Limited feedback and video tutorials optimize learning and resource utilization during laparoscopic simulator training

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Background. *The purpose of this study was to determine the impact of instructor feedback and video tutorials on skill acquisition during proficiency-based laparoscopic suturing training.*
Methods. *Performance data from a prospectively maintained database were reviewed for three groups of novices (n = 34 medical students) who completed the same proficiency-based laparoscopic suturing curriculum on a Fundamentals of Laparoscopic Surgery–type videotrainer model as part of two separate institutional review board–approved, randomized controlled trials. Group I (n = 9) watched the video tutorial once and received intense feedback during each training session; Group II (n = 13) watched the video tutorial once and received limited feedback (<10 min per session); Group III (n = 12) watched the video tutorial several times and also received limited feedback (<10 min per session). Feedback was given by the same instructor and was quantified on a 0 (none) to 4 (extensive) Likert scale.*
Results. *Baseline characteristics were similar for all groups. All participants achieved the proficiency level (512) on two consecutive attempts. Group III required the shortest training time and number of repetitions to reach proficiency, with statistically significant differences compared with Group I* (P *< 0.02). This strategy led to a cost savings of $139 per trainee.*
Conclusions. *Limited instructor feedback appears to be superior to intense feedback during proficiency-based laparoscopic simulator training. Coupled with video tutorials, this type of feedback may accelerate learning and improve resource utilization by minimizing the need for instructor involvement. (Surgery 2007;142:202-6.)*

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INTRODUCTION

The complexity of new laparoscopic surgical techniques, patient safety, medicolegal concerns, fiscal limitations, time constraints especially in the era of the 80-hour work week, and increasing teaching-faculty productivity demands constrain resident training in the operating room and have created the need for formal training in a skills laboratory.[1,2] As a result, multiple simulators have been developed and validated as educational tools for resident training outside the operating room.[3,4] Acquisition of laparoscopic operative skills on a simulator can help overcome the learning curve of a new, complex, and difficult task through repetitive practice in a safe, nonthreatening environment and lead to improved performance during patient encounters. Proficiency-based simulator curricula have proved efficient and effective in providing trainees with surgical skill that translates to the operating room[5,6] and is durable.[7,8] Nevertheless, such curricula need further refinement to provide trainees with optimal skill acquisition.

Performance feedback can be essential for skill acquisition[9]; however, limited work exists on its

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value during simulator training.[10-12] Considering that inappropriate feedback can hinder skill learning,[9,13] it is critical to identify feedback techniques that are optimal for simulator training.

Besides feedback, instruction and demonstration play a crucial role for motor skill training.[9,14] Effective instruction can facilitate skill acquisition and lead to superior learning of trainees.[9,14] As with feedback, however, inappropriate instruction and demonstration can also have a negative impact on performance.[9] A delivery method of instruction and demonstration that is gaining popularity across disciplines involves videotaped tutorials.[9,15,16] Video-based education has proved effective for the acquisition of laparoscopic skills.[17,18]

The objective of this study was to determine the impact of instructor feedback and video tutorials on skill acquisition during proficiency-based training in laparoscopic suturing.

METHODS

Data from proficiency-based training in laparoscopic suturing accrued on novices during two separate institutional review board–approved randomized controlled trials were reviewed.[19,20] The two trials included four groups (two each) of which three with similar training, but variable instructor feedback and video tutorial viewings were included in this study. The excluded group had trained under different conditions. The three groups were comparable because they were drawn from the same participant pool (second-year medical students, n = 34), had no prior surgical or simulator experience, had viewed an instructional video of the suturing technique, had completed baseline testing, and had followed the same proficiency-based laparoscopic suturing simulator curriculum on a Fundamentals of Laparoscopic Surgery–type videotrainer model. In addition, training was distributed in hourly sessions with standardized feedback provided by a single expert instructor and was completed when a previously validated proficiency level (score = 512)[6] was achieved on two consecutive attempts. The rationale to for the limited feedback approach was necessitated by the limited availability of the instructor during one of the randomized controlled trials. The video tutorials were anticipated to enhance skill acquisition.

The following groups were included: Group I (n = 9) had received intense feedback during each session and had no further video exposure, Group II (n = 13) had received limited feedback (<10 min per session) and no further video exposure, and Group III (n = 12) had received limited feedback (<10 min per session) and watched the video tutorial three times before training and at least once during each training session. The number of video tutorial viewings and amount of instructor feedback was recorded during each training session. Feedback was quantified on a 0 (none) to 4 (extensive) Likert scale for each repetition by the same instructor. The primary study end points were time and repetitions to complete the proficiency-based curriculum and the secondary end point was the cost involved. Participant demographics, handedness, experience in laparoscopic surgery, simulator use, and video games were recorded and compared.

