Residents Can Successfully Teach Basic Surgical Skills in the Simulation Center

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OBJECTIVES: Basic surgical skills are frequently taught to surgical interns in simulation centers. Faculty recruitment for teaching of these sessions can be difficult. The goal of this study was to determine whether senior surgical residents can effectively teach basic surgical skills to provide an alternative to faculty-led instruction.

DESIGN, SETTING, AND PARTICIPANTS: Academic medical center. Twenty-eight surgical interns. In this randomized controlled trial, interns were randomized to receive teaching by either faculty or senior residents. Two-hour teaching sessions for each group consisted of modeling and guided practice. All interns underwent baseline knot-tying and suturing skill assessment using a previously validated standardized task scoring scheme and completed a confidence survey. After teaching sessions, both groups underwent repeated skill testing and were again surveyed.

RESULTS: Twenty-eight interns started in the surgery program at our institution during the year of this study. Seventeen of 27 (62.9%) interns participated in both teaching sessions and completed all skill assessments and surveys; 7 (41.2%) interns were taught by faculty, 10 (58.8%) by residents. Overall, skills training improved in both groups for knot-tying, running suture, and subcuticular suture performance. Confidence performing knot-tying tasks also improved. Interns taught by faculty members and residents demonstrated similar levels of improvement in speed and accuracy, although faculty instruction improved speed of performing the simple suturing task (-144 vs -27 s, $p = 0.04$).

CONCLUSIONS: In the simulation center, teaching by senior surgical residents and faculty members resulted in comparable improvement in interns' basic surgical skills. These findings could increase the skill instructor pool for teaching in the simulation center, potentially easing recruitment and providing senior residents with teaching opportunities. (J Surg 69: 617-622. © 2012 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: interns, skills, simulation, Teaching, surgery

COMPETENCIES: Medical Knowledge, Interpersonal and Communication Skills, Systems-Based Practice

INTRODUCTION

There are specific hurdles to technical skill training in the operating room. Extrinsic reimbursement factors weigh on attending surgeons,[1] and the cost of teaching in the operating room is estimated to be close to $60 million annually as participation of residents tend to prolong operative time.[2] Additionally, the pressures on surgical training are now numerous. These include, but are not limited to, new work hour rules, increased emphasis on patient safety, and more public tracking of surgeons' outcomes.[3,4] As a result, progressively more surgical skill training has moved to skills laboratories. In fact, the Accreditation Council for Graduate Medical Education (ACGME) mandated in 2008 that surgery residency programs must offer residents access to a surgical skill center.[5]

Multiple residency programs now hold "intern boot camp" during which interns are taught basic surgical skills necessary for performing their clinical and operative duties. Utility of such skill training has been demonstrated.[6] At most institutions, including ours, members of the surgical faculty typically teach these sessions.

As studies at other institutions have shown, teaching takes significant faculty time, typically drawing on a small subset of the faculty pool.[7] At the same time, this teaching is rarely compensated.[8] These factors conspire to make faculty recruitment for teaching in the skills laboratory logistically challenging. Several alternatives exist. Teaching can be made mandatory for all faculty.[9] Also, video-based teaching with good effect has been described.[10] However, even mandatory participation by faculty does not take into account reimbursement issues, and partici-

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pants in a video-based curriculum report lack of feedback as an obstacle.[10] An alternative that, to our knowledge, has not been formally studied is the utilization of surgical residents as instructors in surgical skill centers. Anecdotally, senior residents are involved in teaching junior residents in skills laboratories at some institutions, but the adequacy of this teaching has not been investigated.

To provide an alternative to faculty instructors, the goal of this study was to determine if basic surgical skills can be taught as effectively by surgical residents as by members of the surgical faculty. The study hypothesis was that residents and members of the surgical faculty are at least equivalent teachers of basic surgical skills. We base this hypothesis on the assumption that residents are more readily able to break down basic surgical skills into teachable components as they have not yet reached true automaticity of tasks, the third stage of Fitts-Posner model of motor skills acquisition,[11] and that interns may feel more comfortable learning from their peers.

MATERIALS AND METHODS

Participants

Skill laboratory instructors—attending surgeons. All attending surgeons already involved in simulation center teaching were eligible to participate in the study. These attending surgeons had previously expressed interest in teaching in the simulation center and had previously overseen or led training sessions. To be a recurring instructor in our simulation center, the attending surgeons must have also received high marks for their teaching on satisfaction surveys.

