ASE

Early and Prolonged Opportunities to Practice Suturing Increases Medical Student Comfort with Suturing during Clerkships: Suturing during Cadaver Dissection

Edward P. Manning,[1*] **Priti L. Mishall**,[2,3] **Maxwell D. Weidmann**,[2] **Herschel Flax**,[2] **Sam Lan**,[2] **Mark Erlich**,[2] **William B. Burton**,[4] **Todd R. Olson**,[2] **Sherry A. Downie**[2,5]

[1]*Section of Pulmonary, Critical Care, and Sleep Medicine, Department of Internal Medicine, Yale School of Medicine, New Haven, Connecticut*

[2]*Department of Anatomy and Structural Biology, Albert Einstein College of Medicine, Bronx, New York*

[3]*Department of Ophthalmology and Visual Sciences, Albert Einstein College of Medicine, Bronx, New York*

[4]*Department of Family and Social Medicine, Albert Einstein College of Medicine, Bronx, New York*

[5]*Department of Physical Medicine and Rehabilitation, Albert Einstein College of Medicine, Bronx, New York*

Medical students are expected to perform common procedures such as suturing on patients during their third-year clerkships. However, these experiences are often viewed by medical students as stressors rather than opportunities for learning. The source of this stress is the lack of instruction on common procedures prior to being asked to observe or perform the procedure on a patient. First-time exposures to procedures in stressful environments may result in decreased confidence in medical students and decrease the frequency with which they perform these procedures in the future. The authors sought to change this paradigm by: (1) introducing a suturing module to first-year medical students in the context of the anatomy dissection laboratory and (2) measuring its effects on student attitudes and behavior over the course of their third-year clerkships when they encounter patients. The authors found that early and prolonged introduction to suturing was associated with increased student confidence relative to suturing a patient. Participation in the suturing module was associated with increased student confidence in identifying suturing instruments ($P < 0.001$) and suturing patients ($P = 0.013$). Further it positively affected their behavior as demonstrated by increased performance of suturing events from students exposed to the suturing module. ($P < 0.001$) This study demonstrates that early and prolonged opportunities to practice a procedural skill in a low-stress environment increases student confidence during patient interactions and alters student behavior. Anat Sci Educ 11: 605–612. © 2018 American Association of Anatomists.

Key words: gross anatomy education; medical education; gross anatomy laboratory; suturing module; surgical skills; early exposure; confidence; behavioral change

*Correspondence to: Dr. Edward P. Manning, Pulmonary, Critical Care and Sleep Medicine Section, Department of Internal Medicine, Yale School of Medicine, 300 Cedar Street TAC - 441 South, New Haven, CT 06520-8057, USA. E-mail: edward.manning@yale.edu

Drs. Edward P. Manning and Priti L. Mishall contributed equally to this report.

Additional supporting information may be found in the online version of this article.

Grant sponsor: National Institutes of Health Predoctoral Training Grant; Grant number: T32-GM007288 (to EPM and MDW); Grant sponsor: National Research Service Award Institutional Research Training Grant; Grant number: T32-HL007778 (to EPM).

Received 31 July 2017; Revised 4 March 2018; Accepted 6 March 2018.

Published online 30 March 2018 in Wiley Online Library (wileyonlinelibrary.com). DOI 10.1002/ase.1785

INTRODUCTION

Medical students, entering their clinical years, often experience anxiety when asked to perform procedures on live patients (Radcliffe and Lester, 2003; Sarikaya et al., 2006). The traditional method for teaching procedural skills is summarized by the adage, "See one, do one, teach one," which implies that medical students are expected to learn a skill by observing it once, then doing it once, then teaching it once (Sadideen and Kneebone, 2012; Hamaoui et al., 2014; Khunger and Kathuria, 2016). A consequence of this paradigm is that medical students frequently enter clerkships without formal training in procedural skills. They perform below the expectations of their supervisors (due to no fault of their own) and feel less motivated to perform procedures if an initial exposure to procedural skills is negative (Stewart et al., 2007). The lack of structured curriculum for procedural skills training and the falsely elevated expectations of supervisors may be significant sources of student discomfort in the clinical years (Reznick 1993; Ringsted et al., 2001; Liddell et al., 2002; Radcliffe and Lester, 2003; Dehmer et al., 2013; Davis et al., 2014).

A common strategy to mitigate medical student anxiety related to performing procedures on patients is to teach students procedural skills. Medical school faculty and students alike value the benefit of teaching procedural skills during the undergraduate medical education (Hamaoui et al., 2013; Glass et al., 2014). Suturing is one of the common procedural skills recognized by the American Association of Medical Colleges (AAMC) as an essential procedural skill that medical students must be able to perform on graduation (AAMC, 1999; Dehmer et al., 2013). It is also one of the most anxiety-provoking skills for medical students to perform on a live patient (Sarikaya et al., 2006).