Performance was assessed with objective scores based on time and errors using the following previously published formula:[6] 600 − (time + accuracy error * 10 + incomplete knot approximation error (gap) * 10 + security error * 10). Cost was calculated based on instructor time spent with the students and suturing expenses; the hourly pay of the instructor and a $1 cost per suture were used for our calculations. Capital cost of simulators and equipment and other miscellaneous supplies were not included.

Statistical analysis. Nonparametric tests were used for statistical analysis; ANOVA on ranks was used for the comparisons of the three groups (SPSS Sigma Stat; Chicago, Ill.). The results are reported as median (range) and $P < 0.05$ was considered significant.

RESULTS

No significant differences were found in the baseline characteristics and performance of the three groups (Table I). All participants were able to achieve the proficiency level (512) on two consecutive attempts. Group I received feedback significantly more often compared with Groups II and III, whereas Group III viewed the video tutorials more often than Groups I and II (Fig 1, Table II).

Compared with Groups I and II, Group III required the shortest training time and number of repetitions to reach proficiency (Table II). Group III required 24% less time to reach proficiency compared with Group II, but this difference was not significant ($P = 0.1$). Group III also demonstrated the most accelerated learning compared with the other groups (Fig. 2). Limiting the frequency of feedback led to substantial cost savings as the average cost per trainee was $179 for Group I, $46 for Group II, and $40 for Group III. The cost savings were mainly the consequence of less instructor involvement. The majority of feedback was provided during the early stages of skill acquisition.

Table I. Baseline group characteristics

	Group I (n = 9)	*Group II (n = 13)*	*Group III (n = 12)*	P *value*
Age (y)	24 (22-32)	25 (24-29)	25 (23-29)	NS
Women (%)	55	54	25	NS
Right-handed (%)	100	100	100	NS
Prior laparoscopy experience*	0 (0)	0 (0-1)	0 (0-2)	NS
Prior simulator experience*	0 (0-1)	0 (0)	0 (0)	NS
Prior video game experience*	3 (1-10)	5 (2-10)	3.5 (2-9)	NS
Baseline time(s)	600 (429-600)	600 (470-600)	600 (546-600)	NS
Baseline score	0 (0-71)	0 (0)	0 (0-24)	NS

Values represent medians (range) unless otherwise noted.
P values refer to ANOVA on ranks group comparisons.
*Ratings on a 1 to 10 Likert scale.

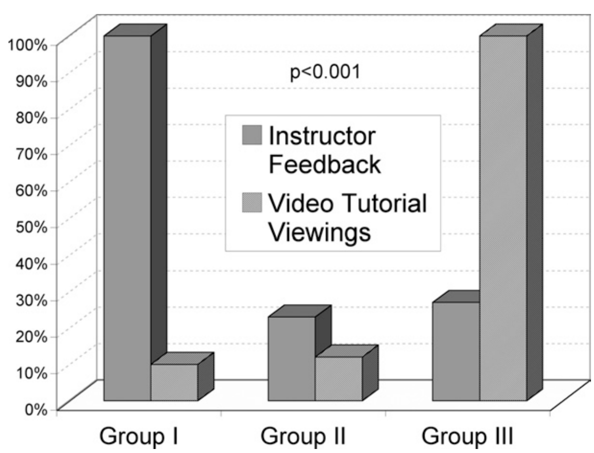

Fig 1. Relative amounts of feedback received and video tutorials viewed by the three groups. Group I feedback and Group III video tutorial viewings have been set at 100% to allow direct comparisons. The *P* value refers to the ANOVA on ranks comparison both for feedback and video tutorials. All pairwise comparisons are significant ($P < 0.05$) except Group I vs Group II video tutorial viewings and Group II vs Group III feedback received.

DISCUSSION

In the skills literature, feedback refers to the return of performance-related information to the performer and can be divided into two major categories: intrinsic feedback and extrinsic or augmented feedback.[9] Intrinsic feedback consists of performance-related information available directly to the sensory system of the performer (i.e., the visual, auditory, or haptic perceptions during the performance of tasks).[9] Extrinsic or augmented feedback is performance-related information that is provided by an external source and aims to augment intrinsic feedback. Augmented feedback plays two important roles in the skill learning process: to facilitate achievement of the action goal of the skill and to motivate the learner to continue to strive toward the achievement of a goal.[9] In medical education, feedback to learners has been defined as an informed, nonevaluative appraisal of performance by the teacher.[21] Its purpose is to both reinforce strengths and foster improvements in the learner by providing insight into actions and consequences and by highlighting the differences between the intended and the actual results of their actions.[21] Indeed, improved performances secondary to augmented feedback have been demonstrated before in clinical skills and during simulator training.[10,11,22,23]

