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RETENTION OF SUTURING AND KNOT-TYING SKILLS IN SENIOR MEDICAL STUDENTS AFTER PROFICIENCY-BASED TRAINING: RESULTS OF A PROSPECTIVE, RANDOMIZED TRIAL

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Abstract

PURPOSE—We evaluated suturing skills performance and retention in senior medical students (MS4) at the beginning of 4th-year and 7 months later.

METHODS—MS4 entering a surgical specialty were randomized to a proficiency-based suturing/knot-tying curriculum at the beginning of 4th year (Intervention, n=10) versus no training (Control, n=9). Time and technical proficiency (TP, proficiency 3) were assessed at baseline and 7 months. Performance was compared to past “Boot-Camp” MS4, categorical PGY-1 interns and PGY-2 residents. Data are mean $\pm$ SD.

RESULTS—At baseline, Intervention and Control MS4 had similar total task times (848 ± 199 vs. 845 ± 209 sec) and TP scores ($1.8 \pm .15$ vs. $1.8 \pm .3$). At 7 months, Intervention MS4 total task times were significantly faster (549 ± 80 vs. 719 ± 151 sec, $p < .01$) and mean TP scores higher (3.3 ± 0.6 vs. 2.1 ± 0.4 , $p < .001$) than Control MS4. Intervention MS4 also performed better at 7 months than Boot-Camp MS4 (662 ± 171 sec and 2.6 ± 0.5 , $p < .04$) and were similar to PGY-1 interns (601 ± 74 sec, TP 2.7 ± 0.7) and end of PGY-2 residents (475 ± 81 sec and 3.6 ± 0.3).

CONCLUSION—A proficiency-based suturing and knot-tying curriculum taught early in 4th-year results in improved MS4 performance compared to no training or a traditional “boot camp” program.

Introduction

Surgical education and training has evolved substantially in recent years with a shift toward increased simulation skills training. While all surgical training programs now have skills laboratory experiences for their residents, the opportunities for skill development of medical students vary widely among institutions. Many factors have led to global changes in surgical training; these include increasing work hour restrictions, the increasing complexity of surgical patients at highly specialized academic medical centers, rapid advances in surgical technology, the need for enhanced operating room proficiency, and greater supervision requirements. As a result, students may have fewer opportunities to learn surgical skills in a real-time setting and may be deficient in their skill level at the outset of internship.¹

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Many institutions have implemented “boot camp” courses for senior medical students and incoming surgical interns to address this perceived need.²⁻⁴ In 2006, we implemented a highly focused skills course entitled “Accelerated Skills Preparation for Surgical Internship” open to any MS4 matching into a surgical specialty.⁵ Courses such as ours have shown that a fundamental surgical skills course gives MS4 an increased sense of confidence and preparedness for internship and results in improved skills performance.⁵⁻⁸ A potential barrier to optimal skills acquisition can be the timing of instruction relative to student rotation experience. Few sub-internship rotations have formal skills training⁹ and 4th year “boot-camp” courses typically take place in the spring when students have completed their surgical rotations and do not have a real-time opportunity to apply these skills in the operating room until internship. To address this issue, we recently moved our MS4 proficiency-based suturing and knot-tying curriculum to the beginning of the academic year. We hypothesized that this approach would result in improved student performance and skills retention compared to traditional approaches.

Methods

In June 2011, we initiated a prospective, randomized study of Washington University MS4 (Class of 2012) who anticipated matching into any surgical subspecialty. Recruitment was via email, and informed consent was obtained under an Institutional Review Board approved protocol. MS4's were randomized into two groups: 1) “Intervention MS4” (N=11) participated in a proficiency-based suturing and knot-tying curriculum at the start of 4th year, and 2) “Control MS4” (N=10) received no specific skills training. Three other groups were included for comparison: 3) historical “Boot-Camp MS4” (N=19) who were in the Accelerated Skills course in the spring of the prior year (Class of 2011); 4) “PGY-1 Interns” (N=8); and 5) End of PGY-2 (N=6) general surgery residents who served as a benchmark for all groups. Both Boot-Camp MS4 and PGY-1 interns completed a similar curriculum.

Curriculum format

The proficiency-based suturing and knot-tying curriculum has been described previously¹⁰ and consists of an initial didactic lecture followed by a 3-hour hands-on skills training session and a one-hour refresher session 4 weeks later. Students had online access to suturing/knot-tying videos and were given instruments and materials for home practice which they kept for the duration of the study. Two suturing tasks (simple interrupted and running subcuticular) and three knot-tying tasks (two-handed tie, one-handed tie, and tying on a pass) were assessed. Feedback with video review was given individually after the 8-week assessment.