There is a large amount of literature describing programs designed to improve the suturing skills of medical students using pig's feet, inanimate objects, wound closure pads, non-preserved cadavers, and manikins (Radcliffe and Lester, 2003; DiMaggio et al., 2010; Böckers et al., 2011, 2014; Kaplan et al., 2013; Preece et al., 2015; Routt et al., 2015; Khunger and Kathuria, 2016). One of these programs utilized a "crash course" approach where a week, immediately prior to clerkship, was dedicated to teaching and learning a variety of procedures (Stewart et al., 2007). A majority of studies, however, reported on informal workshops of a day or few hours duration. These were most often sponsored by student clubs, for example, surgery interest group, and frequently focused on generating student interest in a career in surgery (Tribble et al., 2002; Do et al., 2006; Li et al., 2013; Patel et al., 2013). It is assumed, in all of these studies, that suturing ability is inversely associated with medical student anxiety about suturing live patients. However, there is limited data suggesting that teaching procedural skills to medical students has any effect on their attitudes or behaviors when they apply those skills during their clerkship years (Fincher and Lewis, 1994; Liddell et al., 2002; Stewart et al., 2007).

The goal of the present study was to determine the effects of early and prolonged exposure to suturing on medical student attitudes and behaviors during their clerkships. To this end the authors developed the Anatomy Laboratory Suturing Module (ALSM). The ALSM provided prolonged opportunities for first-year medical students to suture during their anatomy cadaver dissection course. The authors' hypothesis was that early and prolonged exposure to suturing, in a non-stressful environment, would result in increased confidence in medical students during their clerkships and increased numbers of suturing events performed.

MATERIALS AND METHODS

Description of Anatomy Laboratory Suturing Module

The data in this report were collected as part of a three-year prospective study approved by the Institutional Review Board of the Albert Einstein College of Medicine, Bronx, NY. Briefly, the authors developed and implemented a four-week ALSM during the Clinical and Developmental Anatomy (C&DA) course with the goal of exposing first-year medical students to suturing early in their medical school experience in a non-threatening environment. Participation in the ALSM was optional. All students understood that participation in the study would have no effect on their C&DA course grade. The objective of the study was to determine the effects of the ALSM on medical students' attitude and behavior during their clerkships.

The first-year curriculum at the Albert Einstein College of Medicine is presented in a largely traditional format, similar to other gross anatomy courses in the United States (McBride and Drake, 2018). The C&DA course runs from the end of October until the end of February. It comprises 16 weeks of class time, 168 hours of instructional contact time with lectures, small group conferences, and cadaveric dissection. Cadaveric dissection is approximately three-fourths of the total instructional time. In addition to gross anatomy, the course presents major organ system embryology in eight hours of lecture, an introduction to medical imaging in 13 hours of lecture, and an introduction to medical procedures in three hours of laboratory. The medical procedures portion of the course is self-directed learning in which students must research specific procedures, such as tube thoracotomy and cricothyroidotomy, and then perform them on the cadaver while being observed and evaluated by emergency medicine residents. Therefore, encountering procedurally based skills in the C&DA curriculum was not unusual to students, faculty or staff.

The ALSM provided a daily opportunity over a three-week period of time for students to practice suturing. The ALSM was conducted during the four-week head and neck regional dissection unit of the C&DA course, approximately half way through the C&DA curriculum. This unit of the course was chosen because students have been in the laboratory for two months and know each other and the faculty well. The C&DA dissection laboratory provided a familiar and relatively low-stress environment for students to practice suturing. In addition, the head and neck is a small and complex region where it is difficult for more than two students to dissect at one time. Thus, team members took turns completing the day's dissections and practicing suturing on their cadaver-patient's yet-to-be-dissected lower limbs.

At the beginning of the ALSM the team leader of each dissection team was asked to attend a brief orientation meeting with the ALSM director during laboratory hours. Having only one team member attend the meeting minimized disruption to dissection work. The team leader took responsibility for relaying information from the orientation to the rest of the team. All team members were required to watch a short, six-minute "Suturing Module C&DA" video via the course website. This video was created by the first author (E.P.M.) and co-author (H.F) a retired career surgeon. It describes the instruments used

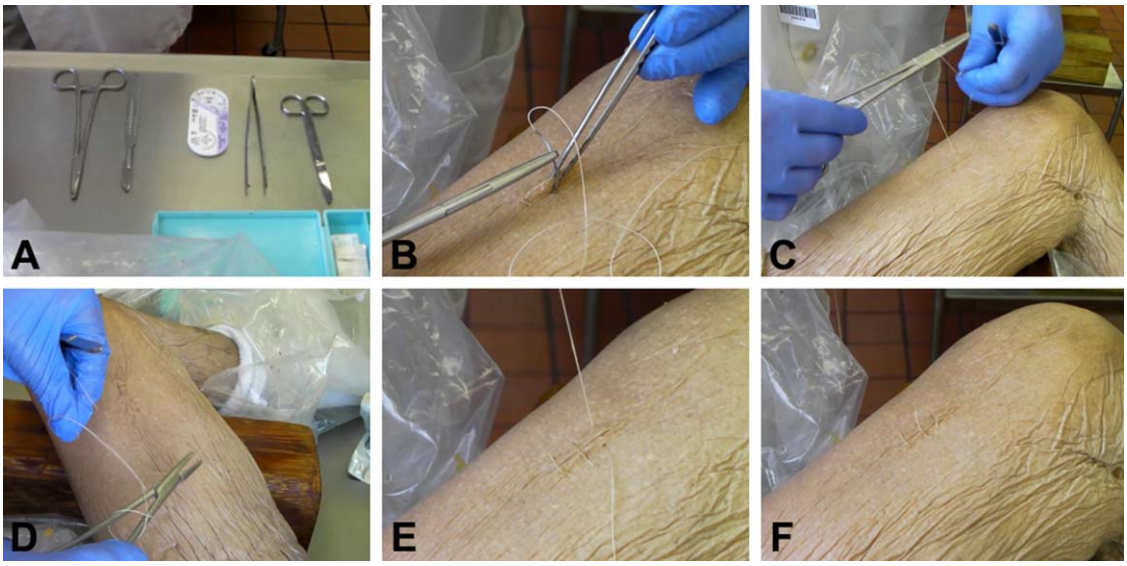

Figure 1.

