Ten Tips for Maximizing the Effectiveness of Emergency Medicine Procedure Laboratories

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Incorporating simulation-based medical education techniques is paramount to ongoing training of emergency physicians. Effective procedure laboratories give learners hands-on experience in life-saving procedures they may otherwise not have clinical exposure to and also prevent skill decay. Using procedural education, adult learning theory, deliberate practice, and mastery learning strategies, the authors offer 10 tips to educators for designing an effective emergency medicine procedure laboratory.

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Given the exponential growth of medical knowledge and the expanding skill set required to become a practicing physician, medical educators are faced with the challenge of trying to bring the novice physician to a mastery level. Medical educators must balance between ensuring patient safety and satisfaction while cultivating competent learners who can meet the needs of patients. Patients want skilled and experienced physicians to perform high-risk procedures. Instead of “learning by doing,” novice physicians must gain hands-on experience through alternative avenues, such as simulation.

Simulation as a teaching method has become a mainstream approach to training and evaluating procedural competency in emergency medicine (EM). Emergency physicians are expected to maintain competence in lifesaving procedures regardless of clinical exposure. Procedure laboratories provide physicians with an opportunity to learn and practice new skills. Using simulation-based medical education (SBME) techniques in procedure laboratories has moved medicine from a “see one, do one, teach one” method to a “see one, practice many, do one” approach.

This article offers 10 tips on designing an EM procedure laboratory in an effective and efficient way that meets the learner’s needs. A literature search was performed using PubMed, Medline, and Google Scholar for procedural education, adult learning theory, and deliberate practice, as well as elements of SBME.
Tips to Designing an EM Procedure Laboratory

Tip 1: Employ instructors with formal training in adult learning concepts.

The importance of expert instructors will increase as simulation and procedural-based training methods grow to become a fundamental teaching modality in EM. McGaghie et al describe instructor training as 1 of the 12 features and best practices of SBME. Training instructors to be competent at SBME requires time and investment and is essential to the success of procedure laboratories. Andragogic content knowledge can be challenging to learn and is not innate. Instructors should be trained in SBME and adult learning theory; they should not solely rely on clinical experience and knowledge. Adept instructors are able to integrate curriculum, use evaluation checklists, and give effective performance feedback. Experienced instructors can adapt their instructional methods to match the learners’ level of training and learning style to help them meet their educational objectives. Instructors do not need to be from the same specialty. Multispecialty instructors and ancillary staff can offer unique insights to procedures and error management and therefore provide a more comprehensive learning environment.

Tip 2: Develop learning objectives that are well defined, specific, and measurable.

Procedure laboratories must have a curricular framework to be effective. The first step is to formulate appropriate objectives, which should be simple concepts that clearly define a target learner, a desired outcome, and a time frame required to successfully perform the procedure. A good objective communicates the expectation and leaves little room for interpretation. Objectives can be cognitive, affective, or psychomotor and should be presented in a logical order. Comprehensive objectives incorporate basic science principles that underlie a clinical procedure, team-building skills, and the concepts of crisis resource management. Measureable objectives allow for impartial evaluation of performance and identify specific areas needing improvement.

Tip 3: Provide learners with training materials before they arrive at procedure laboratories.

Cognitive and psychomotor learning objectives should be separated in the classroom because learners frequently prioritize psychomotor skills without understanding the logic behind the sequence of steps involved in the procedure. Giving learners early access to the training materials provides them time to adequately review the materials and understand the procedure before performing the skills in the laboratory. Learners should be able to list the sequence of steps before attempting the procedure in the laboratory. This knowledge ensures that all learners start the laboratory with the same foundation, allowing for less time spent on basic concepts and more time spent on psychomotor skills and deliberate practice. Given the time constraints in medical education, providing this foundational knowledge in advance allows for more effective use of time in the procedure laboratory with instructors.

Tip 4: Use checklists to identify performance gaps in the execution of a procedure.

