Surgery 165 (2019) 1075–1081

Contents lists available at ScienceDirect

Surgery

journal homepage: www.elsevier.com/locate/surg

Proficiency development for graduating medical students, using skills-level–appropriate mastery learning versus traditional learning for chest tube placement: Assessing anxiety, confidence, and performance

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ARTICLE INFO

Article history:
Accepted 15 January 2019
Available online 7 March 2019

ABSTRACT

Background: Mastery learning is an effective educational tool to assess basic procedural skill proficiency and may also be beneficial for more complex skills along the continuum of surgical training. In addition, anxiety and confidence have effects on cognitive and decision-making performance, both in educational and clinical settings. This study evaluates anxiety and confidence in a skills-level–appropriate mastery learning module for chest tube insertion in graduating medical students.

Methods: A 2-week intern preparatory course was held 2 consecutive years, with 10 and 14 students, respectively. Learners completed a pretest on day 1, didactic session and supervised deliberate practice followed by a Posttest on day 4, and a retention test on day 10. Year one used a traditional educational methodology, and year two provided for remediation as per mastery learning methodology. The chest tube scoring checklist was validated by faculty trauma surgeons to reflect an intern-appropriate skills level. Before and after each test, learners reported state anxiety. Immediately after each test, learners also completed a confidence scale.

Results: No learners in either year achieved mastery on the pretest. A total of 40% of the learners achieved the mastery standard on the posttest in year one. All (100%) of the learners achieved the mastery standard after the posttest in year two. Overall, after state anxiety decreased significantly in both years, confidence increased significantly in year two.

Conclusion: A skills-level–appropriate mastery learning module resulted in higher performance and increased confidence compared with a traditional education model for chest tube placement for incoming surgical interns.

Introduction

Traditional medical education, including surgical skills, has historically used the apprenticeship model, relying on the learner, with variable levels of supervision, to obtain relevant knowledge and technical skills by frequent, direct patient encounters.[1] The knowledge and skills a surgeon is expected to obtain during training is vast and relies on many basic skills obtained in medical school. Today's complex and fast-paced healthcare environments may subject new surgical interns to increased stress and anxiety, which has been associated with a decreased health care efficiency and subsequent increase in patient morbidity and mortality.[2] This may be attributable to a combination of an unfamiliar work environment, new patient-care responsibilities, and varying knowledge and technical skill proficiency because of decreased clinical time in medical school. In response, there has been a call for more simulation-based procedural training to supplement learning opportunities that occur as part of patient care.[3–5] Medical schools must equip their graduating physicians with the basic skills they will need to be successful as interns and lay the foundation for learning the complex skills that will be the focus of their residency training.

Students, particularly in surgical specialties once they have advanced to their residency training, will be required as interns to participate in high-acuity procedures, such as emergent chest tube placement in the setting of trauma. To address needed skills and

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https://doi.org/10.1016/j.surg.2019.01.015
0039-6060/

knowledge, the American College of Surgeons (ACS), the Association of Program Directors in Surgery (APDS), and the Association for Surgical Education (ASE) have collaborated to create a surgical intern preparation curriculum for graduating medical students entering surgical internships.[6–9] This curriculum includes a number of assessment tools but does not define competency in completed tasks. The national curriculum includes a chest tube module, but it does not ensure level-appropriate competency for this complex skill, which is often performed in a high-stress, high-acuity environment with the potential for injury to the physicians completing the task, to other staff members because of the presence of sharps and biologic fluids, and to the patient from incorrect placement of the chest tube. Surgical interns are very unlikely to be unsupervised for this type of procedure; however, they may be asked by more senior trainees or attending surgeons to prepare for the procedure, to follow-up the procedure, or to act as an assistant in the placement of the chest tube, particularly in an emergency setting.