Skill laboratory instructors—residents. All senior residents (surgical residents in postgraduate years 3 to 5, PGY 3-5) were eligible to teach in the intervention arm of this study. We selected PGY 3-5 residents to teach in the skill laboratory because their surgical skills were more likely to be well developed than those of more junior residents. To not interfere with the senior residents' own education, residents were asked only to volunteer to teach in intern boot camp if their participation would not conflict with patient care responsibilities or operating room assignments. The senior residents were all in the clinical portion of their residency training and were not in the laboratory.

The eligible instructors were recruited using e-mails in which they were asked to teach the "intern boot camp" basic surgical skills sessions held between June and August of 2010. The first 6 respondents from each group were selected to teach in the "intern boot camp."

The instructors, regardless of whether they were attending surgeons or residents, were given clear goals and objectives for teaching the skill sessions. No specific training regarding teaching in the skills laboratory was provided.

Interns. All interns in the surgery department are required to participate in the "intern boot camp" as part of their core educational instruction in the skill laboratory. On the initial day of the skills laboratory, all interns were introduced to the study and given the option to opt out of having their performance measures used as part of the study; however, participation in the learning activities was mandatory. The interns were then randomized into 2 groups. One group received instructions by members of the surgical faculty; the other group received instruction by senior residents. Interns were only included in the final analysis if they were able to participate in all sessions taught by the intended instructors and completed all surveys and testing.

An implied consent process was used for both skill laboratory instructors and interns. The study was submitted to the Partners Institutional Review Board for review and was approved with exemption from further review.

Skill Sessions

Skill sessions for the 2 groups were held on alternate dates; 1 session was dedicated to knot-tying and 1 session to suturing. Each session lasted 2 hours. A total of 4 sessions were held over the course of 2 weeks. All instructors were given the same goals and objectives for teaching in the skill sessions. Instructors taught in groups of either 2 or 3; instructors taught in groups to keep the instructor:learner ratio low and to allow each learner to get specific, individualized feedback on his/her performance. The same materials were provided for both sessions and the instructor:learner ratios were kept the same (3:1 for knot-tying sessions and 2:1 for suturing sessions).

Skill Assessment

All interns underwent baseline skill assessment of knot-tying and suturing before the skills session. Performance was reassessed 3 weeks after skill sessions were completed. We used components from a previously established and validated assessment method that used a formula incorporating time to task completion and error rates to calculate performance scores.[10] All interns were assigned codes for all data acquisition to ensure participants' anonymity. Testing stations were set up in the skills center and verbal as well as written instructions as to how to complete the skills were given. Interns were asked to complete a simple 2-handed knot-tying task (×3), a 2-handed surgeon's knot-tying task (×3), a simple running suture task, and a subcuticular running suture task. For the knot-tying task, we used a Basic Operating Skills Station (BOSS) trainer (Simulab Corporation, Seattle, WA, United States). For both suturing tasks we used tissue model pads (Simulab Corporation, Seattle, WA). Suturing materials were obtained from Ethicon (Ethicon, Inc., Sommerville, NJ). Each testing station was equipped with a video camera to capture the interns' performance. To further ensure blinded data analysis and participants' anonymity, only the testing area marked with the residents' unique code and hands of the participants were captured on the video feed; no audio information was recorded.

Skill Data Acquisition

Three reviewers (1 surgical attending, 1 educational psychologist, and 1 surgical resident) reviewed and scored individual videos to assess performance. Reviewers were blinded to the interns' identities and group assignment. Videos were viewed as a group and consensus was reached for timing and errors observed. For each task, the time to completion and the errors as defined in the report by Scott and colleagues were recorded.[10] The performance score was then calculated using Scott and colleague's formula, where score = cutoff time – completion time – 10*sum of all errors.[10] Scores were then corrected such that all negative scores were made equal to zero. The performance scores for the knot-tying tasks were averaged across the 3 performances for statistical analysis.

Demographic and Confidence Surveys

Interns were asked to complete a survey to elicit demographic information, including interns' age and gender. Interns were also asked about their baseline exposure to and experience with knot-tying and suturing, as well as their practice time, be it in the clinical setting or in individual practice, if any, devoted to both skills between the pre-testing and post-testing sessions. The latter questions were used because interns had non-uniform rotation schedules and it was conceivable that the intervening skill exposure may have differed.

Finally, the interns were surveyed regarding confidence with the tested procedures before and after completion of the skill sessions. The interns were specifically asked to rate their confidence performing 2-handed knot-tying and suturing on a 5-point Likert scale with the anchor "not confident at all" at 1 and the anchor "very confident" at 5.