Checklists can provide technical metrics for evaluation. The technical checklist includes a sequence of comprehensive steps for each procedure and can be used for teaching, evaluation, and feedback. Performance gaps can be identified, feedback can be focused, and a plan of action can be developed with checklists.

Although no guidelines for creating checklists have been established to our knowledge, Schmutz et al describe a comprehensive integrative approach that uses
### Tip 5: Use deliberate practice-training strategies.

Deliberate practice requires several criteria to be effective (*Figure 1*). Deliberative training involves repetition of a skill at increasing levels of complexity with immediate coaching and feedback. As training progresses through more advanced levels, the learner must build on previously developed skills and training to obtain a heightened level of expertise. Deliberate practice has been described in a Best Evidence Medical Education systematic review as a superior model to obtain expertise and clinical competence, and other studies found that SBME with deliberate practice is one of the most powerful approaches in the training of medical personnel compared with traditional clinical education.

Effective feedback is a key component of a successful deliberate practice environment and is considered the most important aspect of effective learning. However, a meta-analysis by van de Ridder et al found little consensus on how feedback was defined. They proposed feedback to be “specific information about the comparison between a trainee’s observed performance and a standard, given with the intent to improve the trainee’s performance.” As previously discussed, predetermined learning objectives and checklists provide a clear metric to help both instructors and learners analyze their performance against the desired standard. The content of the feedback given needs to include a plan of how to improve to meet the standard. This model follows the theory of experiential learning in which learners reflect, absorb concepts, and translate them into implications for future actions. Instructors should debrief promptly in a supportive and comfortable environment so learners are more likely to remember the details of the event. Providing this type of objective feedback substantially improves resident performance and skill acquisition.

### Tip 6: Use mastery learning strategies.

Mastery learning strategies involve demonstrating proficiency of a skill before progressing to a more challenging skill level. This model has been shown in multiple studies across multiple disciplines to advance an individual’s potential for learning. Instead of fixed learning times with varied performance on set objectives, mastery learning allows for varied learning time until all trainees meet or exceed the set objectives. Providing learners sufficient time and attention for each skill set allows them to achieve better performance.

Barsuk et al found that residents with poor baseline procedural skills were able to increase their skills substantially with mastery learning strategies. In a meta-analysis of SBME with and without mastery learning strategies, Cook et al demonstrated consistently better learning outcomes and statistical significance for process skills outcomes with mastery learning strategies. When mastering learning strategies, a minimum passing score needs to be established for procedure advancement. Checklists should be used to set rigorous standards to measure a resident’s mastery of objectives. Once learners master the cognitive and associated manual components of a procedure, they will be ready to perform more complex or advanced procedures.

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**Highly motivated learners with good concentration**

**Engagement with a well-defined learning objective or task**

**Appropriate level of difficulty**

**Focused, repetitive practice**

**Rigorous, precise measurements**

**Informative feedback from educational sources (eg, simulators, teachers)**

**Monitoring, correction of errors, and more deliberate practice**

**Evaluation to reach a mastery standard**

**Advancement to another task or unit**

**Figure 1.** Elements to achieve effective deliberate practice.
Tip 7: Practice infrequently performed procedures.

Clinical exposure to high-risk, low-frequency procedures are random and unpredictable. The time constraints on medical education placed by the Accreditation Council for Graduate Medical Education create a need for nontraditional methods of instruction. Procedure laboratories allow learners to practice infrequently used procedural skills, and SBME can recreate these rare scenarios that ideally would not be managed by novice physicians. Although emergency physicians are expected to be able to perform invasive lifesaving procedures, one study found that less than one-fourth of graduating EM residents had performed a cricothyrotomy on a live patient during training. Transvenous pacemaker placement, Minnesota tube placement, peri-cardiocentesis, and thoracotomy are other examples of rare procedures that emergency physicians must be prepared to perform at a moment’s notice. Supplementing patient experience with procedure laboratories provides learners the ability to develop expertise and maintain proficiency in uncommon procedures.