Simulation-based mastery learning (SBML) is a rigorous form of competency-based learning for high-achieving learner populations in which learners acquire a skill or learn knowledge to a predetermined standard of "mastery."[10] Mastery learning differs from traditional educational techniques because it disregards the time needed for a learner to reach the outcome and instead focuses on ensuring that each learner reaches the mastery standard through deliberate practice and supervised remediation—ensuring the mastery standard is obtained. A pretest is taken so that faculty may assess learners' baseline knowledge using a verified standardized checklist. This is followed by a didactic learning session and supervised deliberate practice. A posttest is then completed. Learners unable to achieve mastery on the posttest are provided remediation and retested. This is repeated until mastery is achieved.[11] Application of mastery learning to basic procedures provides a setting to optimize patient safety while providing comprehensive technical training critical for both medical students and residents.[12]

The impact of stress and anxiety on performance can be both beneficial and harmful.[2,13] Anxiety in "therapeutic amounts" can potentiate performance on certain tasks by increasing participant motivation and adrenergic response. However, high levels of stress are associated with detrimental effects on information processing, memory, and learning, resulting in lower quality of performance.[13] Mastery learning may reduce learner anxiety and allow for better skill acquisition attributable to "therapeutic" anxiety created in the pretest but followed by safe and supportive learning. The requirement for success exists with supportive remediation if needed. We sought to apply a simulation-based mastery learning skills-level–appropriate module for chest tube placement during a surgical intern prep course at one Association of American Medical Colleges–accredited medical school for graduating medical students who had matched into an accredited Accreditation Council for Graduate Medical Education (ACGME) surgical residency. We hypothesized that a skills-level–appropriate module for chest tube insertion would improve skills, decrease anxiety, increase confidence, and promote skills retention in time.

Methods

Participants

Fourth-year graduating medical students from 2 consecutive years (2016 and 2017) of the Surgical Intern Preparatory Course (S-IPC) at the University of Wisconsin School of Medicine and Public Health (Madison) participated in this study. Participating students consented to having their data analyzed from a chest tube module portion of the course. The institutional review board approved this study with exempt status. We compared skill development, anxiety, confidence, and skill retention across the 2 years.

Students' demographics for each year were as follows. Year one (March 28, 2016–April 8, 2016) was composed of 10 fourth-year medical students (5 males and 5 females) who completed all components of the S-IPC Mastery Learning Chest Tube Placement Module. All participants had successfully matched into an ACGME-accredited surgical residency program (9 categoric general surgery and 1 categoric vascular surgery). Year two (April 24, 2017—May 5, 2017) was composed of 14 fourth-year medical students (13 males and 1 female). All participants successfully matched into an ACGME-accredited surgical residency program (5 categoric general surgery, 3 neurologic surgery, 2 otolaryngology, 1 plastic surgery, 1 ophthalmology, 1 urology, and 1 radiation diagnostic).

Procedure

During both years of participation in the chest tube module, the students performed a pretest, followed by didactics and practice, a posttest, and a later retention test. For each test, the learners were evaluated using the same procedural checklist. In year one, a traditional educational module was used to teach the steps of chest tube insertion, in which the students had a fixed amount of time for training. In year two, a time-variable mastery module was initiated that included remediation after the posttest, with retesting until a skill-level–appropriate minimum passing standard (MPS) was met.

The mastery learning module for chest tube insertion consisted of three sessions (Fig 1). On course day one a baseline pretest assessment (pretest) was conducted. Two instructors offered the pretest concurrently in separate rooms. Learners were asked to place a chest tube on Trauma Man (Simulab Corporation, Seattle, WA, USA) without having had specific hands-on or didactic training. After the pretest, but before the posttest, in year two, learners were asked to watch a publicly available online chest tube insertion video from the University of Toronto, Sunnybrook Health Sciences Centre (Toronto, ON, Canada).[14] This was not provided during year one. On course day four, students received a didactic teaching session. University of Wisconsin Department of Surgery Faculty gave an hourlong lecture reviewing the requirements and indications for the procedure. There were differences between the year-one and year-two lectures. Year two included a more comprehensive demonstration of the skills and steps the learners were expected to know as part of their didactic session—consistent with the mastery model of learning. Both years, the didactic session was followed by hands-on chest tube deliberate practice on a moderate fidelity simulator. Staff trauma surgeons and upper-level general surgery residents proctored the deliberate practice session, giving immediate feedback, tips, and correction. This session was immediately followed by the posttest. Two instructors offered the deliberate practice sessions and the posttest concurrently in two separate rooms. Any student who did not achieve the predetermined level of mastery received additional deliberate practice followed by remediation testing.