Session Satisfaction Surveys

After each session, the interns completed course evaluations forms used by the simulation center to appraise its curriculum and course design. We used these to look at session satisfaction. We specifically asked whether the session had improved their relevant skill proficiency as well as their ratings of instructors as to whether they were skillful, attentive, communicated effectively, facilitated learning, and provided constructive feedback. The responses were sought on a 5-point Likert scale with the anchor "strongly disagree" at 1 and the anchor "strongly agree" at 5.

Statistical Analysis

Demographic information from surveys was compared using t-test and Fisher's exact test as appropriate. Responses to satisfaction surveys were compared using t-test. Confidence scores were averaged and compared using t-test. Scores attained on basic skill assessment and subsequent assessments following the skill sessions were compared using t-test to determine difference in pre-training and post-training performance for all interns. Change in performance was compared using Student t-test to determine differences between resident-led and faculty-led instruction. Statistical significance was accepted at $p < 0.05$.

RESULTS

Twenty-eight interns were eligible to participate in the study. None elected to have their data withheld from the study. One (3.7%) intern was unavailable for participation in the skill laboratory. The remainder were randomized; 12 (44.4%) to faculty-led instruction (Group A) and 15 (55.5%) to resident-led instruction (Group B). All 27 (100%) randomized interns participated in the knot-tying session. Due to scheduling conflicts, 3 (25%) interns in Group A and 1 (6.7%) intern in Group B were unable to attend the suturing session; 2 (7.1%) interns had to switch from faculty instruction to resident instruction between sessions. Of the interns who stayed in the group they were randomized to, 17 (62.9%) interns completed all surveys and performed baseline and final skill assessments. Of the 17 interns for whom all data were available, 7 (41.2%) interns were taught by faculty and 10 (58.8%) by residents.

Demographics

The average age of interns in Group A was 28.1 (SD 3.2; range 26-35) and the average age of interns in Group B was 27.8 (SD 1.6; range 26-31). There were 4 male interns in Group A and 7 male interns in Group B; the M:F ratio in Group A was 4:3, and in Group B it was 7:3. These demographic differences between Group A and B were not statistically significant.

While all PGY 3-5 residents were eligible to participate, only PGY4s and 5s taught in the skills center. At least 1 resident from each PGY level (4 and 5) was in each resident-led instructor group.

Experience and Practice

Interns in both groups responded similar experience levels with knot-tying and suturing at pre-test time. Both groups also reported similar practice exposures and practice times for both skills between the pre- and post-testing sessions.

Baseline and Overall Performance

At baseline, the performance on all domains was similar for interns in the faculty- and the resident-led instruction groups. Overall participation in the basic skill training improved performance for all interns (Table 1). Statistically significant improvement in performance was seen for simple 2-handed knot-tying: the task was performed faster (52 seconds before training vs 43 seconds after training, $p = 0.02$). Curiously, the task was also performed with more errors (1 before vs 1.4 after, $p = 0.003$). For running suture, task performance was faster (569 seconds before vs 494 seconds after, $p = 0.02$) with fewer errors (9.2 before vs 4.8 after, $p < 0.0001$), better raw (−61 before vs 58 after, $p < 0.001$), and adjusted scores (46 before vs 101 after, $p = 0.02$). For the subcuticular suture task, performance was

TABLE 1. Performance of All Interns Pre-Training Compared with Post-Training

Task	Metric	Pre-Training	Post-Training	p =
Knot	Time seconds (SD)	52 (20.3)	43 (27.1)	0.02
	Errors n (SD)	1 (0.9)	1.4 (1.1)	0.003
	Raw score n (SD)	−2 (26.4)	3 (34.7)	0.3
	Adjusted score n (SD)	7 (8.8)	11 (11.5)	0.06
Surgeon's knot	Time seconds (SD)	61 (19.6)	52 (20.4)	0.2
	Errors n (SD)	1.4 (1.3)	0.9 (0.8)	0.3
	Raw score n (SD)	−15 (29.4)	−2 (25.1)	0.2
	Adjusted score n (SD)	3 (6.4)	7 (7.8)	0.1
Simple suture	Time seconds (SD)	569 (189)	494 (137.7)	0.02
	Errors n (SD)	9.2 (3.7)	4.8 (2.3)	<0.0001
	Raw score n (SD)	−61 (208.8)	58 (153.3)	<0.001
	Adjusted score n (SD)	46 (63.6)	101 (92.9)	0.02
Subcuticular suture	Time seconds (SD)	622 (207)	526 (153.7)	0.02
	Errors n (SD)	2.4 (1.8)	1.6 (1.3)	0.03
	Raw score n (SD)	−43 (198.2)	58 (153.7)	0.01
	Adjusted score n (SD)	47 (75.8)	96 (86.8)	0.03

faster (622 seconds before vs 526 seconds after, $p = 0.02$) with fewer errors (2.4 before vs 1.6 after, $p = 0.03$), better raw (−43 before vs 58 after, $p = 0.01$), and adjusted scores (47 before vs 96 after, $p = 0.03$).