Stills from instructional video. (A) Instruments—needle driver, scalpel, suture, forceps and scissors; (B) Starting at one end of an incision on the lower extremity enter the skin with the needle in a perpendicular manner by rotating your wrist and moving the needle through the skin along a curvilinear trajectory; (C–E) Make a surgeon's knot, or "double throw," using an instrument tie, pulling gently on both sides of the suture and cutting the excess suture material; (F) Three evenly spaced sutures completely close the incision.

for suturing and demonstrates suturing technique. It also sets an arbitrary goal for students to achieve before the end of the ALSM. Still shots from this video are featured in Figure 1.

Supplies for each dissection team (four to five students) included: two needle drivers, two forceps, two scissors, and two to four suture kits per student. Needle drivers were graciously donated by the Office of the Chairman of the Department of Surgery of Montefiore Medical Center, the teaching hospital of the Albert Einstein College of Medicine. Suture and needles were expired materials identified for disposal and provided by the institution's teaching hospital operating room material services. Forceps and scissors were part of a standard dissection kit that students already had. Therefore, there was no added expense to the Department of Anatomy and Structural Biology or the students for the instruments and suturing supplies.

The assigned task was arbitrary: closure of a superficial three cm incision, made on the cadaver-patient's lower limbs, using simple interrupted sutures and instrument ties with three throws. Closure was to be completed in less than 15 minutes with no fewer than three stitches using a single length of suture with pre-attached needle. The emphasis of the ALSM was on exposure to the experience of suturing rather than gaining competence. Assigning a common goal provided clear direction to the students and faculty. It also allowed for planning how much equipment and time was necessary to complete this module.

Course faculty with suturing experience, the majority of whom were retired career surgeons, observed students and provided one-on-one feedback and suggestions. In order to maintain a non-stressful environment there were no measures of suturing quality or ability. There was no pass or fail status assigned. The only objective measure of success from the student perspective was whether they were observed and received feedback by the end of the ALSM. Students could request as many formative feedback sessions as they desired. The purpose of the ALSM was to provide an early and prolonged opportunity for students to suture and receive feedback in a non-threatening environment.

Study Design

To determine the effect of early exposure to suturing on student attitude and behavior in the context of patient care, the authors observed two classes of medical students, Class of 2016 and Class of 2017, longitudinally through the end of their third-year of medical school. The third-year of medical school for Einstein students consists of clerkships in internal medicine, surgery, obstetrics-gynecology, pediatrics, psychiatry, family medicine and neurology.

The Class of 2016 served as the Control group and were not exposed to the ALSM. The Class of 2017 served as the Intervention group and were exposed to suturing as described above. A schematic of the research design is shown in Figure 2. Survey responses were collected from the Intervention group prior to and on completion of the ALSM during their first-year anatomy dissection laboratory in January 2014. In addition, survey responses were collected before the start of third-year clerkships and at the end of third-year clerkships for both the Control (Class of 2016) and Intervention (Class of 2017) groups. Participation in the surveys was voluntary and anonymous. The surveys asked respondents to indicate their level of comfort (five-point Likert scale with anchors of strongly disagree = 1 and strongly agree = 5) with the following: (1) If asked to identify appropriate instruments and equipment necessary to suture a wound on a person right now, I would feel comfortable accomplishing that task and

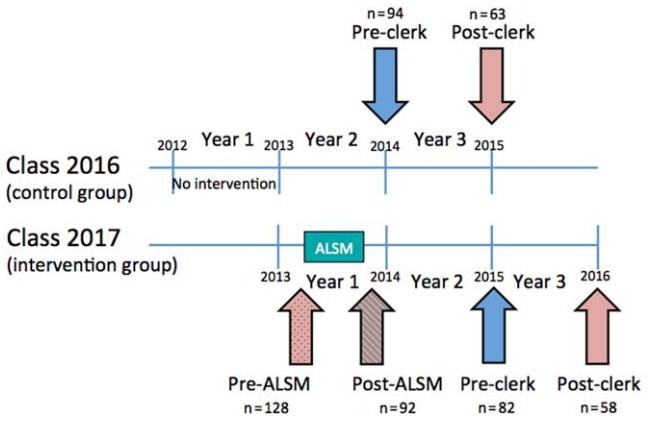

Figure 2.

Schematic of research design. The Anatomy Laboratory Suturing Module (ALSM) was introduced to the Class of 2017 (Intervention group) in the anatomy dissection laboratory, during the first year of medical school. Pre- and Post-ALSM surveys were conducted for the Class of 2017. Pre- and post-clerkship surveys for the Class of 2017 and Class of 2016 (Control group) were conducted at the beginning and on completion of the third-year clerkships.