A retention session was held on course day ten (retention test) on a live, anesthetized porcine model. Three models were available, with three students doing the procedure and being evaluated by three individual instructors at the same time. No additional didactic instruction or deliberate practice was provided in the interim. Although evaluated against the skill-level–appropriate mastery standard checklist, this component of the module did not provide for specific remediation or retesting. During all sessions, learners were given as much time as they needed to complete the procedure.

Trauma surgery staff surgeons administered the pretest evaluation of the students. The didactic lecture was delivered by either a

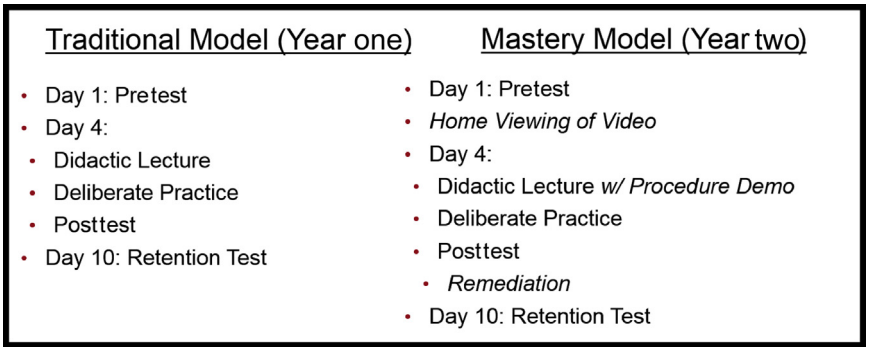

Fig 1. The chest tube module in year one in comparison with the mastery model in year two (differences between years in italics).

staff trauma surgeon or a surgical critical-care fellow. Deliberate practice of chest tube placement was proctored by trauma surgery faculty, senior general surgery residents, surgical critical-care fellow, and learner peers. Trauma surgery faculty had been practicing 5–10 years as attendings, residents had all had multiple rotations on the trauma service, and the surgical critical care fellow was nearing the completion of the clinical fellowship year. Trauma surgery faculty and senior general surgery residents used the checklist to evaluate students' chest tube insertion performance for the posttest and the retention test. All evaluators underwent an instructor orientation to understand mastery learning, how to administer the test, and how to score the checklist. Only 1 evaluator was available for each of the assessment stations, so we were unable to measure interobserver agreement. In all of the assessment environments, there were not additional stressors added to the environmental context to produce stress or anxiety (eg, a panicked assistant or demanding instructor). Thus, anxiety experienced by the students can presumably be attributed to their feelings related to performing the chest tube insertion skills.

Measures

Mastery learning checklist

The skill-level–appropriate checklist for chest tube mastery was determined by a consensus of 8 attending trauma surgeons from the University of Wisconsin Hospitals and Clinics from a 17-item checklist obtained from the American College of Surgeons, Association of Program Directors in Surgery, and Association for Surgical Education national curriculum.[15] The checklist included 3 possible outcomes for the individual steps as "not done," "done incorrectly," or "done correctly." The checklist was provided individually to each of the staff and they indicated which steps they considered essential. Differences were discussed among all staff until consensus was obtained. The MPS for this module was set based on attending-staff expectations of how a new surgical intern should perform on essential items using a modified Yudkowsky Patient Safety standard setting method.[16] The developed mastery standard focused on steps that a *surgical intern* could be expected to accomplish independently (essential)—primarily set-up for the procedure and appropriate patient evaluation and follow-up after the procedure, consistent with the ACGME Milestones for Surgery and Surgical Critical Care, setting it at a level appropriate for the clinical level of the learner.[17,18]

Of the original 17 items, 8 were determined to be "essential," where the learner needed to achieve 100 % of these items as "done correctly" to achieve the level-appropriate MPS (Fig 2). The remaining "nonessential" items were required to be attempted, but whether they were "done correctly" or "done incorrectly" was not required for mastery. We compared the percentage of students who achieved mastery on the pretest, posttest, and retention test within each year and between year one and year two.