Performance as a Result of Faculty-led Instruction Compared with Resident-led Instruction

Performance improvement was generally comparable for the interns receiving faculty-led instruction and those receiving resident-led instruction with some exceptions. Interns taught by residents improved their surgeon's knot time by 13 seconds, while faculty-taught interns time slowed by 6 seconds ($p < 0.04$). Interns in the resident-led instruction group also improved their raw score by 29 points as compared to a slight worsening in raw score to −9 for the interns in the faculty-led instruction group ($p = 0.05$). In contrast, interns in the faculty-led instruction group performed the simple suturing task more quickly, taking 144 seconds off their pre-training time compared with interns in the resident-led instruction group who improved their time by 27 seconds ($p = 0.04$). The data are summarized in Table 2.

Confidence

Confidence in performing knot-tying tasks improved significantly after participation in the skill sessions (2.9 before training vs 3.5 after training, $p < 0.001$). While confidence in suturing improved as well, this was not statistically significant. There was no appreciable difference between post-training confidence reported by the interns in the faculty-led and resident-led instruction groups (data not shown).

Session Satisfaction

The course evaluations showed a similar positive effect on perceived proficiency for knot-tying; the average score was 4.5 for

TABLE 2. Change in Performance of All Interns on the Tasks Comparing Faculty-Led Training with Resident-Led Training

Task	Metric	Faculty-Led	Resident-Led	p =
Knot	Time seconds (SD)	–3 (34.9)	–12 (19.9)	0.2
	Errors n (SD)	0.6 (0.7)	0.3 (1.2)	0.3
	Raw score n (SD)	−3 (38.5)	9.6 (25.8)	0.2
	Adjusted score n (SD)	2 (10.8)	4 (12.4)	0.8
Surgeon's knot	Time seconds (SD)	6 (27.3)	−13 (19.9)	0.04
	Errors n (SD)	0.3 (1.7)	−1 (1.6)	0.1
	Raw score n (SD)	−9 (40.9)	29 (31.7)	0.05
	Adjusted score n (SD)	2 (13.6)	5.5 (9.5)	0.6
Simple suture	Time seconds (SD)	−144 (151.4)	−27 (53.9)	0.04
	Errors n (SD)	−3.3 (2.2)	−5.1 (3.3)	0.2
	Raw score n (SD)	177 (148.7)	78.3 (75.8)	0.1
	Adjusted score n (SD)	90 (119.6)	29.8 (56.8)	0.2
Subcuticular suture	Time seconds (SD)	−27 (117.6)	−140 (162.5)	0.2
	Errors n (SD)	−0.7 (1.8)	−0.9 (1.2)	0.8
	Raw score n (SD)	33 (111.3)	149 (160.7)	0.2
	Adjusted score n (SD)	28 (40.9)	63 (101.2)	0.4

TABLE 3. Instructor Ratings*

	The Instructors. . .				
	Were Skillful Mean (SD)	**Were Attentive Mean (SD)**	**Communicated Effectively Mean (SD)**	**Facilitated Learning Mean (SD)**	**Provided Constructive Feedback Mean (SD)**
Knot-tying session					
Faculty-led instruction	5 (0)	5 (0)	5 (0)	4.9 (0.3)	4.9 (0.3)
Resident-led instruction	4.8 (0.4)	4.8 (0.5)	4.6 (0.7)	4.7 (0.7)	4.5 (0.9)
p =	0.15	0.08	0.05	0.27	0.17
Suture session					
Faculty-led instruction	4.9 (0.4)	4.9 (0.4)	4.9 (0.4)	5 (0)	5 (0)
Resident-led instruction	4.7 (0.8)	4.4 (0.8)	4.4 (0.8)	4.4 (0.8)	4.4 (0.8)
p =	0.6	0.3	0.17	0.06	0.06

*Ratings provided on a 5-point Likert scale with 1 = strongly disagree and 5 = strongly agree.

the faculty-led sessions and 4.3 for resident-led sessions ($p = 0.5$). However, interns thought suture sessions had resulted in more perceived proficiency when taught by members of the surgical faculty; the average score was 4.9 for faculty-led sessions and 3.9 for resident-led sessions ($p = 0.02$). The ratings for instructor skills on the measured domains across both sessions were not significantly different and are summarized in Table 3.

