Developing Technical Expertise in Emergency Medicine—The Role of Simulation in Procedural Skill Acquisition

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Abstract

Developing technical expertise in medical procedures is an integral component of emergency medicine (EM) practice and training. This article is the work of an expert panel composed of members from the Society for Academic Emergency Medicine (SAEM) Interest Group, the SAEM Technology in Medical Education Committee, and opinions derived from the May 2008 *Academic Emergency Medicine* Consensus Conference, ''The Science of Simulation in Healthcare.'' The writing group reviewed the simulation literature on procedures germane to EM training, virtual reality training, and instructional learning theory as it pertains to skill acquisition and procedural skills decay. The authors discuss the role of simulation in teaching technical expertise, identify training conditions that lead to effective learning, and provide recommendations for future foci of research.

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Developing technical expertise in medical procedures is extremely important for practicing emergency physicians (EPs). The ability to perform these procedures reliably and skillfully, with little or no warning in stressful situations on potentially unstable and unoptimized patients, is a challenge that EPs face on a daily basis.

Unlike other specialists who often require a narrow focus of expertise, the EP is required to perform a wide array of procedures covering a broad spectrum of expertise in many disciplines. These include emergent resuscitation and airway management, minor surgical skills, orthopedic manipulation, and team management. Additionally, the opportunity to perform certain critical life-saving maneuvers in emergency medicine (EM) is often rare and dependent on random chance for exposure. Residency work hour restrictions may further limit opportunities for clinical exposure. As such, the scope and complexity of practice are unique for EPs and may require specific procedural training.

The purpose of this paper is to review frameworks for skill acquisition and to examine the existing instructional methodology for teaching technical expertise in EM procedures. The current state of EM procedural instruction and recommendations for further advancement will be discussed.

CONSENSUS CONFERENCE SESSION

This article represents consensus recommendations derived from input from participants at the 2008 *Academic Emergency Medicine* Consensus Conference

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(Washington, DC, May 28, 2008) and research conducted by the members of the writing group. National EM educators with experience in simulation and stakeholders from national organizations (list of participants available in Appendix A) participated in a consensus session. Questions related to simulation-based training were discussed and the recommendations are summarized below.

I. CURRENT LITERATURE ON SIMULATION-BASED PROCEDURAL TRAINING IN THOSE PROCEDURES RELEVANT TO EM

The Core Content of Emergency Medicine provides an extensive list of the procedures and skills integral to the practice of EM[1] (Table 1). The Accreditation Council for Graduate Medical Education (ACGME) has also delineated procedures that the Residency Review Committee for Emergency Medicine (RRC-EM) designates as critical for the EM trainee to have performed (Table 2). The ACGME guidelines provide the recommended number of times each procedure should be performed by the EM resident in ''both patient care and laboratory simulations.''[2] The ACGME guidelines were used to identify the procedures for review, which were classified into low or high frequency and low or high acuity (Table 3).

Airway Procedures

Simulation has the potential to aid the learner in all facets of airway management including dexterity and experience, using an adjunct/rescue device, choosing appropriate induction agents, deciding whether to use paralytics, and immediately recognizing errors and correcting them.

What Equipment Is Optimal for Which Procedure?

There are numerous mannequins with varying degrees of fidelity that may be used for teaching intubation skills, none of which is clearly superior.[3–5] Fiber-optic intubations can be taught on simulators, and clinicians trained on simulators do equally well on fresh cadavers and live patients.[6–8] Other airway adjuncts have also been taught via simulation modalities.[3,9–14]