Participant anxiety scoring

The 6-component State Trait Anxiety Index (STAI) short form was used to assess anxiety.[19] The STAI is a tool composed of 2 portions, trait and state, each of which is composed of 6 questions on a 4-point scale. Baseline anxiety of the learners was assessed 2 weeks before the course start date, using the Trait Anxiety Scale of the STAI. Both immediately before and immediately after each testing component of the chest tube module (pretest, posttest, and retention test) the state scale of the STAI was administered to participating learners. Confidence was measured after each testing component (pretest, posttest, and retention test), using the 6-component Cato Confidence Scale.[20] This scale is made up of 6 components each, with a scale of 6, ranging from anxious (1) to high confidence (6).

Analysis

To investigate level-appropriate chest tube insertion mastery across the 2 years, we compared the percentage of students who achieved mastery on the pretest, posttest, and retention test within each year and between year one and year two. An independent samples *t* test was used to compare trait anxiety between students in year one and year two. To look at students' anxiety related to the process of chest tube insertion, we used repeated measures analysis of variance (ANOVA) to look for differences in both the before skills state scale and after skills state scale across the 3 testing points. If the ANOVA was significant, we followed-up with a pairwise matched-pairs *t* test to determine at which time points state anxiety was significantly different. We also compared the change in state anxiety levels between and within year one and year two, using a mixed ANOVA and follow-up *t* tests. Finally, to better understand learners' confidence after the completion of each of the chest tube insertion tests during each iteration of the module, we compared post skill confidence between and within year one and year two, using a mixed ANOVA and follow-up *t* tests. All tests for significance used an α level of .05 and were performed using IBM SPSS Statistics v 24 (IBM, Armonk, NY).

Results

Mastery

In year one, after the pretest on course day 1, no learners achieved the mastery standard. On course day 4, the posttest, 4 out of 10 learners (40%) achieved mastery on the first attempt. Remediation was not provided. On course day 10, the retention test, 8 out

Step	Proficiency			Step	Proficiency		
1. Use of sterile technique	Not Done	Done Incorrectly	Done Correctly	10. Grasp chest tube w/ Kelly	Not Done	Done Incorrectly	Done Correctly
2. Locate insertion site	Not Done	Done Incorrectly	Done Correctly	11. Insert chest tube	Not Done	Done Incorrectly	Done Correctly
3. Prep site w/ chlorhexidine	Not Done	Done Incorrectly	Done Correctly	12. Advance tube cephalad	Not Done	Done Incorrectly	Done Correctly
4. Drape and orient patient	Not Done	Done Incorrectly	Done Correctly	13. Suture, tape tube in place	Not Done	Done Incorrectly	Done Correctly
5. Widely anesthetize insertion area	Not Done	Done Incorrectly	Done Correctly	14. Apply dressing to site	Not Done	Done Incorrectly	Done Correctly
6. Make incision	Not Done	Done Incorrectly	Done Correctly	15. Attach tube, start suction	Not Done	Done Incorrectly	Done Correctly
7. Perform blunt dissection to pleura	Not Done	Done Incorrectly	Done Correctly	16. Obtain CXR for placement	Not Done	Done Incorrectly	Done Correctly
8. Insert Kelly, open jaws	Not Done	Done Incorrectly	Done Correctly	17. Reassess patient	Not Done	Done Incorrectly	Done Correctly
9. Insert finger, sweep and clear	Not Done	Done Incorrectly	Done Correctly				

Fig 2. Mastery checklist for chest tube insertion. Steps 1–4 and 14–17 had to be completed correctly, and steps 5–13 had to be attempted to achieve mastery.

of 10 (80%) learners achieved the level-appropriate checklist standard.

In year two, after the pretest on course day 1, no learners achieved the mastery standard. On the course day 4, the posttest, 14 of the 14 learners (100%) achieved the level-appropriate–mastery standard. One learner did not achieve mastery on the first attempt of the posttest, but did so after remediation. This learner required approximately 10 minutes of remediation and practice on skills that were missed and then was able to achieve mastery on the second attempt. On the course day 10 retention test, 13 of the 14 learners (92.2%) achieved the mastery standard. Remediation was not provided.

