Laparoscopic simulation training: Testing for skill acquisition and retention

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Background. Simulation in laparoscopy leads to skill acquisition. Although many curricula for simulation training have been described, the nature of skill deterioration remains unclear. We evaluated skill acquisition and retention after laparoscopic simulation training.

Methods. Thirty-six novices in surgery (medical students) underwent a 5-day curriculum consisting of 9 skills of increasing complexity. Each subject underwent baseline and post-training evaluation after completion of the course. Skill retention testing was measured after 6 weeks (group 1; n = 18) and after 11 weeks (group 2; n = 18). Neither group had access to a training facility during this interval. Task completion was measured in time (s) with penalties for inaccurate performance.

Results. Comparison of the baseline and post-training values revealed a significant learning outcome for all exercises in both groups (P < .001). In group 1, skill retention testing found no significant decrease in skill level when compared to post-training values in all but 1 task (extracorporeal knot tying; P = .007). In group 2, differences between skill retention and post-training evaluation were observed for 5 of the 9 tasks (transfer task, positioning, loop tie, extracorporeal knot, and intracorporeal knot; P ≤ .05 for each).

Conclusion. Basic laparoscopic skills can be learned successfully by novices in surgery using a compact curriculum. These skills are retained for at least 6 weeks. Eleven weeks after initial training, skill deterioration is likely, and therefore an opportunity for practice and repetition is desirable. (Surgery 2012;152:12-20.)

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All manual tasks require practice in order to achieve proficiency; in the case of laparoscopic procedures, learning curves have been examined extensively.¹⁻⁵ Techniques crucial for orientation, tissue handling, and coping with decreased tactile sensation or amplification of tremor need to be learned by a novice laparoscopic surgeon in order to practice laparoscopic surgery safely.⁶ Training of these skills in the operating room is becoming increasingly difficult because of time constraints, planning issues, and ethical considerations regarding patient safety. Therefore, the best way to overcome the learning curve associated with a novel procedure may be by formal training in a skills laboratory using simulated scenarios.⁷⁻⁹ Once a skill has been learned, transfer from simulation into the operation room can equally be achieved.¹⁰⁻¹¹ A number of different tools and training concepts have been developed, in which the main focus has been the testing and identification of skill proficiency in surgery residents.¹²⁻¹⁵ The transferability of acquired simulated skills between different types of simulators has been shown.¹⁶ Irrespective of the hardware used in simulation, procedural skills can be acquired by surgery residents outside of the operating room; however, it remains unclear when the natural course of skill loss commences without regular practice. This topic becomes especially important for trainees, who are not using their acquired skills regularly in the operating room or do not have the option of a continuous education in a skills laboratory facility.

In this study, we investigated whether a 5-day, dry laboratory curriculum can be used to teach basic laparoscopic skills to novices in surgery (medical students) in team pairs and whether skill retention can be achieved over a designated period.

METHODS

Participants and study design. The study population consisted of 36 medical students forming 2
groups. Participation was voluntary, and all students agreed to the evaluation of their results. All clinical semesters before internship at our medical school were entitled to enroll. From all applicants, the participants were chosen randomly. All selected students stated an interest in a future career in surgery. A questionnaire concerning demographic data (age, sex, and dominant hand) and previous surgical experience (open surgery and laparoscopic) was completed by each participant. Previous experience was rated on a 5-point Likert scale, with 5 indicating no experience and 1 indicating very experienced. On the first and last day of the course, participants noted which task they felt to be the easiest and the most difficult.

Curriculum design was equal in both groups apart from the duration of time between post-training (PT) evaluation and retention testing (RT). The participants were assigned a designated training time for the duration of the course. Within these sessions, the students formed team pairs for each workstation. Once assigned a timeslot and workstation, no changes between groups were allowed.

The course began with an introduction tutorial regarding laparoscopic techniques, equipment handling, and an explanation of the course tasks. Baseline (BL) evaluation was performed the next day, with each task being performed twice without further explanation or coaching.

The 2 following days consisted of training sessions with a total of 4 course cycles being performed by each pair. Intensive individual coaching, feedback, and demonstrations by an expert accompanied the training on these days. Throughout the courses, the same 4 tutors took part, each rotating through the workstations to ensure unbiased coaching. The frequency of feedback was determined by the student (if they had questions) and by the tutor if handling errors were observed. On the last day of the course, PT testing without coaching was performed. Each task was performed twice. The training was completed by a short week review and feedback session.