(2) If asked to suture a wound on a person right now, I would feel comfortable accomplishing that task.

The survey also asked respondents to indicate (Yes or No) if they had the following experiences: (1) Have you ever been trained to identify the necessary equipment to suture?; (2) Have you ever been trained to suture a wound in human tissue?; and (3) Have you ever sutured a wound in human tissue? If respondents answered "Yes" to the last question, a follow-up question asked them to indicate the number of separate times they sutured a wound in human tissue.

Statistical Analysis

Analyses were performed using SAS statistical software, version 9.3 (SAS Institute, Cary NC). Comparisons between the pre-ALSM and post-ALSM responses of the Intervention group were analyzed with independent sample t-tests (paired t-tests were not available because a common identifier was not used to link the pre- and post-intervention responses). Comparisons between the Likert scale responses of the Intervention and Control groups were analyzed with independent sample *t*-tests. The authors justify the use of parametric tests to analyze Likert scale data based on the argument that, "parametric statistics can be used with Likert data ... with no fear of coming to the wrong conclusion" (Norman, 2010; Sullivan and Artino, 2013). The comparison of the number of times members of the Intervention and Control groups sutured a wound in human tissue was analyzed using a chi-square test of homogeneity. For all tests, a significance level of $P < 0.05$ was deemed significant. Survey responses from the participants were calculated as mean level of agreement.

RESULTS

Demographics of the Control and Intervention groups were similar (Table 1). One hundred percent (174/174) of the students in the Class of 2017 (the Intervention group) agreed to participate in the ALSM. Seventy-four percent (128/174) returned pre-ALSM surveys and fifty-three percent (92/174)

Table 1.

Demographics of Control Group (Class of 2016) and Intervention Group (Class of 2017)

Demographics	Control Group (Class of 2016) N (%)	Intervention Group (Class of 2017) N (%)
Number of students	172 (100)	174 (100)
Sex		
Women	50 (29)	46 (26)
Men	72 (71)	128 (74)
Mean age and range (in years)	23 (20–30)	24 (21–39)
Under-represented in medicine	11 (6)	14 (8)
International students	0 (0)	2 (11)
Born outside of the US	23 (13)	16 (9)
Non-science majors	27 (16)	23 (13)
BA degrees	46 (27)	54 (31)
BS degrees	42 (24)	36 (21)
Advanced degrees	7 (4)	6 (3)
Number of EMTs	24 (14)	26 (15)

US, United States; BA, Bachelor of Arts; BS, Bachelor of Science; EMT, Emergency Medical Technician.

Table 2.

Comfort Level with Suturing and with Identifying Instruments used in Suturing

Item	Timing	Control Group (Class of 2016) Mean (±SD)	Intervention Group (Class of 2017) Mean (±SD)	*P*-value
Comfort with suturing	Pre-ALSM	—	2.81 (±1.30)	<0.001[a]
	Post-ALSM	—	4.40 (±0.59)	
Comfort with identifying instruments	Pre-ALSM	—	1.96 (±1.04)	<0.001[a]
	Post-ALSM	—	3.62 (±0.82)	
Comfort with suturing	Pre-clerkship	1.68 (±1.01)	2.45 (±1.08)	<0.001
Comfort with identifying instruments	Pre-clerkship	2.03 (±1.14)	3.34 (±1.02)	<0.001
Comfort with suturing	Post-clerkship	3.06 (±1.23)	3.62 (±1.20)	0.013
Comfort with identifying instruments	Post-clerkship	3.30 (±1.21)	3.97 (±1.08)	0.002

The five-point scale ranged from 1= strongly disagree to 5 = strongly agree; [a]Independent sample *t*-tests comparing Likert scale responses of the Intervention Group before and after the Anatomy Laboratory Suturing Module (ALSM) intervention.

returned post-ALSM surveys. Fifty-four percent (94/174) responded to pre-clerkship surveys, and thirty-six percent (63/174) responded to post-clerkship surveys. The Control group, the Class of 2016, included 172 students who did not participate in the ALSM. Forty-eight percent (82/172) responded to pre-clerkship surveys. Thirty-four percent (58/172) responded to post-clerkship surveys.

Students who participated in the ALSM enjoyed the experience and gained confidence in suturing. Comparison of the pre-ALSM and post-ALSM surveys indicated that students felt more comfortable after the module when anticipating suturing patients [pre-ALSM 2.81 (±1.30) vs. post-ALSM mean 4.40 (±0.59), $P< 0.001$; all values expressed in means (±SD)] (Table 2). Similarly, students felt more comfortable after the module identifying appropriate instruments to suture a wound on a person (pre-ALSM 1.96 [±1.04] vs. post-ALSM 3.62 [±0.82], $P< 0.001$) (Table 2). Overall students were satisfied with the experience of suturing in the setting of anatomy dissection laboratory. They rated the ALSM as 4.4 out of 5.0 on their final C&DA course evaluation, where five is "extremely satisfied" and one is "extremely dissatisfied."