Anxiety

An independent samples t test indicated no significant difference in trait anxiety between learners in year one and year two (t [23.76] = −.371, P = .714, year one: 10.29 ± 2.64 versus year two: 10.62 ± 1.94).

For before-skill anxiety in year one, there was not a significant difference in before skill state anxiety (day 1: 11.6 ± 3.7 versus day 4: 11.9 ± 3.0 versus day 10: 10.6 ± 4.3) across the 3 assessment time points (F [1.31,13.01] = .145, P = .775). However, there was a significant difference in after skills state anxiety (F [1.43,12.85] = 9.381, P = .005). Follow-up tests indicated that state anxiety was significantly greater after the course day 1 pretest than after the course day 4 posttest and course day 10 retention test (mean ± SD; day 1: 14.5 ± 4.6 versus day 4: 9.1 ± 3.5 versus day 10: 10.0 ± 3.6).

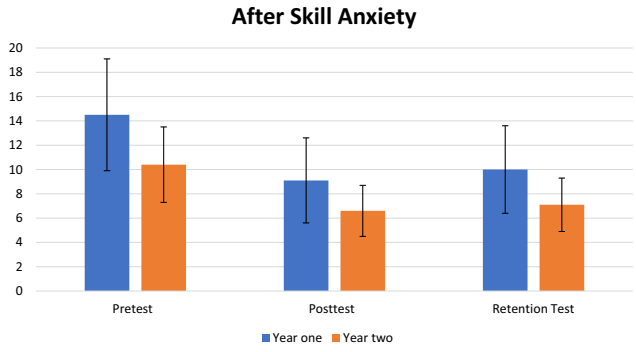

Fig 3. Differences in after-skill anxiety in year one and year two. Year one had a significant change, P < .005. Year two had a significant change, P < .001.

The difference in after skill state anxiety between the course day 4 and course day 10 sessions was not statistically significant (Fig 3).

Changes in before-skill anxiety in year two were different from the previous year in that there was a significant difference (F [1.53,19.90] = 3.826, P = .049) in the before skill state anxiety scores of the learners between the 3 testing sessions (day 1: 10.4 ± 3.3 versus day 4: 8.5 ± 3.6 versus day 10: 8.4 ± 3.5). Follow-up comparisons revealed the only significant difference between the pretest on day 1 and the retention test on day 10. A significant decrease was also found in after skill state anxiety scores across the 3 assessment time points (F[1.55, 20.19] = 16.222, P < .001). Follow-up tests indicated a significant decrease between the after

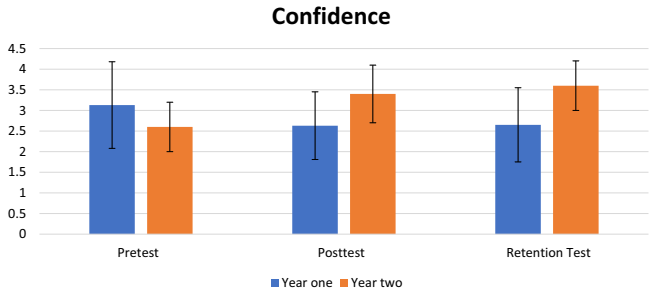

Fig 4. Differences in confidence in year one and year two. Year one had no significant change. Year two had a significant change, $P < .001$.

skill state anxiety between the pretest and posttest and no significant change between the posttest and retention test (day 1:10.4 ± 3.1 versus day 4: 6.6 ± 2.1 versus day 10: 7.1 ± 2.2).

The mixed ANOVA indicated a significant interaction between year and test time for change in state anxiety ($F [1.885, 41.479] = 3.651$, $P = .037$). Follow-up tests indicated that there were significantly greater changes in state anxiety during year one than in the following year (day 1: 2.9 ± 2.5 versus day 4: -2.8 ± 2.4 versus day 10: −.60 ± 3.5). However, learners state anxiety levels ended up lower in year two, particularly after the retention test, after which there was a larger reduction in state anxiety than the previous year (day 1: .30 ± 2.0 versus day 4: −1.9 ± 2.9 versus day 10: −1.3 ± 2.1).