In group 1 (n = 18) the participants returned for RT after 6 weeks; in group 2, participants returned after 11 weeks. In between, they had no access to the simulation facility or to clinical laparoscopic procedures. Task evaluation was preceded by a short introduction and refresher concerning the 9 tasks to be completed. Retesting was performed in the same pairs as in training in the assigned timeslots.

Tasks. Camera navigation: An abstract small bowel model with mesentery fixed on a workboard filling the cavity of the box trainer was used. Ten numbers (0–9) were distributed equally within the cavity. For the purpose of standardizing the distribution of the numbers, the workboard was divided virtually into 4 quadrants; in addition, the inner surface of the box trainer (ceiling) was used as a fifth quadrant. During each task repetition, each quadrant always contained at least 1 number. The task was performed by each participant alone using 1 hand for camera navigation and the other for positioning of the small bowel model with a blunt grasper to achieve adequate view. A standard 30° optic was used. The task began with introduction of the instruments and ended when each number had been visualized and photodocumented once by the participant.

All following tasks were performed in pairs; the participant performing the task was scored. The camera navigation was performed by the (passive) partner and adequate field of vision was maintained by verbal instruction by the participant (communication and command skill).

Grasping: The small bowel model was used as the workboard. 5 wooden beads with differing size and shape were distributed centrally on either side of the mesentery. The task began when 2 graspers were introduced in the central field of vision. All beads were to be grasped and placed in a marked field. Time was stopped once all beads had been placed.

Transfer: As described above, 5 wooden beads of differing size and shape were distributed. The task began with introduction of the graspers in the central field of vision. Each bead was to be grasped, transferred into the other instrument, and placed in the marked field.

Positioning/placement: A workboard with 3 equally spaced nails was used. 3 pairs of colored blocks with a central hole were to be placed in correct color grouping on each nail. The task began with introduction of the 2 graspers and finished when all blocks had been placed.

Pattern cutting: A predrawn circle was to be cut out of a 10-cm × 10-cm piece of gauze modified from the established task of pattern cutting as described previously.14,17-19 The task began with introduction of the laparoscopic scissors and grasper and ended when the circle was fully cut free.

Loop tie: The target was a line marked with black ink on a foam rectangle at the base of a tubular appendage modified from the established endoloop task as described previously.14,17-19 The task began with introduction of a pretied slip knot and a blunt grasper. The loop was to be placed around the appendage on the marked line. The task was completed when the knot had been pulled fully closed.
**Extracorporeal knot tying.** A metal hook with a closed eyelet was fixed to the center of the work field and used as the target. For suturing, 2 laparoscopic needle holders were used; the exercise began with flaccid introduction of the suture in the right-handed needle holder and positioning both instruments in the field of vision. The participants were required to position the needle, pass it through the eyelet, transfer the needle back into the right needle holder, and retract the suture to perform an extracorporeal knot with 3 throws using a metal knot pusher. The exercise was finished when the suture tails were cut by the laparoscopic scissors.

**Intracorporeal knot tying.** A cloth rectangle with a central defect measuring 1 × 0.5 cm was fixed to 2 crocodile clamps in a loose fashion so that tension-free adaptation of the edge was possible. Targets were marked in black ink 0.25 cm from defect borders on both sides. Two laparoscopic needle holders were used, and the exercise began with introduction of the 18-cm suture in the right-handed needle holder and positioning both instruments in the field of vision. The participants were required to position the needle, penetrate the cloth at the first target, exit in the defect, reposition the needle, and penetrate the contralateral target from beneath the cloth. Afterward, a knot using an established C-loop technique was created. The exercise was finished when the suture tails were cut by the laparoscopic scissors.

**Clipping.** Rubber tubing filled with water was marked circumferentially twice, each marking 0.5 cm apart with black ink. The task began with introduction of the clip applicator and a blunt grasper. Two 10-mm titanium clips were to be applied at the marked targets. Before clip closure, the free tip of the clip had to be visualized. The task finished once the tubing had been divided using the laparoscopic scissors.