Students who participated in the ALSM were more confident when suturing during clerkships and sutured patients more frequently. Comparison of pre-clerkship survey responses revealed that students in the Intervention group were more comfortable than those in the Control group when anticipating suturing patients (Intervention 2.45 [±1.08] vs. Control 1.68 [±1.01], $P < 0.001$) and in their ability to identify instruments used in suturing (Intervention 3.34 [±1.02] vs. Control 2.03 [±1.14], $P < 0.001$) (Table 2). Comparison of post-clerkship survey responses revealed that students in the Intervention group were still more comfortable than those in the Control group when anticipating suturing patients (Intervention 3.62 [±1.20] vs. Control 3.06 [±1.23], $P = 0.013$) and in their ability to identify instruments used in suturing (Intervention 3.97 [±1.08] vs. Control 3.30 [±1.21], $P = 0.002$) (Table 2). Additionally, students in the Intervention group reported a greater number of suturing events during their clerkships, in comparison to students in the Control group (Table 3).

DISCUSSION

This report presents an analysis of the impact of exposing students to suturing during first-year anatomy cadaver dissection. The authors measured medical students' attitudes and behavior over a three-year period. The findings demonstrate

Table 3.

Number of Separate Suturing Events During Clerkships in both Intervention and Control Groups

	Suturing a wound in a patient		
Study Group	1–5 times	6–10 times	10+ times
Control Group (Class of 2016)	31	13	12
Intervention Group (Class of 2017)	15	14	27

The chi-square test for homogeneity was significant ($P < 0.001$). There were 56 respondents from the Control and Intervention groups.

that early exposure to suturing leads to increased confidence when students are asked to suture patients. This confidence persists throughout their clerkships. In addition students with early exposure to suturing reported significantly more patient suturing events during clerkships than those without this exposure.

One unique aspect of this study was its longitudinal nature. The first year of medical school was selected for intervention largely because the C&DA course provided a natural setting to expose students to suturing. Cadavers are available. The course features other clinical procedures so suturing was consistent with the learning objectives of the course. The timing of the ALSM at the half-way point of the C&DA course meant that the students were familiar with the laboratory and comfortable with the faculty. To determine the effects of this early exposure to suturing on student attitudes and behaviors in the context of patient care, the authors needed to observe them through the end of their third-year of medical school. While other studies have demonstrated immediate effects of teaching suturing to first-year medical students (Moss and McManus, 1992; Wilson and Nava, 2010) or effects of teaching procedures to medical students immediately before entering clerkships, (Liddell et al., 2002; Stewart et al., 2007) the authors are not aware of other studies describing interventions introduced during first-year anatomy courses and measuring their effects after third-year clerkships. The closest were Liddell and colleagues who introduced a clinical skills tutorial (injections and suturing) and a three-hour session at the end of the third year of a six-year medical curriculum (Liddell et al., 2002). They evaluated the effects of their intervention approximately one year later in year five. The results indicated that fourth-year students were more willing to perform a simpler procedure (injection) but not suturing. One major difference between Liddell et al. (2002) and the present study is the prolonged practice time (three hours versus three weeks) that ALSM students had. In addition, the ALSM occurred in the first year of medical school, not immediately before the clinical year. Despite a delay of almost two years between the ALSM and the clerkships, the present study demonstrated that intervention students experienced significantly increased levels of comfort with suturing and a corresponding increase in the number of suturing events during their clerkship year.

A second unique aspect of the present study was the prolonged time that Intervention students had to practice suturing. Over the three-week ALSM, students had ten laboratory sessions (2.5 hours each) during which they could suture. No other study has described this amount of time for learning and practice. At the Albert Einstein College of Medicine both the Intervention and Control groups had similar opportunities to suture by attending adhoc events sponsored by student clubs, for example, a Surgery Interested Group pig's feet suturing workshop. The increased comfort documented for the Intervention group at the pre-clerkship point of the study may be attributed to their participation in the ALSM which provided significant time and opportunity for spaced practice (Roediger and Pyc, 2012) and formative feedback (Hattie and Timperley, 2007). The terminal nature of feedback and allowing students to independently learn may have allowed them to retain skills and confidence after the ALSM (Hatala et al., 2014). One-on-one feedback was likely beneficial in the ALSM, though other studies have shown that a ratio of one instructor to four students is optimal when teaching procedural skills such as suturing (Dubrowski and MacRae, 2006).

Studies have demonstrated that training medical students in surgical procedures for the purpose of improving their skills makes them better at those procedures but does not address their attitudes (Peyre et al., 2006; Are et al., 2009, 2010; Zaid et al., 2010; Patel et al., 2013). It has been shown that medical school graduates lack self-confidence in common procedures and participation in a medical school procedures course is associated with increased self-assessed competency in common procedures (Promes et al., 2009). The data collected in the current study suggests that focusing on skill competency is not necessary to improve medical student confidence in clinical applications of that skill. The learning environment, rather than objective measures of skill, can be effective in bolstering student confidence and willingness to participate in future procedures. A critical goal in designing this study was to create a non-threatening environment where students could focus on the experience of suturing and not feel pressure by being graded, judged or evaluated. In the present study the ALSM was conducted in the first-year dissection laboratory at the half-way point in the C&DA course. Students had developed relationships with their peers, faculty and cadaver and were quite at home in the laboratory (Hafferty, 1998). This setting decreased the stress of learning allowing the opportunity for repetitive and deliberate practice (Naylor et al., 2009; Sadideen and Kneebone, 2012). Similar observations were reported by DiMaggio et al. (2010) and Kaplan et al. (2013) where students found the cadaver laboratories and surgical skills laboratories to be helpful in learning to suture in comparison to the operating room and emergency department. Moreover, in the hospital setting the patient's clinical needs take precedence over the students' educational needs (Sadideen and Kneebone, 2012). Hence, the cadaver laboratory setting gives the students the opportunity to ask questions that might be inappropriate in the patient-care setting (Nelson and Traub, 1993). The laboratory provides an unpressured and relaxed learning environment (Hamaoui et al., 2014; Preece et al., 2015).