Confidence

The mixed ANOVA indicated a significant interaction between year and test time for confidence scores ($F [1.834,42.184] = 12.026$, $P < .001$). Follow-up tests indicated that, during year one, that there was no significant difference in self-reported learner confidence on the Cato Confidence Scale across the 3 sessions (day 1: 3.13 ± 1.05 versus day 4: 2.63 ± .82 versus day 10: 2.65 ± .90). However, during year two, learners' confidence significantly changed across the 3 chest tube assessment time points (day 1: 2.6 ± 0.6 versus day 4: 3.4 ± 0.7 versus day 10: 3.6 ± 0.6), with follow-up tests revealing a significant increase between the pretest and posttest but no significant increase between the posttest and retention test (Fig 4).

See the Table for a summary of data from both year one and year two of the intervention.

Table
Mastery percentages, means, and standard deviations for anxiety and confidence on the pretest, posttest, and retention test

Year one—2016 SIPC			
	Mean score ± SD ($N = 10$)		
	Pretest	Posttest	Retention test
Mastery	0/10 (0%)	4/10 (40%)	8/10 (80%)
Before-skill anxiety	11.6 ± 3.7	11.9 ± 3.0	10.6 ± 4.3
After-skill anxiety	14.5 ± 4.6	9.1 ± 3.5	10.0 ± 3.6
Anxiety difference	2.9 ± 2.5	−2.8 ± 2.4	−.60 ± 3.5
Confidence	3.13 ± 1.05	2.63 ± .82	2.65 ± .90
Year two—2017 SIPC			
	Mean score ± SD ($N = 14$)		
	Pretest	Posttest	Retention test
Mastery	0/14 (0%)	14/14 (100%)	13/14 (92.2%)
Before-skill anxiety	10.1 ± 3.3	8.5 ± 3.6	8.4 ± 3.5
After-skill anxiety	10.4 ± 3.1	6.6 ± 2.1	7.1 ± 2.2
Anxiety difference	.30 ± 2.0	−1.9 ± 2.9	−1.3 ± 2.1
Confidence	2.6 ± 0.6	3.4 ± 0.7	3.6 ± 0.6

Discussion

Stress and anxiety are significant factors affecting performance in many medical fields, including surgery. These responses can cause detrimental effects on cognitive processes, including memory, knowledge recall, and attention or, conversely, they can create a beneficial level of attention.[13] When newly graduated medical students enter a residency program as a surgical intern, they are generally unfamiliar with the work environment and lack significant clinical experience required of their newly acquired role, potentially leading to increased anxiety. New tasks and procedures may further increase this level of anxiety and contribute to decreased performance. This study sought to implement a mastery learning module for skill-level–appropriate mastery assessment of a skill a new intern would be expected to know to assist with chest tube insertion. The purpose of this module was to improve skill performance, reduce learner anxiety, and increase learner confidence. The module also sought to evaluate the retention of learned skills, albeit during a short time. The focus was on the steps of the skill that faculty trauma surgeons and senior residents would expect of a new surgical intern, keeping patient safety in mind. The introduction of a high-stakes procedure, experienced by learners in a safe, simulated environment before the start of an internship is anticipated to improve the coping of the learner during the clinical experiences throughout their internship.

Simulation-based surgical education is a method that can shift education away from clinical patient-based training to a safe and supervised educational setting, making it synergistic with principles of mastery learning.[11] This is the first study to report chest tube placement as the skill for a mastery learning curriculum. This is important because it is an invasive procedure with conceivable high risk to the performer, the patient, and surrounding staff because of the potential for high-stress placement, critical illness of the patient, ambulatory environment (trauma bay), need for sharps, and exposure to blood. In today's medical education environment such high-stakes procedures are infrequently performed at the medical student learner level, in turn leading to interns and residents having a more gradual acquisition of these skills. Historically, mastery has held the same proficiency (mastery) standard regardless of the level of trainee or the experience of performer. However, as attempts are generated to establish skills-based proficiency throughout the trainee and professional physicians' or surgeons' career, the authors believed that adjustment of this viewpoint is prudent and warranted.

