, we used a hard level of the clip-and-cut task because the hard level needs more than 10 repetitions to reach a significant learning curve through the simulator [14]. Furthermore, previous work using a control group and this exact model has shown this not to be the case [15].

All 44 participants of the course were requested to do one's best during the performance on the laparoscopy simulator. This study showed that after a three-day laparoscopic course novices and advanced test groups performed the clip application task of the LapSim® faster with less errors and with a better economy of motion than before the course.

In the before and after comparison of the test group (novices and advanced residents), the advanced residents demonstrated the best and significant reduction of all measured parameters after the practical course, so that this group had the best learning profit from a three-day laparoscopic skills course.

The novices who performed less than ten laparoscopic operations showed after the practical course only slight improvement of the performance parameters without statistical significance.

Before the course the baseline parameter of the test group and both control groups did not significantly differ.

Although the students of the control group did not participate in the practical course, they performed the clip-and-cut task before the course faster than the test and the expert control group. However, the students performed faster at the expense of more errors. Perhaps, the mean aim of the students, who lack clinical background was to perform the clip application task very fast without making allowance for safety. Thus, all other participants showed a lower error score compared to the student group.

This surprising difference in performance between students and gold standard might be as result of lack of force feedback, since experts trust in tactile feedback during laparoscopic as well as during open surgery more than less experienced surgeons. Tactile feedback is an option for some laparoscopy simulators and can be achieved by exchanging hardware solution. The available systems with haptic feedback are not technically matured yet. However, there is no evidence regarding the superiority of training with tactile feedback, which might justify the high costs of tactile hardware. For the clip-and-cut task used in this study tactile feedback was not essential, because feedback could be achieved by changing the colour of the vessel in the case of stretch damage. However, the gold standard had significantly less incomplete target areas compared to the students, which indicate better precision in performance. This was statistically the only significant difference in parameter between the students and gold standard. Although after the course the students were faster and had a slightly lower error score than the gold standard, this difference was statistically not significant.

Both control groups (students and experts) did not significantly improve their parameter of performance. This is important to exclude improvement due to familiarisation with the simulator rather than true skills improvement through the practical course.

In contrast to the finding of this study, Schijven et al. could not identify a significant increase of improvement of skills after a one-day practical course assessed by the laparoscopic simulator Xitact LS500 [16]. They found no significant differences comparing time and score between residents attending the course and the control group comprised of interns. Schijven concluded that the Xitact LS500 cholecystectomy simulator was not able to detect significant improvement in MAS performance among a group of surgical residents attending the Basic Surgical Skills course. It is possible that a one-day practical course is too short to improve laparoscopic skills of novices. In addition, the test group might have not been homogenous with respect to their surgical status or not suitable to profit from such a course.

Another study with a positive result was that of Torkington et al. who assessed with the virtual reality simulator MIST-VR the improvment of laparoscopic skills of 13 novices after a Basic Surgical Skills course. They concluded that the Basic Surgical Skills course produces quantifiable improvements in laparoscopic skill that were assessed by the MIST-VR simulator [17].

In contrast to the test groups of Torkington and Schijven, Hance et al. assessed in a recent study the improvement of psychomotor skills of 3 different laparoscopic cholecystectomy courses. The participants of each course were not homogeneous and varied from basic surgical trainee to surgical consultants. There were no significant differences in laparoscopic baseline experience between the subjects attending the 3 courses measured by the number of cholecystectomies performed. They found only significant improvement of laparoscopic skills after 2 of the 3 courses assessed by the clip-and-cut task in box trainer [18].

The current study is the first study that demonstrates that residents with some degree of experience in laparoscopic surgery excluding novices profit mostly from laparoscopic skills courses when psychomotor skills are assessed by a virtual reality simulator. This group of residents should be the target group of courses like the sixth Warnemuende laparoscopic skills course.

Direct comparison of different courses and different simulation systems is not allowed without standardised curricula. These may include the definition of target groups, length of the course, training with synthetic models, alcohol fixed or perfused animal organs, use of uniform laparoscopic instruments and uniform technique. Further studies are needed to identify effective curricula for surgical residents at the best time during their residency. Perhaps we need basic skills courses, eg laparoscopic simulators [7], during the first years of residency and more sophisticated courses like laparoscopic skills courses or anastomoses courses during a more advanced stage of residency.

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