Assessment

Performance assessment was based on task time and technical proficiency scores. Time (sec) was recorded for each individual task and included a total task time (sum of 5 individual tasks). Students were given goal times for each task (Table 1). Technical proficiency (TP) was evaluated through videotaped assessment using a dual-camera video capture system (Simbridge, B-Line Medical, Washington, DC). Videos were de-identified and rated by one expert senior surgeon (LMB) blinded to the student group. Technical proficiency was scored using a 5 point Objective Structured Assessment of Technical Skills as previously described (1=novice, 3=proficient, 5=expert).(Zeng). Proficiency was defined as meeting both time and technical proficiency (TP score ≥ 3) benchmarks.

The Intervention MS4 group was tested at 3 time points: baseline (pre-instruction), 8 weeks post-course, and at 7 months. The 8-week evaluation followed completion of at least one surgical sub-internship. Control MS4 students were assessed at baseline and 7 months.

Historical Post Boot-Camp MS4 from the prior year who had participated in the same curriculum through the Accelerated Skills course were tested at baseline and 8 weeks post instruction. Categorical PGY-1 interns were tested at baseline (1 week prior to start of internship) and four months into the internship year. PGY-2 residents were tested after completion of two clinical years of categorical general surgery training.

For each group, individual and total task times and TP scores were analyzed and intergroup comparisons were made. Statistical analysis was carried out using Student's t-test and the Kruskal-Wallis test. Data are presented as mean and standard deviation ($\alpha=.05$).

Results

Twenty-one students were enrolled in the prospective, randomized study (Intervention MS4 N=11; Control MS4 N=10). The demographics of the two groups are shown in Table 2 and were similar regarding age, gender, and planned surgical specialty. Only one student in the study (Intervention MS4) was left-handed. Two students in the Intervention group did not complete the 7-month assessment. One student in the Control MS4 group who was unable to complete the tasks at both baseline and 7 months was excluded from the analysis.

Baseline task times and technical proficiency scores for both groups are shown in Fig. 1. No significant differences in baseline student performance were seen between groups for any of the five tasks. When comparing Intervention MS4 to the Control MS4 group, there were no significant differences at baseline for total task time (855 ± 190 vs. 859 ± 202 , $p=0.97$) or TP scores (1.72 ± 0.31 vs. 1.75 ± 0.33 , $p=0.77$). At the 8-week post-course assessment time point for the Intervention MS4 group, the total mean time to complete all five tasks had improved significantly to 543 ± 80 seconds ($p<.001$) and TP score improved to 3.04 ± 0.3 ($p<.001$). Statistically significant improvements were also observed for both time and TP in all five tasks individually (Fig. 2).

Data from the 7-month assessment for the individual tasks for both groups are shown in Fig. 3. The Intervention group maintained their post-training performance level for both task times and TP scores (no difference vs post-course assessment; significantly improved vs. baseline, $p<0.001$). The Control MS4 group showed an insignificant improvement in total task times from baseline to 7 months and a small but significant increase in average TP scores (Table 3). Compared to the Control MS4 group at 7 months, the Intervention MS4 group had significantly faster total task times (549 ± 80 vs. 719 ± 151 , $p<.009$) and individual task times for the two suturing tasks ($p<.01$). Intervention MS4 also had significantly higher TP scores than the Control MS4 group for all 5 individual tasks ($p<.05$) and a higher mean TP score (3.3 ± 0.6 vs. 2.1 ± 0.4 , $p<.001$).

Total task time and TP scores for Intervention and Control MS4 groups at the 7-month assessment in comparison to historical Boot-Camp MS4 from the prior year, PGY-1 surgical interns at 4 months of internship, and end-of-PGY-2 general surgery residents are shown in Table 3. Intervention MS4 had significantly faster total task times and higher TP scores both at the 8-week and 7-month assessments compared to historical post Boot-Camp MS4 students ($p<.05$) despite similar baseline times and TP scores (not shown). Compared to PGY-1 surgery interns, the Intervention MS4 group had somewhat faster total task times and higher TP scores, but the differences were NS. Intervention MS4 were similar in time and TP scores to end of PGY-2 residents. In contrast, both the Control MS4 and historical post Boot-Camp MS4 groups had significantly lower TP scores and were slower at performing all five tasks compared to PGY-1 interns and end of PGY-2 residents.