**Performance measure and scoring.** Each trial of the task was assessed quantitatively (time in seconds) and qualitatively (error score). The completion time was obtained using a stopwatch with designated start- and endpoints. During scoring, each error was documented and later converted to penalty points. Minor errors, such as deviation from marked targets, were penalized with 1 s per mm; more substantial errors, such as loose knots, sliding knots, gap formation between cloth pieces, and leaking from clipped tubing, were penalized with 10 s (per leaking side in the clip task). Each task was limited to 300 s. All unfinished tasks could be completed during the training sessions without cut-off scoring; during evaluation testing, the task was aborted and scored with 300 s.

**Statistical analysis.** In testing the demographic data between the groups, categorical data were evaluated with the Pearson chi-square test and continuous variables with the Mann–Whitney U test. For differences in testing results between groups, the Mann–Whitney U test was used. For data within 1 group, the Wilcoxon signed-rank test was used. *P* < .05 indicated statistical significance. All continuous data are shown as median with interquartile ranges in brackets unless otherwise stated. Statistical evaluation was performed with SPSS software (version 17.0; SPSS Inc, Chicago, IL).

**Task difficulty.** In order to obtain a grading for the 9 tasks, results from the student questionnaires were analyzed. Each task that was named solely as easy or difficult was graded as such. Tasks named by some participants as easy and by the others as difficult were graded as moderate. In addition, all 4 coaches evaluated the task difficulty after having observed their participants during the course.

**RESULTS**

BL, PT, and RT data were available for all participants. No significant differences were found in the general demographic characteristics of the 2 groups (Table I). For all tasks except for the transfer task, the BL values between the groups showed no differences (Table II). Regarding the PT values after completing the curriculum, a difference between the groups was noted for the extracorporeal knot task (112 s [97–121 s] in group 1 compared to 124 s [107–142 s] in group 2; *P* = .036; Fig 1). After completing the course, the measured PT values in both groups were improved compared to the initially recorded BL values in all tasks (*P* < .001). The comparison of the RT values measured after 6 or 11 and the initial BL values showed significant better values during the RT in all tasks (Tables III and IV).

In group 1, comparison of the values measured directly at the end of the curriculum (PT) with values measured after the 6-week interval (RT) showed no significant deterioration of acquired skill in all tasks apart from the extracorporeal knot tying task. The time measured to complete the pattern cutting task during the RT was significantly less and therefore improved when compared to the values measured at the end of the curriculum (PT). The measured score for completion of a sufficient extracorporeal knot was significantly greater during the RT when compared to the PT values (Table III).

In group 2, comparisons of the PT and RT values measured after an interval of 11 weeks showed no significant deterioration of acquired
skill for the easy tasks (grasping and clipping) nor for the moderately difficult tasks (camera navigation and pattern cutting). For the difficult skills (extra- and intracorporeal knot tying) and the moderately difficult tasks (transfer, positioning, and loop tie), the RT values were significantly poorer when compared to the PT values (Table IV; Fig 2).

Twenty-four novices completed the questionnaire concerning the level of difficulty of the tasks on the first and last practice day. The following results were recorded: the easiest tasks on the first practice day were clipping (n = 15; 63%), grasping (n = 6; 25%), transfer (n = 2; 8%), and positioning (n = 1; 4%). On the last day, the easiest tasks were clipping (n = 12; 50%), grasping (n = 8; 33%), transfer (n = 2; 8%), camera navigation (n = 1; 4%), and pattern cutting (n = 1; 4%).

The most difficult tasks on the first practice day were intracorporeal knot tying (n = 14; 58%), pattern cutting (n = 6; 25%), and transfer (n = 4; 17%). On the last day, the most difficult tasks were transfer (n = 8; 33%), intracorporeal knot tying (n = 6; 25%), camera navigation (n = 4; 17%), pattern cutting (n = 4; 17%), positioning (n = 1; 4%), and extracorporeal knot tying (n = 1; 4%).

The tasks were classified as follows: easy—grasping, clipping; moderate—camera navigation, transfer, positioning, pattern cutting, loop tie; and difficult—intracorporeal and extracorporeal knot tying. All tutors were in accordance of this grading.