In this study, we aimed to evaluate the effect of the frequency and amount of augmented feedback provided to our trainees and demonstrated that intense feedback (100%) during the early stages of skill acquisition can hinder learning. Although this finding may seem surprising at first, it is supported by evidence from other disciplines. Winstein and Schmidt[24] first suggested in 1990 that the optimal frequency for providing augmented feedback is less than 100%. Although a reduced frequency appears to benefit skill learning, the optimal frequency is unknown and task specific.[9] The guidance hypothesis proposed by these authors provides a good explanation for our findings. According to this hypothesis, if augmented feedback is provided too frequently, it can cause the learner to develop dependency on its availability and to perform poorly in its absence.[24] Furthermore, continuous, intense feedback likely inhibits the intrinsic learning strategies and problem-solving activities in which learners need to engage to master a skill.[9] Consequently, the groups of students who received limited feedback (<10 min) during each training session likely benefited both from the time they were practicing on their own and developing their own learning strategies and from the presence of the instructor who answered their questions and directed their attention to potential

Table II. Group comparisons during training

	Group I (n = 9)	*Group II (n = 13)*	*Group III (n = 12)*	P *value*
Instructor feedback*	44 (22-79)	7 (3-18)	9 (3-12)	<0.001
Video tutorial viewings (no.)	1 (1-2)	1 (1-3)	8 (6-12)	<0.001
Training time to proficiency (min)	146 (44-226)	102 (47-213)	78 (55-149)	<0.02
Repetitions to proficiency (no.)	53 (18-76)	35 (21-67)	30 (20-56)	<0.02
Cost per trainee	$179	$46	$40	<0.001

Values represent medians (range).
P values refer to ANOVA on ranks group comparisons.
*Total values of instructor feedback received during training. Feedback was recorded on a 0 to 4 Likert scale for each repetition.

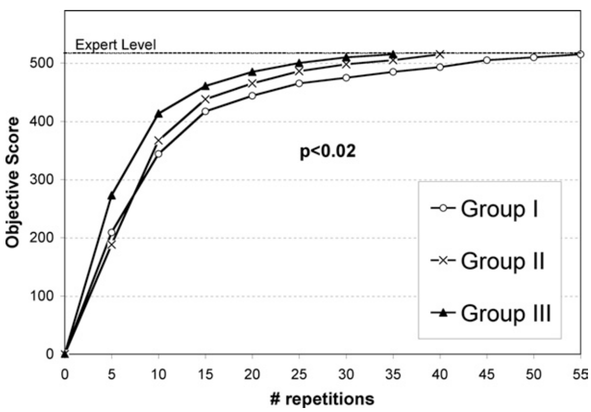

Fig 2. Comparison of learning curves among the three groups. The figure depicts the number of repetitions needed to achieve proficiency (score of 512 set as expert level).[6] The *P* value refers to the ANOVA on ranks group comparison of median repetition numbers to achieve proficiency. Pairwise comparisons differ only between Groups I and III ($P < 0.05$).

performance deficiencies. Nevertheless, the frequency with which we provided feedback in this study was chosen arbitrarily, and further research is needed for its optimization.

Also, our study possibly suggested a trend toward faster achievement of simulator proficiency with the incorporation of frequent video tutorial viewings in the curriculum. Rosser et al.[17] demonstrated that a CD-ROM tutorial on laparoscopic skills transferred effectively cognitive information necessary for skill development. In a further study from that group, trainees who watched a CD-ROM tutorial on laparoscopic suturing performed this task better compared with those who did not watch it.[11] Many other studies have confirmed the positive effect of video tutorials for skill acquisition.[15,16,18,25] Our results are congruent with these studies because the student group that viewed the video tutorials more often tended to achieve proficiency faster, but we have lacked the power to achieve statistical significance. It is also important to note that the video demonstrations were provided before and during training, which has been shown to lead to superior learning.[9]

In addition to small sample sizes, a limitation of our study is that although it was based on performance data accrued during two separate randomized controlled trials, it is not the product of true randomization. Nevertheless, we believe that because trainees in both studies had similar baseline characteristics, followed exactly the same curriculum, and received feedback by the same instructor, our study offers potentially valuable information for simulator training. In addition, skill acquisition data of students may not be generalizable directly to other levels of experience, and our findings may not hold true for complex laparoscopic procedures. Nevertheless, students represent the residents and surgeons of tomorrow and are an ideal population for skills studies as their learning is not influenced by ongoing practice. Furthermore, laparoscopic suturing is an advanced laparoscopic skill that is an integral part of many advanced laparoscopic procedures, and the acquisition characteristics of suturing may translate to other parts of such procedures. Moreover, procedural videos are available today that in conjunction with appropriate feedback may enhance surgeons' learning in a similar fashion as we encountered in this study.

The implications of this study are important because the study provides evidence against continuous and intense feedback and support for the use of video tutorials during simulator training. Moreover, it revealed that this strategy can lead to substantial cost savings in training by minimizing the need for instructor involvement. It remains to be proven in a randomized controlled fashion, however, whether these interventions affect learning by examining the transferability of the simulator acquired skill to the operating room.

In conclusion, limited instructor feedback appears to be superior to intense feedback during proficiency-based laparoscopic simulator training. Coupled with video tutorials, this type of feedback may accelerate the learning curve and improve resource utilization by minimizing the need for instructor involvement.

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