Discussion

Numerous changes have taken place in the training environment for medical students over the last several years that have necessitated rethinking traditional teaching methods. In many institutions, time spent on general surgical rotations has decreased, and rotation experiences for individual students can be quite diverse between rotations and among different institutions¹¹ and may be skewed by the more highly specialized practices at academic medical centers today.¹² In some institutions including our own, elective rotations during the 3rd year 12-week “surgery” block may include anesthesia and other non-operative experiences. Opportunities for engagement in basic skills such as suturing and knot tying may also be limited by the prevalence of laparoscopic surgery and small subcuticular or tissue glue closures of many wounds. As a result, the students of today may be particularly disadvantaged when it comes to performing these basic operative skills that comprise the foundation on which many surgical skills are built.

Many surgical training programs now have a one week “boot-camp” experience to attempt to make up the gap from medical school and ensure a common baseline knowledge and performance level of their incoming trainees.¹³⁻¹⁴ To address this issue at the national level, the American College of Surgeons (ACS), the Association for Surgical Education (ASE), and the Association of Program Directors in Surgery (APDS) have formed a joint-committee that is developing a comprehensive one-month boot-camp type preparatory curriculum for MS4 planning to enter surgery that emphasizes fundamental surgical skills.¹⁵ This approach has a major opportunity to impact the gap between medical school and internship. A common theme of 4th year student preparation courses is that they are held in the spring of the academic year shortly after the match. This approach has the dual advantage that only students entering surgery are enrolled, and students should be motivated by the specter of internship looming on the horizon. However, a major disadvantage for acquiring these skill sets may be that the students do not have the opportunity to utilize their newly taught skills in real-time. By this point in the year, students have usually completed all of their sub-internships and other major surgical rotations.

The two main premises of the training approach used in this study were that 1) training should occur at the outset of the 4th year and 2) it should be proficiency-based. In addition, we stipulated that the initial post-training assessment not take place until students had completed at least one surgical sub-internship rotation so they had the opportunity to apply those skills in the OR. The value of proficiency-based training is that it ensures uniformity of performance for basic skills, and has been shown to result in improved performance in the operating room.¹⁶⁻¹⁸ Goova and colleagues¹⁹ demonstrated the value of an open skills curriculum for suturing and knot tying to enable PGY-1 residents to reach proficiency in these tasks. Palter and associates¹⁸ found that novice surgical residents who underwent proficiency-based training on a fascial closure model outperformed an untrained resident group in the operating room. Sanfrey et al²⁰ used the ACS/APDS surgical skills curriculum to assess verification of proficiency (VOP) components for 11 basic skills (8 of which were suturing and knot-tying related). Similar to our PGY-I interns, only 35% of 23 residents passed all skills on the 1st attempt, and 1st attempt pass rates on the individual suturing and tying skills ranged from 58-100%. Of note is that only VOP and not time were used to assess performance in this analysis.

Few groups have studied the impact of skills training on skills retention in medical students or junior trainees. Sonnadara and colleagues²¹ examined retention rates of basic skills taught during a one-month boot camp program at the beginning of orthopaedic residency and found that performance immediately post course was maintained 6 months later. In another study, laparoscopic skills retention was assessed in novice medical students after a 5 day

curriculum.²² Skills were maintained at the immediate post-training level at 6 weeks but by 11 weeks had deteriorated significantly. In our study, despite the extended 5 month interval between post-training assessment and the 7-month time point, there was no deterioration in mean performance observed for any of the 5 suturing and tying tasks. In fact, a slight improvement in TP scores and time was noted for each task, which implies that students were able to retain their skills despite no longer being on operative rotations. Several factors may account for this observation; these include students having the materials to practice these skills for the duration of the study and the opportunity to ingrain their skills after completion of the course while on sub-internship rotations. We were not able to measure practice times or time spent viewing the on-line videos in the Intervention MS4 group, but surgical sub-internship rotations were comparable between them and the controls. While we did not assess operative performance in this study, the improvement in task time performance – an average of 300 seconds for all 5 tasks combined - should be clinically relevant as a trainee would be expected to perform these tasks many times over during the course of an operative procedure.

An important feature of our curriculum is the distributed training model for instruction, practice, and assessment, which has been shown to result in more effective skills acquisition.²³⁻²⁵ An interesting finding of this study is that the students in our Intervention MS4 group outperformed students who participated in a similar curriculum as part of our traditional spring “boot camp” type course. Possible explanations for this finding include the longer time for practice, inclusion of a feedback session post-assessment, and the opportunity to apply the learned skills while on their surgical rotations toward the beginning of the 4th year. However, the time from baseline assessment to initial post training assessment (8 weeks) was approximately the same in both of these groups. Our results suggest that for some of the skill sets being taught in internship preparation courses, consideration should be given to integrating them earlier into the 4th year experience. We have already developed a Masters suturing and knot tying program for our PGY-1 categorical interns¹⁰ and would envision a day when all incoming interns would have completed proficiency based training during the 4th year that might lessen the need for this type of basic skills training during internship.