DISCUSSION

Modern training in surgery is evolving, with additional emphasis being placed on the development of hands-on psychomotor training in an environment outside of the operating room. For this purpose, surgical skills laboratories have been established and have gained importance over the last decade, acknowledging the need for new aspects in training. The integration of simulation in ongoing training has proven effective. In addition, the transferability of the acquired skills into the operating room scenario and the correlation of measured simulator skill with operating room performance has been shown.  

In this study, we aimed at teaching individual basic laparoscopic skills that are required for laparoscopic surgery. In choosing tasks, we considered the need for reproducible simple tasks such as those previously described and validated by other groups. We adapted these basic tasks

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**Table I. Participant demographics**

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (n = 18; 6 wks)</th>
<th>Group 2 (n = 18; 11 wks)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>24 (23–37)</td>
<td>24 (23–37)</td>
<td>.93</td>
</tr>
<tr>
<td>Sex (male:female)</td>
<td>12:6</td>
<td>9:9</td>
<td>.49</td>
</tr>
<tr>
<td>Semester</td>
<td>8 (7–10)</td>
<td>9 (7–11)</td>
<td>.23</td>
</tr>
<tr>
<td>Previous experience in surgery (self-rating 1–5)</td>
<td>3 (2–5)</td>
<td>3 (2–4)</td>
<td>.34</td>
</tr>
<tr>
<td>Previous laparoscopic experience (self-rating 1–5)</td>
<td>5 (4–5)</td>
<td>4 (3–5)</td>
<td>.16</td>
</tr>
<tr>
<td>Previous experience in camera navigation (yes/no)</td>
<td>7/11</td>
<td>11/7</td>
<td>.32</td>
</tr>
<tr>
<td>Dominant hand (right/left)</td>
<td>17/1</td>
<td>18/0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Values for age, semester, and previous surgery and laparoscopic experience are shown as medians with ranges in brackets. P values of Pearson Chi-square test for categorical data and Mann–Whitney U test for continuous data. Self-rating was reported according to 5-point Likert scale, with 1 indicating very experienced and 5 indicating no previous experience.

**Table II. Comparison of baseline results of groups 1 and 2**

<table>
<thead>
<tr>
<th>Task</th>
<th>Baseline group 1 (n = 18)</th>
<th>Baseline group 2 (n = 18)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera navigation</td>
<td>300 (300–300)</td>
<td>300 (300–300)</td>
<td>.743</td>
</tr>
<tr>
<td>Grasping</td>
<td>120 (86–151)</td>
<td>120 (98–143)</td>
<td>.938</td>
</tr>
<tr>
<td>Transfer (L/R)</td>
<td>300 (293–300)</td>
<td>300 (300–300)</td>
<td>.030</td>
</tr>
<tr>
<td>Positioning/placement</td>
<td>208 (178–235)</td>
<td>223 (179–250)</td>
<td>.343</td>
</tr>
<tr>
<td>Pattern cutting</td>
<td>300 (281–300)</td>
<td>300 (275–300)</td>
<td>.521</td>
</tr>
<tr>
<td>Loop tie</td>
<td>149 (94–180)</td>
<td>104 (84–128)</td>
<td>.116</td>
</tr>
<tr>
<td>Extracorporeal knot</td>
<td>221 (184–252)</td>
<td>226 (186–271)</td>
<td>.457</td>
</tr>
<tr>
<td>Intracorporeal knot</td>
<td>300 (281–300)</td>
<td>300 (300–300)</td>
<td>.067</td>
</tr>
<tr>
<td>Clipping</td>
<td>69 (59–73)</td>
<td>59 (54–66)</td>
<td>.070</td>
</tr>
</tbody>
</table>

Data reported as median (interquartile range) in seconds. P values were assessed with the Mann–Whitney U test.
because of the restriction in available equipment at our unit. Beyond these tasks, we introduced additional skills to the curriculum, such as camera navigation, clipping, and precision positioning. So far, no standardized curriculum for such purposes exists in Germany. Current efforts towards a European curriculum through the European Association of Endoscopic Surgery (EAES) are in development but are not yet in place.

