

ORIGINAL RESEARCH

Education

Development of a pilot procedural skills training course for preclerkship medical students

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Abstract

Objective: Despite procedural skills being recognized as an important component of medical school education, medical students are not confident in their ability to carry out a range of medical procedures. We conducted an institutional needs assessment and used the results to inform the creation of a procedure-based preclinical elective for first- and second-year students.

Methods: We surveyed second-, third-, and fourth-year medical students at Alpert Medical School as well as select program directors to guide selection of a list of procedures to be taught in the elective. We then created an extracurricular 10-week procedural skills course for preclerkship medical students utilizing a hands-on, flipped classroom practice model. Volunteer preceptors were recruited from the Department of Emergency Medicine to participate with a student-to-faculty ratio not exceeding 5:1. Knowledge and skill acquisition were assessed using a multiple-choice knowledge exam and 4-station practical exam, respectively. Pre- and post-course online surveys were used to assess self-perceived confidence for all procedures.

Results: We implemented our procedural skills training course for first- and second-year medical students in the fall of 2015. Forty-four students applied for the first iteration of the course and 15 students were selected to participate. Fourteen students ultimately completed the elective as well as the subsequent course surveys, multiple-choice exam, and practical exam. Students who participated in the elective had increased levels of self-reported confidence at the conclusion of the elective and performed better on a practical exam and multiple-choice exam compared to students who participated in only the standard curriculum.

Conclusion: A longitudinal preclerkship procedural course early during medical school is a feasible method of teaching procedural skills to a cohort of learners. A number

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of adjustments could be made to the course in order to scale up and include a larger cohort of students at our own or another institution.

KEYWORDS

education, elective, emergency medicine, medical student, procedural skills, simulation

1 | INTRODUCTION

1.1 | Background

Procedural competency is an important component of physician training, yet development of these skills varies widely across medical schools and within individual medical school curricula.¹ Several studies have documented the concerning trend of graduating medical students who feel neither confident nor competent performing basic procedural skills.²⁻⁴ A recent review article by Gisondi et al (2017) highlighted the increasing competition that exists for procedural training in teaching hospitals owing to an increased number of learners seeking to gain these skills.⁵ Furthermore, some of these procedures are performed by nursing staff and technicians, leaving fewer opportunities for medical student exposure. Although some argue that procedural skills are best developed during postgraduate residency training, most residents are expected to be competent in basic procedures at the start of residency.⁶

1.2 | Importance

A recent survey of incoming first-year residents at 3 separate US residency programs found that 44% of respondents were marginally or not adequately prepared to perform a number of both basic and more advanced key procedures when self-reporting competency as defined by the Dreyfus module of knowledge development.⁶ This gap in procedural skills performance between medical school and residency provides a clear opportunity to identify areas within an institution's preexisting curriculum for medical students to learn these critical skills.

The need to address this deficiency in medical school is further supported by the release of the Core Entrustable Professional Activities (EPAs) by the Association of American Medical Colleges.⁷ The EPAs indicate that medical school graduates should demonstrate competency in various procedures including but not limited to venipuncture, suturing, splinting, arterial puncture, laceration repair, and lumbar puncture.⁷ Even though these procedures are recognized as essential competencies, medical students are typically not exposed to these skills until the traditional clerkship years and even then exposure is sporadic, often lacking in adequate feedback, and insufficient to achieve competency.²

Literature supports that teaching procedural skills early to medical students can lead to increased self-perceived skills and increased knowledge retention.⁸⁻¹⁰ It may also promote more self-directed learning when opportunities to practice arise outside of the classroom setting. Though it is unclear if this translates into adequate compe-

tency, early exposure may provide students with the experience and confidence necessary to further improve skills during medical school and ultimately become better prepared for residency training.¹¹ This builds on the theory of deliberate practice,^{12,13} which has been used as a framework recently for the acquisition of clinical skills training in medical student learners and formed the foundation for our curricular approach.¹⁴

1.3 | Goals and hypothesis

This article describes an approach to meet the need for additional procedural skills training at one institution. We designed and implemented an extracurricular procedural skills training program for first- and second-year medical students. We hypothesized that such a curriculum would provide necessary hands-on practice and increase self-perceived confidence in procedural skills beyond that gained through the standard curriculum.

2 | METHODS

2.1 | Study design and setting

This was a single site, educational intervention study completed at the Warren Alpert Medical School of Brown University (AMS). The Brown University Institutional Review Board reviewed and deemed this research exempt.