The study has a number of limitations and potential biases. All videos were analyzed and scored by one surgeon. However, the TP scores and times correlated closely, which makes reviewer bias unlikely to explain the observed differences. Students in the Intervention group had use of the suture pads also used for testing, whereas the Control MS4 did not and had undergone one additional assessment session. However, historical “Boot Camp” students also had access to the same suturing pads for practice, and none of the student groups had access to the one and two handed tying models used for assessment. Thus, the differences in performance of the two groups are not likely explained by differences in practice on the testing model itself. Only one class took part in the randomized trial, and the number of students participating was relatively small. Despite randomization, the students were well balanced by specialty choice and the differences in performance at 7 months were highly significant in spite of the relatively small N for each group. Finally, we cannot totally exclude the possibility of a type 1 statistical error given the relatively small sample size of the randomized groups and the fact that 3 students did not complete the final assessment at 7 months. However, the statistical analysis was even stronger in favor of the Intervention group at the 8 week time point when compared to both the Control and Historical MS4 groups, which makes a statistical error less likely in our view.

Conclusion

In summary, we have shown that a proficiency-based suturing and knot-tying curriculum for 4th year medical students taught early in the academic year results in improved performance and skills retention compared to no training and to a traditional “boot camp” experience. This approach results in student performance comparable to PGY-1 interns at 4 months and approaches that of end of PGY-2 residents. In conclusion, we suggest that fundamental skills training for senior medical students entering surgery should be proficiency-based and carried out early in the 4th year to optimize performance and preparation for internship.

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Fig. 1. Baseline task times and technical proficiency scores for Intervention MS4 and Control MS4 groups. A) Task times; B) Technical proficiency scores. SI=simple interrupted, SQ = subcuticular, 1H = one handed tying, 2H= two handed tying, pass = tie on a pass. iMS4 = Intervention MS4 group; cMS4 = Control MS4 group. p=NS all comparisons.

Fig. 2. Intervention MS4 group task times (A) and technical proficiency scores (B) at baseline vs 8 weeks post training. Abbreviations are the same as Fig. 1. * $p < .001$.

Fig. 3. Task times (A) and technical proficiency scores (B) at 7 months for Intervention MS4 vs Control MS4 groups. Abbreviations are the same as Fig. 1. A) * $p < .01$; B) * $p < .05$ for individual TP scores and $< .001$ for mean TP score comparison.

Table 1
Suturing and knot tying tasks with proficiency goal times

Task	Time Goal
Simple interrupted suture	200 sec
Running subcuticular suture	250 sec
One-hand tying	80 sec
Two-hand tying	100 sec
Tie on an instrument pass	70 sec

Each task consisted of 4 repetitions except tie on an instrument pass which entailed two repetitions. Proficiency was defined as meeting both time benchmarks and a technical proficiency score 3.

Table 2
Demographics of Intervention and Control MS4 groups

	Intervention MS4 (N=11)	Control MS4 (N=10)	p-value
Age (yrs)	26.2 ± 2.1	25.9 ± 1.1	NS
Gender (M:F)	7:4	4:6	NS
Planned specialty			NS
General Surgery	4	4	
Cardiothoracic	1	0	
Otolaryngology	2	1	
Orthopedics	1	2	
Urology	1	1	
OB/GYN	1	0	
Ophthalmology	1	1	
Undecided	0	1	

Table 3
Total task times and technical proficiency scores after training for all groups AT FINAL ASSESSMENT[#]

Group	Total task times (sec)	p-values	Mean TP Scores	p-values
Intervention MS4 (N=9)	549 ± 80	-	3.3 ± 0.6	-
Control MS4 (N=9)	719 ± 151	<0.05	2.1 ± 0.4	<0.001
Historical MS4 (N=19)	662 ± 171	<0.05	2.6 ± 0.5	<0.004
PGY-1 Interns (N=8)	601 ± 74	0.18	2.7 ± 0.7	NS
PGY-2 Residents (N=6)	475 ± 81	0.10	3.6 ± 0.3	NS

TP=technical proficiency.

*
p-values vs. Intervention MS4

[#]
At 7 months post-training for Intervention and Control MS4, 8 weeks for Boot Camp MS4, 4 months for PGY-1 interns.