The elements of the curriculum were performed in a box trainer. Much debate remains about the value of different types of simulators. Although box trainers have been criticized as being unrealistic and inferior to virtual reality simulators with regard to the assessment of objective measurements, transferability of acquired skills between simulator types has been shown.\textsuperscript{16,34,35} Our model allowed only a measurement of required time for task completion, which may be a poor parameter for skill measurement, because this approach may encourage the participant to work quickly rather than correctly. Therefore, we chose a penalty system similar to systems described previously by groups using box trainers.\textsuperscript{17-19,29} Interestingly, this penalty score was not required during PT or RT, because these errors were no longer observed. In addition, whether additional assessments of parameters, such as instrument pathway and smoothness are of benefit for training or proficiency assessment remains unclear and requires further investigation.\textsuperscript{36}

We chose medical students as surgical novices because we wanted to avoid the influence of previous and ongoing experience in surgical technique. Both groups represent novices in surgery, even though when questioned, approximately half the participants stated to have had some previous experience in laparoscopic camera navigation and stated that they had some access to operating rooms during electives; however, none of the participants had received any form of structured surgical or laparoscopic training. Our aim was to achieve a nonbiased experimental design to evaluate only the influence of the curriculum in a previously surgically unskilled group and to evaluate the effect of time between training and retesting without outside influences of exposure to surgical procedures (open or laparoscopic). Previous research has revealed that a group of medical students as novice surgeons are just as capable at acquiring the necessary technical skills in a simulator environment as senior surgery residents.\textsuperscript{37} In our groups, we therefore viewed the achieved results as minimum achievable results. Residents in training with previous surgical skills could possibly do better in this curriculum and could possibly also demonstrate a greater duration of skill retention. Although using surgical novices limits the transferability of this data, we believe that these results show the phenomenon of skill loss in a purer group without outside influences.

Training of the groups was not performed simultaneously; therefore, other possibly unrecognized factors may have been present and impacted the training results. But because the sustainability of the skills acquired using this specific curriculum were unknown, both groups had to be tested subsequently. This fact is a limitation in this study, but because both groups were chosen randomly and the observed BL and PT values did not differ between groups in all but 1 task, we believe that the groups and training results are comparable for evaluation. In addition, we did not aim at measuring proficiency levels; rather, we allowed a set number of repetitions equal within the groups after having recorded baseline values. This approach was used intentionally because we wanted to set the scenario as it would be for trainees without access to a skills facility only participating in courses of set duration (day/weekend/week) throughout their training. These courses remain very popular in Germany; a national survey revealed that of questioned directors of a surgery department, 93% stated that their

![Fig 1. Boxplots (median, interquartile range, and range) showing post-training values after the 5-day curriculum for each group (1 or 2) for each task. Task 1, Camera navigation; task 2, grasping; task 3, transfer between left and right hand; task 4, positioning; task 5, pattern cutting; task 6, endoloop tie; task 7, extracorporeal knot; task 8, intracorporeal knot; and task 9, clipping.](image-url)
residents participated in such courses, whereas only 27% of these departments had a skills facility available for regular use in order to train residents to proficiency. Because in our area many departments still opt for interval training, we chose to evaluate the skill retention in a similar scenario. Both groups achieved comparable PT results allowing the comparison of the outcomes of the 2 different, selected, training-free intervals. The PT values revealed a significant improvement in performance when evaluated in time. Other groups have shown that during an ongoing training program, such as offered in a Fundamentals of Laparoscopic Surgery curriculum, surgical residents in the United States retained acquired skills for a period of 6–8 months. Despite the continuous training and additional contact to operative experience throughout this period, these groups showed that performance of complex tasks is likely to deteriorate over the months after the curriculum. It is possible that residents in training do not have the opportunity to practice these more complex skills in a clinical environment. In addition, refresher training is of great importance in skill retention. In our study, we aimed at excluding factors such as parallel ongoing training in an operating room scenario. Because recruitment was voluntary, a selection of students interested in surgery resulted. Because each re-evaluation for testing purposes also represents a refresher, we chose to re-evaluate for skill retention 6 weeks after the initial training. Given that previous research found retained skill in the evaluation of RT at 2, 4, and 9 weeks, we felt that testing at 6 weeks without previous interval retesting would show whether any skill was retained after initial training while excluding the influence of a refresher through retesting at lesser intervals. The results of this first group revealed that apart from the extracorporeal knot tying skill, in all other tasks skills had been retained.