DISCUSSION

In this randomized controlled study using a skill assessment approach anchored in a previously validated tool,[10] we found that teaching by senior surgical residents and faculty members resulted in comparable improvement in interns' basic surgical skills. We demonstrate here that, consistent with previous reports of the effects of skill training,[6] any participation in the skills laboratory improved performance. With minor exceptions, interns performed better after training regardless of whether instruction sessions were led by faculty members or residents. In the few instances in which there was a statistically significant difference between the interns taught by residents compared with faculty, teaching delivered by residents seemed to convey a performance advantage. In addition to finding that teaching by senior surgical residents and faculty members resulted in comparable improvement in interns' basic surgical skills, interns also rated residents and faulty similarly on teaching skills. The efficacy of the senior resident instructors in this study shows the important potential for utilizing senior residents as skill instructors.

Studies in gynecology have shown that faculty members are not necessary to teach clinical content successfully.[12,13] Additionally, teaching by peers has been shown to be a viable alternative to teaching by faculty members as reflected in performance scores.[14,15] Peer teaching has been deemed more accessible and has been associated with less learner anxiety.[14] Thus, our findings are in line with previously published results.

With the pressures on resident time imposed by recent duty hour restrictions, some may question the feasibility of using residents as instructors in skills laboratories. In our study, residents were available to teach in the skills laboratory despite their clinical responsibilities; as stated, all residents who volunteered were in the clinical portion of their residency training and were not in the laboratory. This was feasible since our institution's simulation center is easily accessible from the main hospital. Thus, residents not actively participating in an operation or other immediate direct patient care responsibilities could get to the simulation center for teaching. They were available by page if necessary and could have returned to clinical care if needed. Of note, this did not occur during the teaching session (i.e., no senior resident was called away for an urgent issue). Thus, the location of our simulation center allowed senior residents the needed flexibility to lead the teaching sessions. We suspect that many institutions have similar close proximity of the simulation centers to the hospital. Another factor that helped to minimize overlap of simulation center time with operating room times for all residents, interns and senior residents was that all simulation center session were scheduled in the afternoons, specifically from 4 to 6 pm.

One limitation of the study is that while overall participation in the skill laboratory sessions was high, only 62.9% of the interns completed all surveys, training sessions, and skill assessments needed to be meaningfully included in our data set. While participation in the "intern boot camp" was mandatory, some interns had conflicts that mandated that they had to switch assignments or could not attend a testing session and, therefore, had to be excluded. This potentially biases our results; however, we did not see a difference in baseline performance between the interns who completed all stages of the study and those who were not included in the final analysis. Further limitations of this study are that it was conducted at a single institution. Also, we did not include a qualitative measure to review the content and quality of the teaching sessions to have a deeper understanding as to the parallels or differences between resident and faculty teaching styles and methods.

Despite these limitations, we believe that our findings are significant because they suggest that recruitment of instructors for basic surgical skill training can be targeted to residents. This

conclusion is beneficial in several important ways. Namely, it could make recruitment for teaching in the simulation laboratory easier, freeing up members of the surgical faculty to pursue their other clinical duties, and will be more cost-effective. More generally, using residents as instructors in a skill laboratory may make establishment of a skill laboratory, now a requirement for surgical residencies, possible for smaller programs that may not have a sufficient faculty pool from which to draw. The findings furthermore support programs where the practice of using senior residents for intern skill instructions is already in place. Finally, exposing residents to teaching opportunities will prepare them for future teaching responsibilities as they advance in their careers. While resident time is limited due to duty hour restrictions in the 80-hour workweek, we believe that the experience of teaching is of significant benefit and justifies inclusion of residents as skill laboratory instructors. Despite the fact that senior residents appear to be able to teach and that teaching adds to their professional development, there are potential downsides to allowing residents to take over teaching in the skills laboratory exclusively. Specifically, having attending surgeons involved sends a message about the department's educations priorities, gets interns in contact with attending surgeons in a non-high stakes environment, and, finally, allows attending surgeons to identify potential "problem" interns early for early remediation. Perhaps then the best approach would be to have senior residents teach alongside an attending surgeon, thus maximizing potential benefits while also allocating resources thoughtfully.

In summary, our study shows that residents can successfully teach in the skills laboratory and that their teaching skills are acceptable to interns as reflected in their teaching skill ratings compared with faculty instructors. These findings have potentially important implications as skills laboratories play an expanding role in surgical education.

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