2.2 | Selection of participants for needs assessment

We identified several key AMS stakeholders for an initial needs assessment including all second (MS-2), third (MS-3), and fourth (MS-4) year medical students as well as program directors in emergency medicine, internal medicine, family medicine, surgery, and pediatrics. Students were invited to participate via survey to establish baseline self-perceived confidence in procedural skills at different stages of training. MS-2 students were surveyed before and after their required Clinical Skills Clerkship (CSC) – a 3-week course that includes procedural training designed to prepare them for third-year clerkships. The procedural component of the course is covered in 2 half-day sessions where students rotate through procedural stations. MS-3 and MS-4 students were surveyed at the end of their clinical third and fourth year, respectively.

2.3 | Curriculum development and implementation

The list of procedures taught in the course was determined using data from the initial needs assessment, recommendations from the EPAs, and the existing procedural training curriculum at AMS. The final list of procedures deemed high yield were lumbar puncture, bedside ultrasound, airway management, arterial blood gas sampling, splinting, intravenous line placement and phlebotomy, and wound repair [Table 1].

The proposed course fit well into an existing AMS curricular format known as a preclerkship elective – a non-credit bearing course open to all MS-1 and MS-2 students with a minimum of 20 instructional hours. The preclerkship elective format is a manageable means of allowing further study of important topics outside of the standard curriculum. Preclerkship electives are graded on a satisfactory/no credit basis and can be student led with faculty mentorship. All preclerkship electives are submitted to the AMS Medical Curriculum Committee for review and approval before implementation. Although preclerkship electives are optional and have a smaller class size, they provide an ideal opportunity to create a structured learning experience with more direct observation of skills practice.

Building on the theory of deliberate practice,^{12,13} we sought to maximize time for students to perform hands-on practice followed by focused feedback from preceptors who are directly observing the learners. We used a flipped classroom model, a format in which students are introduced to content at home and then have the opportunity to practice and reinforce skills in the classroom, for the weekly 2-hour didactic sessions where students were asked to complete \approx 1 hour of required preparation before each class. Required preparation consisted of watching videos covering the risks, benefits, indications,

The Bottom Line

Medical student training in critical procedures is limited. This manuscript describes a procedure-based curriculum that may help institutions meet undergraduate medical education training needs.

contraindications, equipment used, and technique behind performing a procedure. Classroom sessions started with a brief review of the procedure including consent, risks, benefits, indications, contraindications, and steps in the procedure, before students practiced the skills hands on with faculty preceptors.

We used an institutionally available content delivery system (CANVAS, Instructure Inc, <https://www.instructure.com/>) for the asynchronous delivery of course content before each session. A course syllabus was created that covered the given procedure each week, session objectives, required readings, required supplies, and a facilitator guide included in the instructor version. All classes were taught at the medical school or the affiliated tertiary academic teaching hospital. Volunteer preceptors were recruited from the Department of Emergency Medicine. A total of 10 residents, 1 fellow, 2 nurses, and 4 faculty members participated as preceptors during the course. For each weekly session, we aimed for a student-to-faculty ratio not exceeding 5:1 based upon published trainer-to-student ratios in health care skills training.¹⁵ Financial support for supplies was provided by AMS and the Department of Emergency Medicine. Available procedural models and equipment from AMS were also used.

TABLE 1 Curriculum overview

Session #	Content	Location	Supplies
1	Informed consent, sterile technique, gowning and gloving	Hospital meeting room and operating room	Gloves, sterile gowns, scrub brushes
2	Airway management	Medical school	Bag-valve-masks, laryngoscope handles and blades, oropharyngeal airways, nasopharyngeal airways, gum elastic bougies, intubation models, endotracheal tubes, stylets, syringes, laryngeal mask airways
3	Basic suturing	Medical school	Suture, suture instruments, gloves, pork belly, sharps container
4	Advanced suturing	Medical school	Suture, suture instruments, gloves, pork belly, sharps container
5	Ultrasound	Medical school	Ultrasound machines, gloves, ultrasound gel, towels
6	Lumbar puncture	Medical school	Lumbar puncture practice models, lumbar puncture trays
7	Splinting	Medical school	SAM® splints, undercast padding, stockinette, elastic compression bandages
8	Intravenous line placement and arterial blood gas (ABG) sampling	Medical school anatomy lab	Intravenous catheters, intravenous practice models, ABG tray, ABG model
9	Practice session	Medical school	Pork belly, suture instruments, suture, LP model and tray, ABG model and tray, intubation model and airway equipment
10	Final exam and practicum	Medical school	Student laptops, pork belly, suture instruments, suture, lumbar puncture model and tray, ABG model and tray, intubation model and airway equipment

TABLE 2 Comparison of confidence levels and exam scores for medical students at various stages in training