Finally, the present study demonstrated that students who had participated in the ALSM in their first year reported a greater number of suturing events during their third-year clerkships than the control group. Overall these findings support the hypothesis that a basic procedural skills module introduced early in the medical school curriculum increases students' comfort and confidence which may be associated with their willingness to perform procedures on patients during clerkships. Similar studies by Fincher and Lewis (1994) and Dehmer et al. (2013) examined medical students' self-assessment of clinical competence following a skills training session and found that self-assessment of competency correlated with the frequency of performance of procedure. Viewed in terms of the Kirkpatrick model of learning, the authors identify this increased willingness to suture as a behavioral change (Level 2A) (Hammick et al., 2010).

Limitations of the Study

This study's findings should be interpreted in light of several considerations. Although the response rates to the surveys were relatively high the authors were only able to gather limited demographic data about the respondents and unable to gather any data from non-respondents limiting the authors

ability to evaluate sampling and non-response bias (Phillips et al., 2016). Individual identification was not possible limiting the depth of comparison that could be applied. Another limitation was the fact that the Control group and Intervention group were separated by a year, making the study prone to period effects. It is possible that there were unidentified curriculum differences between the groups in addition to the intervention. Randomizing a single class of medical students into Control and Intervention groups for future studies can minimize such errors. The authors did not survey groups as to the amount of suturing workshops in which they participated outside the ALSM; however, the number of extracurricular suturing workshops offered by interest groups in the medical school remains relatively stable from year-to-year. By design the ALSM specifically avoids exposing students to objective measure of skill; therefore, the authors are unable to comment on skill competency.

CONCLUSION

Medical students who participated in an early and prolonged suturing module during the dissection laboratory of their first-year anatomy course demonstrated improved confidence by the end of the module which lasted through their third-year clerkships. Furthermore, these students reported an increased number of suturing events during their third-year clerkships. Self-learning in a low-stress environment where cadavers and supervising faculty are available to medical students at their discretion results in a positive and sustained impact on medical student attitude and behavior.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Stephanie Rand for her efforts in providing feedback to students on suturing skills, and acknowledge Ms. Iris Villatoro's expertise with organizing supplemental material using the Excel tables. The authors also want to thank Mr. Christopher Martinez and Mr. Robert Caragliano for ensuring the logistics with distribution of suture material and instruments. Most importantly, the authors acknowledge and gratefully thank the individuals whose bodies were used in this study for the advancement of medical education and patient care.

The authors have no conflicts of interest to disclose. Some of the material in this manuscript was reported as a poster presentation at the 31st Annual Meeting of the American Association of Clinical Anatomists in 2014.

NOTES ON CONTRIBUTORS

EDWARD P. MANNING, M.D., Ph.D., is a fellow in the section of Pulmonary, Critical Care, and Sleep Medicine in the Department of Internal Medicine at Yale School of Medicine, New Haven, Connecticut. He graduated from the Albert Einstein College of Medicine and taught and tutored Medical Histology and Clinical and Developmental Anatomy for five years. His research interests include medical education, medical decision-making, theoretical molecular biophysics, and pulmonary disease.

PRITI L. MISHALL, M.D., P.G. Cert.Med.Ed., M.B.B.S., is an assistant professor in the Department of Anatomy and Structural Biology and Department of Ophthalmology and Visual Sciences at Albert Einstein College of Medicine, Bronx, New York. She teaches Medical Histology and Clinical and Developmental Anatomy to first-year medical students and is the laboratory director for the MD/PhD program at Albert Einstein College of Medicine. Her research interests include impact of technology (especially e-learning tools and softwares) in learning of medical students, developing cadaveric training modules for learning procedural skills for medical students and anatomical variation.

MAXWELL D. WEIDMANN, M.S., is an MD/PhD candidate at Albert Einstein College of Medicine. He is currently planning to pursue clinical practice in psychiatry, and is interested in using functional medical imaging, such as fMRI and EEG to better understand the neurological correlates of psychiatric disease, in order to design more directed, and less invasive, therapies. He is also interested in studying how behavioral and mindfulness therapies may be used to alter the course of psychiatric disease progression.

HERSCHEL FLAX, M.D., Ch.M., M.A., F.R.C.S. (England), F.A.C.S., is a professor in the Department of Anatomy and Structural Biology at Albert Einstein College of Medicine, Bronx, New York. He teaches anatomy, including clinical applications, to first-year medical students. His research interest is in the area of breast cancer. He investigated the effects of different concentrations of estrogens, androgens and prolactin on the breast cancer cells in cell cultures.