Table III. Results of measurements of group 1 (n = 18)

<table>
<thead>
<tr>
<th>Task</th>
<th>BL</th>
<th>PT</th>
<th>RT-6</th>
<th>P value</th>
<th>Level of difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (IQR)</td>
<td>Median (IQR)</td>
<td>Median (IQR)</td>
<td>PT vs BL</td>
<td>RT-6 vs PT</td>
</tr>
<tr>
<td>Camera navigation</td>
<td>300 (300–300)</td>
<td>201 (169–220)</td>
<td>223 (176–259)</td>
<td>.000</td>
<td>.196</td>
</tr>
<tr>
<td>Grasping</td>
<td>120 (86–151)</td>
<td>39 (30–49)</td>
<td>49 (36–58)</td>
<td>.000</td>
<td>.052</td>
</tr>
<tr>
<td>Transfer (L/R)</td>
<td>300 (293–300)</td>
<td>163 (153–227)</td>
<td>208 (136–248)</td>
<td>.000</td>
<td>.417</td>
</tr>
<tr>
<td>Positioning/placement</td>
<td>208 (178–235)</td>
<td>94 (80–123)</td>
<td>97 (74–136)</td>
<td>.000</td>
<td>.632</td>
</tr>
<tr>
<td>Pattern cutting</td>
<td>300 (281–300)</td>
<td>171 (152–219)</td>
<td>162 (111–211)</td>
<td>.000</td>
<td>.037</td>
</tr>
<tr>
<td>Loop tie</td>
<td>149 (94–180)</td>
<td>38 (31–58)</td>
<td>42 (33–57)</td>
<td>.000</td>
<td>.873</td>
</tr>
<tr>
<td>Extracorporeal knot</td>
<td>221 (184–252)</td>
<td>112 (97–121)</td>
<td>152 (108–148)</td>
<td>.000</td>
<td>.007</td>
</tr>
<tr>
<td>Intracorporeal knot</td>
<td>300 (281–300)</td>
<td>176 (156–214)</td>
<td>200 (171–235)</td>
<td>.000</td>
<td>.193</td>
</tr>
<tr>
<td>Clipping</td>
<td>69 (59–3)</td>
<td>37 (27–40)</td>
<td>31 (27–39)</td>
<td>.000</td>
<td>.151</td>
</tr>
</tbody>
</table>

Data are reported as median (interquartile range) in seconds. P values were assessed with the Wilcoxon signed-rank test; P < .05 indicates statistical significance. The level of difficulty was graded as easy, moderate, or difficult.

BL, Baseline; PT, post-training; RT-6, retention testing at 6 weeks.

Table IV. Results of measurements of group 2 (n = 18)

<table>
<thead>
<tr>
<th>Task</th>
<th>BL</th>
<th>PT</th>
<th>RT-11</th>
<th>P value</th>
<th>Level of difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (IQR)</td>
<td>Median (IQR)</td>
<td>Median (IQR)</td>
<td>PT vs BL</td>
<td>RT-11 vs PT</td>
</tr>
<tr>
<td>Camera navigation</td>
<td>300 (300–300)</td>
<td>220 (182–250)</td>
<td>288 (228–300)</td>
<td>.000</td>
<td>.080</td>
</tr>
<tr>
<td>Grasping</td>
<td>120 (98–143)</td>
<td>38 (35–46)</td>
<td>42 (34–51)</td>
<td>.000</td>
<td>.587</td>
</tr>
<tr>
<td>Transfer (L/R)</td>
<td>300 (300–300)</td>
<td>173 (130–199)</td>
<td>195 (165–266)</td>
<td>.000</td>
<td>.042</td>
</tr>
<tr>
<td>Positioning/placement</td>
<td>223 (179–250)</td>
<td>113 (82–132)</td>
<td>155 (123–176)</td>
<td>.000</td>
<td>.012</td>
</tr>
<tr>
<td>Pattern cutting</td>
<td>300 (275–300)</td>
<td>153 (135–182)</td>
<td>146 (130–202)</td>
<td>.000</td>
<td>.525</td>
</tr>
<tr>
<td>Loop tie</td>
<td>104 (84–128)</td>
<td>47 (38–49)</td>
<td>61 (48–71)</td>
<td>.000</td>
<td>.077</td>
</tr>
<tr>
<td>Extracorporeal knot</td>
<td>226 (186–271)</td>
<td>124 (107–142)</td>
<td>160 (126–187)</td>
<td>.000</td>
<td>.002</td>
</tr>
<tr>
<td>Intracorporeal knot</td>
<td>300 (300–300)</td>
<td>197 (180–218)</td>
<td>240 (216–283)</td>
<td>.000</td>
<td>.005</td>
</tr>
<tr>
<td>Clipping</td>
<td>59 (54–66)</td>
<td>31 (27–32)</td>
<td>34 (31–39)</td>
<td>.000</td>
<td>.083</td>
</tr>
</tbody>
</table>