Tip 8: Train learners to develop backup strategies, error management, and stress inoculation.

Errors trigger stress and emotional responses from trainees and can be a strong stimulus for learning. Bless and Schwarz found that negative emotions can trigger organized and careful processing of information, and positive moods are linked to careless processing of information. Most learners can recall what they did incorrectly because the situation in which the error occurred provides an “activated” environment. Error management training and stress inoculation training capitalize on that stress response, allowing learners to develop contingency plans, backup strategies, and stress regulation. Many curricula do not consider this information during emergency physician training.

King et al posit that patient safety can be improved by allowing errors to occur in low-risk settings (ie, simulation laboratory). Stress induced by a complex medical situation or medical error can lead to cognitive errors and poor decision-making. Once learners have their stress response under better control, they are able to make improved strategic decisions in difficult circumstances. One way to improve performance in high-risk situations is stress inoculation training, which uses a 3-phase approach to decrease the effect of stress on performance (Figure 2). Simulating stressful scenarios in which learners must manage a major error or crisis that occurred before their arrival tests their decision-making skills and ability to perform subsequent emergent procedures. For example, EM learners should develop the ability to manage a case in which a recently attempted central venous catheter resulted in a tension pneumothorax in a patient with septic shock. Learners must prioritize the needle decompression, central venous catheter placement on the same side of the suspected pneumothorax, and ultimately tube thoracostomy in a controlled fashion.

Error management training is a method that encourages learners to make errors in a simulated environment to gain a greater understanding of the manifestations of mismanagement. The exposure to errors can help identify deficits in knowledge, allowing for the development of countermeasures to flawed decision making. This method allows learners to develop better emotional control in crisis situations. Using stress inoculation training and error management training to improve communication may prevent future errors.

Tip 9: Schedule procedure laboratories regularly to prevent skill decay.

Skill decay is defined as a “loss or decline in the quality of acquired knowledge or skills over time due to non-practice or nonuse.” Residents and tenured physicians alike must continually practice skills to keep their skill level sharp. In procedure laboratories, learners are able to use deliberate practice and mastery learning strategies to maintain skills. Wayne et al found that by using deliberate practice strategies, advanced cardiac life support skills did not decay even after 14 months without intervention.
Furthermore, by focusing on repetition of procedures, including practicing low-frequency and high-risk procedures until mastery, acquiring skills through progressively more challenging skill levels, developing backup strategies, and demonstrating ability to teach other trainees, learners have the opportunity to become experts in lifesaving EM procedures.

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All authors provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; all authors drafted the article or revised it critically for important intellectual content; all authors gave final approval of the version of the article to be published; and all authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

**Tip 10: Require learners to teach the procedure under faculty supervision to confirm mastery.**

Procedural mastery can be demonstrated by requiring the learner to teach the procedure to more novice learners under the supervision of a faculty member. Residents can spend approximately 25% of their time in the supervision and training of other residents and students. Teaching necessitates an in-depth understanding of the procedure and leads to greater knowledge attainment. Senior residents should therefore be required to teach other residents during procedure laboratories so that faculty supervisors can identify whether mastery has been achieved and provide guidance on best practices for teaching learners.

**Conclusion**
The tips described in this article provide EM educators a framework to develop and execute effective procedure laboratories. Learners benefit from adult learning theory and mastery learning strategies. Thus, instructors should be trained in SBME and adult learning theory. They should develop specific and measurable objectives, incorporate checklists to identify performance gaps, and integrate error management training and stress inoculation training. Procedure laboratories provide opportunities to improve communication skills in stressful environments, which is necessary for the leadership development of emergency physicians.

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Figure 2. Phases of stress inoculation training.

**Conceptualization**
Establish relationship between trainer and learner to learn about nature and impact of stress.

**Skills Acquisition and Rehearsal**
Acquire and practice coping skills.

**Application and Follow Through**
Apply coping skills across increasingly difficult stressors, and continue education through training sessions.


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