SAM LAN, M.D., Ph.D., F.A.C.S., F.R.C.S.C., is an associate professor in the Department of Anatomy and Structural Biology at the Albert Einstein College of Medicine, Bronx, New York. He teaches histology and Clinical and Developmental Anatomy to first-year medical students. His research interest involves studying the influence of detailed anatomy knowledge on practice of surgery.

MARK A. ERLICH, M.D., F.A.C.S., is an assistant professor of clinical gross anatomy in the Department of Pathology and Cell Biology at the Columbia University College of Physicians and Surgeons, New York, New York. He is also an instructor in the Department of Anatomy and Structural Biology at the Albert Einstein College of Medicine, Bronx, New York. His research interests are in the types of biomaterials used in facial plastic surgery, History of science and medicine and Anatomical Education.

WILLIAM B. BURTON, Ph.D., is an associate professor of family and social medicine at the Albert Einstein College of Medicine, Bronx, New York. He has served as the Director of the Office of Educational Resources since 2014 and has been a member of the Society of Directors of Research in Medical Education since 2006. He teaches Epidemiology, Population Health, and Evidence-based Medicine courses to first-year medical students. He also teaches in the Course Design and Teaching for graduate school course and his research interests include the impact of technology on teaching and learning and the medical school learning environment.

TODD R. OLSON, Ph.D., is an emeritus professor of anatomy at Albert Einstein College of Medicine, Bronx, New York. He was Director of Anatomical Sciences Education and Anatomical Donations Program (1989–2015) when the module and study began. He is past President (2009–2011) of the American Association of Clinical Anatomists.

SHERRY A. DOWNIE, Ph.D., is a professor of clinical anatomy and structural biology and professor of clinical physical medicine and rehabilitation at the Albert Einstein College of Medicine, Bronx, New York. She is Director of the Clinical and Developmental Anatomy course, and lectures

and directs a laboratory section in Medical Histology. Her research interests are in the areas of anatomical variation and medical education.

LITERATURE CITED

AAMC. 1999. Learning objectives for medical student education—Guidelines for medical schools: Report I of the Medical School Objectives Project. Acad Med 74:13–18.

Are C, Stoddard HA, Northam LC, Thompson JS, Todd GL. 2009. An experience in surgical anatomy to provide first-year medical students with an early exposure to general surgery: A pilot study. J Surg Educ 66:186–189.

Are C, Stoddard HA, Thompson JS, Todd GL. 2010. The influence of surgical demonstrations during an anatomy course on the perceptions of first-year medical students toward surgeons and a surgical career. J Surg Educ 67:320–324.

Böckers A, Lippold D, Fassnacht U, Schelzig H, Böckers TM. 2011. Ready for the OR? - Clinical anatomy and basic surgical skills for students in their preclinical education. GMS Z Med Ausbild 28:Doc45.

Böckers A, Mayer C, Böckers TM. 2014. Does learning in clinical context in anatomical sciences improve examination results, learning motivation, or learning orientation? Anat Sci Educ 7:3–11.

Davis CR, Toll EC, Bates AS, Cole MD, Smith FC. 2014. Surgical and procedural skills training at medical school - A national review. Int J Surg 12: 877–882.

Dehmer JJ, Amos KD, Farrell TM, Meyer AA, Newton WP, Meyers MO. 2013. Competence and confidence with basic procedural skills: The experience and opinions of fourth-year medical students at a single institution. Acad Med 88:682–687.

DiMaggio PJ, Waer AL, Desmarais TJ, Sozanski J, Timmerman H, Lopez JA, Poskus DM, Tatum J, Adamas-Rappaport WJ. 2010. The use of a lightly preserved cadaver and full thickness pig skin to teach technical skills on the surgery clerkship–A response to the economic pressures facing academic medicine today. Am J Surg 200:162–166.

Do HS, Min JH, Hong SW, Han SK, Kim IS, Ryu S, Lee JW, Kim SW, Yoo IS. 2006. Evaluation of the educational efficacy of a cadaver-based model for teaching a simple suture technique to medical students. J Kor Soc Traumatol 19:121–125.

Dubrowski A, MacRae H. 2006. Randomised, controlled study investigating the optimal instructor: Student ratios for teaching suturing skills. Med Educ 40:59–63.

Fincher RM, Lewis LA. 1994. Learning, experience, and self-assessment of competence of third-year medical students in performing bedside procedures. Acad Med 69:291–295.

Hafferty FW. 1998. Beyond curriculum reform: Confronting medicine's hidden curriculum. Acad Med 73:403–407.

Glass CC, Acton RD, Blair PG, Campbell AR, Deutsch ES, Jones DB, Liscum KR, Sachdeva AK, Scott DJ, Yang SC. 2014. American College of Surgeons/Association for Surgical Education medical student simulation-based surgical skills curriculum needs assessment. Am J Surg 207:165–169.

Hamaoui K, Saadeddin M, Sadideen H. 2014. Surgical skills training: Time to start early. Clin Teach 11:179–183.

Hamaoui K, Sadideen H, Saadeddin M, Onida S, Hoey AW, Rees J. 2013. Is it time for integration of surgical skills simulation into the United Kingdom undergraduate medical curriculum? A perspective from King's College London School of Medicine. J Educ Eval Health Prof 10:10.