Data are reported as median (interquartile range) in seconds. P values were assessed with the Wilcoxon signed-rank test; P < .05 indicates statistical significance. The level of difficulty was graded as easy, moderate, or difficult.

BL, Baseline; PT, post-training; RT-11, retention testing at 11 weeks.
Although extracorporeal knot tying represents an essential task in programs of proficiency-based training, we observed that a substantial aspect of the skill required for completing the task in our study population was the adequate performance of a hand-tied knot. Without previous surgical training, most of our students struggled in performing the extracorporeal knot task. At the end of the course, this task was the only skill for which a significant difference in PT values between groups was observed. Especially with regard to this task, residents in training would most likely achieve better results, because a hand-tied knot represents a basic skill used frequently in surgical tasks.

The grading of the tasks as easy, moderate, or difficult was chosen using the student rating along with the tutors’ rating. During training, the tutors saw similar errors being made amongst the participants, identifying pitfalls for different tasks. This observation was used in the coaching to aid the participant. The tutor grading of the tasks was unanimous after having followed the 36 participants over the courses. We are aware that this grading system represents a subjective opinion of our tutors and students; nevertheless, it was a helpful tool in viewing the results.

After seeing that the majority of skills had been retained at 6 weeks, we chose the second interval of 11 weeks for the second group in order to evaluate how long the skill level could be maintained. Data from studies in the field of emergency skills training have shown rapid skill decay in novices and in trained health care professionals within a period of 30–90 days PT. In contrast, results from colonoscopy training using virtual reality trainers have revealed skill retention for >3 months. To our knowledge, no comparable information for surgical procedural skills without the influence of ongoing training or repeated simulator re-evaluation is available. We chose the time-frame of 11 weeks. Had the results at 11 weeks shown skill retention for the tasks, then another group would have been required to test a later date, but from the results we received, reassessment was not required. The results showed that the skills rated as easy (clipping and grasping) and some of the skills considered moderately difficult (pattern cutting and camera navigation) had been retained over this greater period of time, without significant differences between the RT values and those measure initially after the course. The tasks rated as difficult (intracorporeal and extracorporeal knot tying) were performed significantly poorer when compared to values after the initial training. In addition, intermediate skills, such as transfer, loop tie, and positioning, had deteriorated equally. Nevertheless, when rating the performance of the novices at 11 weeks, we also considered their results in relation to their initial baseline values. All students had retained elements of the basic skills training, because the values recorded after 11 weeks were still significantly better than the results recorded initially during the BL measurement. Therefore, despite the noted deterioration of skill during the period between 6 and 11 weeks, a measurable positive effect of the initial training was still observable within the group.

This study shows the effect of time on skill deterioration in a surgical experimental setting. Transferability to a clinical setting is limited by the study design; nevertheless, in the setting of surgery residents without continuous training in a skills facility, the described curriculum could be used to teach basic laparoscopic skills initially in a 5-day course. This approach may be optimal for training before starting a formal surgery residency. From these data, we would recommend the opportunity for a refresher training either clinical or within a simulator environment after an interval of 6–11 weeks because this duration seems to be the minimum retention timeframe in a novice group. Whether the complex tasks should be included in this initial training or a second advanced course.

Fig 2. Boxplots (median, interquartile range, and range) showing post-training (PT) and retention testing (RT) values for group 2. Task 1, Camera navigation; task 2, grasping; task 3, transfer between left and right hand; task 4, positioning; task 5, pattern cutting; task 6, endoloop tie; task 7, extracorporeal knot; task 8, intracorporeal knot; and task 9, clipping. *Significant differences between measurements (Wilcoxon signed-rank test) in tasks 3, 4, 6, 7, and 8.
should be offered at a later phase of training remains debatable.

REFERENCES