To address the graduated progression of skills and clinical decision-making within residency training programs, the ACGME has developed milestones specific to specialties. Applicable to general surgery interns and residents are both the surgical critical care milestones (patient care procedural competence) and the surgery milestones.[17,18] These milestones are likely to undergo additional modification and development with time, as more emphasis is placed on specific disease processes and procedures. There is an expectation that this will develop with maturation and experience with proficiency-based training. Introducing more complex skills, such as chest tube placement, in addition to studied basic procedures, such as intravenous and nasogastric placement, provides opportunities for learner evaluation using the mastery model. This is a beneficial approach for systematic teaching and learning of these complex skills, because many technical and nontechnical skills in surgery are obtained during the time of the 5 years of required clinical surgical residency.

In clinical and educational surgery contexts, there is an expectation that learners will gradually acquire skills appropriate for their level of training—with proper supervision provided along the way—by more experienced senior level trainees or faculty. In the

process of obtaining these skills, these learners will be exposed to and will be expected to assist with the completion of these skills at the bedside. In this study, we focused on ensuring that graduating medical students about to enter a surgical internship could participate in a complex and invasive procedure in a manner that will help ensure patient, performer, and staff safety, while also assessing the impact of anxiety and confidence comparing a traditional learning methodology to a mastery learning methodology. We considered that the skills-level–appropriate mastery standard model could also provide interns a better idea of what they should be able to do on their own and when they should seek help from a senior resident or attending.

Our methodology included modifying Yudkowsky's method[16] of setting essential and nonessential criteria based on patient safety considerations to establish a skills-level–appropriate mastery standard appropriate to the incoming July surgical intern. We believe this is justified because it is no longer expected, nor responsible, for a new surgical intern to complete this procedure without supervision of key steps. However, the essential items corresponded to steps that could be expected of this level, namely prepping the patient and procedure, and follow-up of the patient after the completion of the procedure. In this way, those skills are transferrable to any sterile technique and patient care scenario, increasing the applicability of this module. It also provides familiarity with the steps of the procedure to establish a graduated educational model to be developed with time. This then establishes mastery of a basic skill while ensuring safety and knowledge of other key steps that may be performed in an emergent environment outside the control and safety of the simulation laboratory.

Overall, a skills-level–appropriate mastery learning curriculum for chest tube placement was successfully applied to a surgical intern preparatory course for graduating medical students. During both years, learners demonstrated improved performance as scored by the skills-level–appropriate checklist for their expected level of performance, and there was decreased anxiety on the after-anxiety scale for the posttest. Confidence did not improve in the first year, but did in the second year, likely attributable to application of the mastery learning method and improvements made to the curriculum. We observed no significant increase in state anxiety either year, suggesting the method of mastery learning did not add additional stress for learners. The reminder of discussion considers the findings with regard to mastery, anxiety, and confidence in more detail.

Mastery

No learners in either year were able to fulfill the mastery criteria on the pretest. This was not unexpected because students do not have specific instruction on chest tube placement during their medical school curriculum. Therefore, any preexisting knowledge would have been acquired during a surgical rotation or by self-study. Students in both years demonstrated an increase in mastery on the first attempt of the posttest (40% vs 92%). The increased success on the posttest in the second year may have been attributable to individual learner characteristics, a change in delivery of the didactic instruction, which included enhanced skill demonstration of the checklist criteria consistent with mastery learning, or the availability of the online video for learner self-study. The effect of these changes is unclear, but this type of delivery improvement is typical of educational process improvement.

As is congruent with the method of mastery learning, in year two all learners who did not obtain mastery on the posttest were given additional instruction (remediation) and were readministered the skills test. Thereby, all participants obtained the skills-appropriate–mastery level. During year one, remediation and retesting was not done. In an attempt to demonstrate retention, each student was asked to demonstrate the steps of chest tube placement during the final lab activity of the S-IPC. This was completed on a live, anesthetized porcine model that more closely simulates a live patient encounter. High levels of success were observed (year one 80% and year two 92%) demonstrating a self-motivated learner population even after their confidence was diminished after the posttest in year one. Because a live model was being used, retesting as required by a mastery curriculum was not possible, but students were given feedback and verbally reiterated each step to reinforce the skills-level–appropriate mastery standard.