Hammick M, Dornan T, Steinert Y. 2010. Conducting a best evidence systematic review. Part 1: From idea to data coding. BEME Guide No. 13. Med Teach 32:3–15.

Hatala R, Cook DA, Zendejas B, Hamstra SJ, Brydges R. 2014. Feedback for simulation-based procedural skills training: A meta-analysis and critical narrative synthesis. Adv Health Sci Educ Theory Pract 19:251–272.

Hattie J, Timperley H. 2007. The power of feedback. Rev Educ Res 77: 81–112.

Kaplan SJ, Carroll JT, Nematollahi S, Chuu A, Adamas-Rappaport W, Ong E. 2013. Utilization of a non-preserved cadaver to address deficiencies in technical skills during the third year of medical school: A cadaver model for teaching technical skills. World J Surg 37:953–955.

Khunger N, Kathuria S. 2016. Mastering surgical skills through simulation-based learning: Practice makes one perfect. J Cutan Aesthet Surg 9:27–31.

Li R, Buxey K, Ashrafi A, Drummond KJ. 2013. Assessment of the role of a student-led surgical interest group in surgical education. J Surg Educ 70: 55–58.

Liddell MJ, Davidson SK, Taub H, Whitecross LE. 2002. Evaluation of procedural skills training in an undergraduate curriculum. Med Educ 36:1035–1041.

McBride JM, Drake RL. 2018. National survey on anatomical sciences in medical education. Anat Sci Educ 11:7–14.

Moss F, McManus IC. 1992. The anxieties of new clinical students. Med Educ 26:17–20.

Naylor RA, Hollett LA, Valentine RJ, Mitchell IC, Bowling MW, Ma AM, Dineen SP, Bruns BR, Scott DJ. 2009. Can medical students achieve skills proficiency through simulation training? Am J Surg 198:277–282.

Nelson MS, Traub S. 1993. Clinical skills training of U.S. medical students. Acad Med 68:926–928.

Norman G. 2010. Likert scales, levels of measurement and the "laws" of statistics. Adv Health Sci Educ Theory Pract 15:625–632.

Patel MS, Khalsa B, Rama A, Jafari F, Salibian A, Hoyt DB, Stamos MJ, Smith BR. 2013. Early intervention to promote medical student interest in surgery and the surgical subspecialties. J Surg Educ 70:81–86.

Peyre SE, Peyre CG, Sullivan ME, Towfigh S. 2006. A surgical skills elective can improve student confidence prior to internship. J Surg Res 133:11–15.

Phillips AW, Reddy S, Durning SJ. 2016. Improving response rates and evaluating nonresponse bias in surveys: AMEE Guide No. 102. Med Teach 38: 217–228.

Preece R, Dickinson EC, Sherif M, Ibrahim Y, Ninan AS, Aildasani L, Ahmed S, Smith P. 2015. Peer-assisted teaching of basic surgical skills. Med Educ Online 20:27579.

Promes SB, Chudgar SM, Grochowski CO, Shayne P, Isenhour J, Glickman SW, Cairns CB. 2009. Gaps in procedural experience and competency in medical school graduates. Acad Emerg Med 16:S58–S62.

Radcliffe C, Lester H. 2003. Perceived stress during undergraduate medical training: A qualitative study. Med Educ 37:32–38.

Reznick RK. 1993. Teaching and testing technical skills. Am J Surg 165: 358–361.

Ringsted C, Schroeder TV, Henriksen J, Ramsing B, Lyngdorf P, Jonsson V, Scherpbier A. 2001. Medical students' experience in practical skills is far from stakeholders' expectations. Med Teach 23:412–416.

Roediger HL, III, Pyc MA. 2012. Inexpensive techniques to improve education: Applying cognitive psychology to enhance educational practice. J Appl Res Mem Cognit 1:242–148.

Routt E, Mansouri Y, De Moll EH, Bernstein DM, Bernardo SG, Levitt J. 2015. Teaching the simple suture to medical students for long-term retention of skill. JAMA Dermatol 151:761–765.

Sadideen H, Kneebone R. 2012. Practical skills teaching in contemporary surgical education: How can educational theory be applied to promote effective learning? Am J Surg 204:396–401.

Sarikaya O, Civaner M, Kalaca S. 2006. The anxieties of medical students related to clinical training. Int J Clin Pract 60:1414–1418.

Stewart RA, Hauge LS, Stewart RD, Rosen RL, Charnot-Katsikas A, Prinz RA. 2007. A CRASH course in procedural skills improves medical students' self-assessment of proficiency, confidence, and anxiety. Am J Surg 193: 771–773.

Sullivan GM, Artino AR. 2013. Analysing and interpreting data from Likert-type scales. J Grad Med Educ 5:541–542.

Tribble C, Kern J, Smith M, DuBose J. 2002. The establishment of a surgical interest society for medical students. Am J Surg 183:618–621.

Wilson DR, Nava PB. 2010. Medical student responses to clinical procedure teaching in the anatomy lab. Clin Teach 7:14–18.

Zaid H, Ward D, Sammann A, Tendick F, Topp KS, Maa J. 2010. Integrating surgical skills education into the anatomy laboratory. J Surg Res 158:36–42.