Mean confidence in...	Needs assessment data				Course data			
	MS2 pre-CSC (n = 45)	MS2 post-CSC (n = 35)	MS3 (n = 31)	MS4 (n = 30)	EPS MS2 students pre-EPS (n = 9)	EPS MS2 students post-EPS (n = 9)	EPS MS2 students 7 months post-EPS/2 months post CSC (n = 9)	CSC students 2 months post CSC (n = 9)
Informed consent					2.80/5	4.30/5	3.62/5	4.00/5
Aseptic technique					1.90/5	4.20/5	4.38/5	4.44/5
Basic suturing	1.71/5	3.26/5	3.19/5	3.50/5	1.60/5	4.00/5	4.00/5	4.11/5
Advanced suturing					1.20/5	4.00/5	3.25/5	2.67/5
Lumbar puncture	1.07/5	1.46/5	1.42/5	1.50/5	1.00/5	3.90/5	3.25/5	2.44/5
Bag-valve-mask	1.42/5	3.31/5	3.52/5	3.43/5	1.60/5	4.30/5	4.00/5	4.44/5
Endotracheal intubation	1.29/5	1.89/5	1.65/5	2.00/5	1.10/5	3.60/5	3.25/5	2.89/5
Intravenous insertion	1.51/5	2.51/5	1.97/5	2.30/5	1.70/5	4.10/5	3.38/5	3.67/5
Ultrasound	1.16/5	2.00/5	1.71/5	1.70/5	1.30/5	3.40/5	2.75/5	2.22/5
Arterial blood gases	1.09/5	2.14/5	1.77/5	2.53/5	1.00/5	4.40/5	3.88/5	2.22/5
Splinting	1.60/5	2.20/5	1.90/5	2.63/5	1.50/5	3.60/5	3.25/5	2.67/5
Mean score on...								
Practical exam						20.55/22	11/12	9.67/12
Multiple-choice exam						15.31/23	7.01/12	4.96/12

For confidence 1 = Not at all confident, 2 = Mildly confident, 3 = Moderately confident, 4 = Confident, 5 = Extremely Confident.

CSC, Clinical Skills Clerkship; EPS, Essentials of Procedural Skills; MS2, second-year medical student; MS3, third-year medical student; MS4, fourth-year medical student.

2.4 | Program evaluation

To better understand the initial impact of the pilot curriculum, we decided to assess short-term and long-term knowledge and skill retention gained through the Essentials of Procedural Skills (EPS) course in addition to student satisfaction and self-perceived confidence through a final course evaluation.

A multiple-choice exam was developed by course faculty to assess knowledge acquisition, as well as a 4-station practical exam to assess skill acquisition. Internally created checklists were created for key action items modeled after the steps emphasized in Roberts and Hedges' Clinical Procedures in Emergency Medicine.¹⁶⁻¹⁹

Although the short-term knowledge and skill retention of both MS-1 and MS-2 EPS students was assessed, we chose to focus primarily on assessing the long-term knowledge and skill retention of MS-2 EPS students only because all MS-2 students undergo procedural training through CSC as part of the standard curriculum before they begin third year, thus providing a control group for comparison. Long-term knowledge and skill retention were assessed 7 months post completion of the elective and 2 months post completion of CSC. MS-2 students who took CSC alone were recruited via email and 9 students were randomly selected to serve as a control group. A larger control group could not be obtained because of difficulty recruiting study participants during clinical rotations.

For long-term knowledge acquisition, a multiple-choice knowledge exam with a smaller set of questions from the original exam (12 vs 23 questions) but similar content was used. For long-term skill acquisition, a 2-station practical exam (use of bag-valve-mask and lumbar puncture) was used instead of 4 stations given time constraints for students during clerkships. The 2 procedures used in the practical exam were taught in both EPS and CSC. Finally, self-perceived confidence levels of EPS students were obtained via online surveys for all procedures before and after the course, as well as at the long-term follow-up for both EPS students and the control group.

3 | RESULTS

The 10-week extracurricular course, "Essentials of Procedural Skills: An Introduction," was approved and implemented in the fall of 2015. Forty-four students applied for the first iteration of the course and based upon available resources, 15 students were selected to participate. Fourteen students ultimately completed the elective as well as the subsequent course surveys, multiple-choice exam, and practical exam. Students who took EPS reported higher levels of confidence post-course compared to pre-course and performed better than non-EPS students on a practical exam and multiple-choice exam [Table 2]. Course materials, including the course syllabus and assessment materials, are in the supplemental materials.

4 | LIMITATIONS

Very few medical schools have formal procedural training curricula.³ One reason may be limited access to necessary supplies, which was one of the major factors for limiting enrollment in the elective to only 15 students. This ultimately provided a very low sample size for data analysis, limiting both the external validity of our findings and the internal structure validity of our statistical analysis. We therefore excluded inferential statistics and the conclusions that can be drawn from the pilot data are limited. Though self-perceived confidence levels increased after the course, the internal validity of the measurements is limited, and we do not know whether this increase in confidence was a direct result of EPS or other external factors. Though learner confidence has been shown to have poor accuracy and low association with external measures of competence,^{20,21} we nonetheless use it as evidence to reflect student investment in the curriculum.