We believe that the application of the skills-level–appropriate mastery curriculum to a complex and invasive surgical skill was possible during a 2-week S-IPC for graduating medical students. Even though we were unable to assess a longer-term retention, this group of highly motivated learners retained important skills within the 2-week course curriculum.

Anxiety

The authors have been interested in the stress of learners in a simulation environment and have reported it elsewhere.[21] These same methods were applied to the chest tube mastery curriculum method used in this study. The mastery method requires multiple tests and demonstration of skills, which are perceived by learners as "high-stakes" situations, and we were concerned that this could place an undo amount of stress on the learners. To assess anxiety, we chose a validated self-assessment tool to facilitate ease of use and reproducibility during multiple testing sessions within the S-IPC course. In this study, the state-trait anxiety scale was used to assess learner anxiety.

We observed a decrease in after-skill anxiety between the chest tube pretest and the posttest. There was less of a decrease in after-skill anxiety between the posttest and the retention test. This may represent the level of anxiety experienced by the learners inherent in doing the procedure and/or in combination with a testing environment. We are unable, based on this study, to parse out that difference, although it can be expected that both the procedure and the testing environment each contribute to anxiety on behalf of the learner. Because this is an invasive procedure, it may be assumed that even the most experienced surgeon may experience some level of anxiousness when performing such a procedure.

Confidence

The Cato Confidence Scale was administered to learners after each testing intervention. Year one demonstrated a decrease in learner confidence across the module, although not statistically significant, but year two demonstrated overall significantly increased confidence with completion of the mastery module. Although this decrease in year one was unexpected, it may reflect the stresses of traditional education that do not allow for supervised remediation and demonstration of skill attainment with additional practice. Year two did not demonstrate this trend and showed an increase in the confidence of the learners. In year two, students were provided additional didactic information and what the expected steps for successful mastery were, allowing for better buy-in on the part of the learner.

This study has a number of limitations, including being completed at a single institution with a small number of learners per year, a short interval retention evaluation, and self-reported anxiety and confidence. Randomization was not possible because of the small sample size. However, the benefits of the mastery curriculum have been established in other domains,[7,8] and application to a surgical skill is important, because this is already a highly motivated group of learners that selected a surgical

residency with a demand of high skill. We were unable to collect data on physiologic measures of anxiety, such as heart rate or amylase. Future studies could collect these measures to determine whether they correlate with the self-reported anxiety measures, which allow for less invasive collection of anxiety data. Finally, anxiety could have been influenced by other factors in addition to the remediation and mastery practice. For example, we did not formally measure the mindset from which the students approached the learning of this skill, but based on anecdotal comments, we believe that students used this as an opportunity to understand the status of their performance and to develop proficiency in components of a skill that they would be expected to perform in a couple of months. Reflection on their levels of performance may have contributed to the anxiety experienced by some of the students.

The method of mastery learning supports patient safety, especially in an era when simulation can substitute for the often-hectic clinical situation. Education of skills and clinical implementation can be smoother and more effective for both patient and learner. Literature has shown that simulation-based mastery learning compared with the traditional model not only leads to more confident and competent surgeons but also leads to better patient outcomes. We plan to continue to employ the methodology of mastery learning in future surgical intern preparatory courses.

In conclusion, a chest tube placement module successfully establishes uniform basic skills of patient preparation and follow-up while ensuring familiarity of the complex, invasive steps that will be encountered in clinical environments. Skill-level–appropriate mastery should be considered as part of a growing and developing trend of competency assessments along the continuum of surgical training. We encourage further implementation of skill-level–appropriate mastery learning in proficiency-based medical education.

Acknowledgement

The authors thank the University of Wisconsin School of Medicine and Public Health Shapiro Summer Research Program and the Department of Surgery for their support of this project.

Disclosure

There are no pertinent financial conflicts to report on the behalf of any authors. No outside funding was used in the completion of this study.

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