Scores on long-term knowledge and skill acquisition exams also improved when comparing EPS and non-EPS students 7 months after the course, but neither exam was validated. The practical skills exam was based on both local expert consensus and a widely accepted procedural textbook²² which provides some support for its content validity, with more limited construct validity given the lack of available data to support performance of these procedures in the clinical environment. However, response process validity for the practical skills exam is supported by using a hands-on skills component and measuring short- and long-term retention of skills.

Concerning generalizability, we believe the curriculum designed for this elective is sufficiently adaptable for other institutions and can be used as a stand-alone curriculum or as part of an already existing curriculum. Our initial program evaluation is limited by the small sample size but provides preliminary support of such a curriculum having a positive impact on the ability of students to find opportunities to engage in procedural skills practice during the clinical phase of their education.

5 | DISCUSSION

A preclerkship procedural training course for a small cohort of first- and second-year students at a large academic institution is feasible and may lead to long-term procedural skill retention beyond what is commonly taught in most medical school curricula. We believe that students reporting increased levels of confidence at the conclusion of the elective demonstrated investment in the EPS curriculum and in procedural training at large. Although we cannot directly attribute the increased confidence to EPS, it nonetheless supports the idea that early procedural skills training for medical students can lead to increased self-perceived skills.⁸⁻¹⁰

In order to gather more robust data to draw meaningful conclusions, the course would need to be scaled up beyond the small group of students in the pilot. One important factor when increasing the number of learners is maintaining an adequate number of instructors for each

session. Having a resident directly coordinate the resident schedule was a much-valued administrative component that was added toward the end of the course. Similarly, having faculty leaders solicit faculty instructors directly was useful.

Although the pilot implementation involved only 15 students, obtaining essential materials such as task trainers, suture and splinting materials, sharps containers, and gowns/gloves required for each session took several hours of preparation each week during the first iteration of the course. EPS was implemented using equipment already available for medical student education. Though our curriculum involved the use of task trainers [Table 1], many of the procedures can still be taught using low-fidelity simulators, which have been shown to be as effective or even better than high-fidelity simulators in some cases.^{23,24} We also recommend investigating any available local resources from anatomy labs, simulation centers, and other allied health professional schools where procedural skills are taught.

Concerning implementation of the curriculum, we found that a procedural training curriculum is generally better suited to learners who have completed anatomy since knowledge of anatomic landmarks is critical to understanding many of the common procedural techniques. First-year students may have therefore been at a disadvantage compared to second-year students in our elective. Providing an orientation to anatomy as it relates to procedures was an added component of the course that should be carried forward in future iterations. The flipped classroom model provided ample time for skills practice during classroom sessions and proved to be an effective means of encouraging student motivation and engagement. If the course is scaled up, it may help clarify whether flipped classroom models increase learner knowledge and skills compared to traditional learning methods.²⁵ Based upon the published literature, the ratio of instructors to students could be increased up to 8:1, but maintaining an instructor to student ratio of 5:1 was well received by students and allowed adequate feedback, which has been suggested as a requirement for long-term competence.^{2,15} This was in keeping with the optimal instructor to student ratio for motor learning of 4:1.²⁶ Providing students with a low-tension learning environment was another successful aspect of the course, as high-tension learning environments that can be encountered in the clinical setting can cause anxiety and inhibit motor learning.¹

This initial pilot project suggests that a preclerkship curriculum that addresses gaps in procedural training skills is feasible for first- and second-year medical students and may lead to short- and long-term retention of skills. Assuring long-term retention of skills is important as knowledge and skills demonstrated shortly after learning a skill can easily decay. Numerous studies have shown that much of the basic knowledge and skills gained by medical students in their undergraduate education is lost by the time they enter graduate training.²⁷⁻²⁹ Scaling up the elective to eventually reach a larger cohort of students and to provide more robust data for analysis are important next steps for this research. If appropriately scaled up, such a curriculum may be one piece of the larger solution needed to close the growing gap between graduating medical students who report low confidence levels and first-year interns who report that they are not prepared to perform most basic procedures.

AUTHOR CONTRIBUTIONS

AA conceived of the pilot curriculum. All authors were involved with the development and execution of the curriculum as well as development of the study design. All authors discussed and reviewed the results and contributed to the final manuscript.

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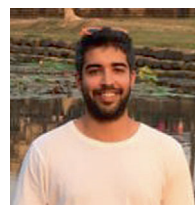
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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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