Table 1
2007 Model of the Clinical Practice of Emergency Medicine

Airway Techniques
Airway adjuncts
Cricothyrotomy
Foreign body removal
Intubation
Mechanical ventilation
Percutaneous transtracheal ventilation
Capnometry
Non-invasive ventilatory management
Anesthesia
Local
Regional nerve block
Sedation - analgesia for procedures
Blood, Fluid, and Component Therapy Administration
Diagnostic Procedures
Anoscopy
Arthrocentesis
Bedside ultrasonography
Cystourethrogram
Lumbar puncture
Nasogastric tube
Paracentesis
Pericardiocentesis
Peritoneal lavage
Slit lamp examination
Thoracentesis
Tonometry
Compartment pressure measurement
Genital/Urinary
Bladder catheterization
1. Foley catheter
2. Suprapubic
Testicular detorsion
Head and Neck
Control of epistaxis
Laryngoscopy
Drainage of peritonsillar abscess
Removal of rust ring
Tooth ***stabilization***
Lateral canthotomy
Hemodynamic Techniques
Arterial catheter insertion
Central venous access
Intraosseous infusion
Peripheral venous cutdown
Obstetrics
Delivery of newborn
Other Techniques
Excision of thrombosed hemorrhoids
Foreign body removal
Gastric lavage
Gastrostomy tube replacement
Incision/Drainage
Pain management (See Anesthesia)
Violent patient management/restraint
Sexual assault examination
Trephination, nails
Wound closure techniques
Wound management
Procedural ultrasonography
Escharotomy
Resuscitation
Cardiopulmonary resuscitation (CPR)
Neonatal resuscitation
Skeletal Procedures
Fracture/Dislocation immobilization techniques
Fracture/Dislocation reduction techniques
Spine immobilization techniques
Thoracic
Cardiac pacing
1. Cutaneous
2. Transvenous
Defibrillation/Cardioversion
Thoracostomy
Thoracotomy
Universal Precautions
Biohazard Decontamination

Bold italics indicate additions for 2007.

Table 2
EM Guidelines for Procedures and Resuscitations[2]

Adult medical resuscitation	45
Adult trauma resuscitation	35
ED bedside ultrasound	*
Cardiac pacing	06
Central venous access	20
Chest tubes	10
Procedural sedation	15
Cricothyrotomy	03
Dislocation reduction	10
Intubations	35
LP	15
Pediatric medical resuscitation	15
Pediatric trauma resuscitation	10
Pericardiocentesis	03
Vaginal delivery	10

Numbers include both patient care and laboratory simulations.
EM = emergency medicine; LP = lumbar puncture.
*See procedural competency guideline—one of the selected procedures must be ED bedside ultrasound (PR V.B.2.b; Table 1).

Managing the Uncomplicated Airway: "Routine Intubation." Simulation has been used to teach the principles of routine, uncomplicated intubation. Medical students who practice intubation on simulators can be proficient within 75 to 90 minutes of training with a 2:1 teacher to student ratio[15] and show significantly less decay in their skill level over time.[16] Simulation-trained paramedic students performed similarly compared to operating room–trained paramedic students with respect to successful intubation of live patients, first-pass success, and complication rate.[17] These findings support the use of simulation for teaching this skill.

Managing the Complicated Airway: "Difficult Intubation." Fewer patients with challenging airways are being electively intubated due to the availability of laryngeal mask airways. Thus, simulation may be used to enable trainees to practice managing the complicated airway.[18–20]

Experiential Learning and Intubation Skills. Simulation studies demonstrate that students objectively perform better if role-playing is involved[21] and that interrater reliability for reviewing and evaluating resident performance is good.[22] Medical school graduates who had just taken the advanced trauma life saving (ATLS) course reported that the ATLS course did not adequately prepare them for airway management, but that simulated airway training may have reinforced the critical concepts.[23]

How Much Training Is Enough, and How Often Do Practitioners Require Skill Review? It is unclear whether clinical practice alone is sufficient to prevent skill decay. A study of students participating in simulated airway management training[24] demonstrated that their skills decayed quickly without practice and were retained optimally when they practiced the procedures on their own and received periodic feedback.

Preventing Errors in Intubation. Improved patient outcomes should be a major goal of simulation research. Studies should be used to identify medical errors as well as methodology to correct errors.[22,25] For example, simulation may be used to assess paramedics' and physicians' ability to detect appropriate endotracheal cuff pressure when inflating the balloon cuff.[26,27] In a British study using an esophageal intubation scenario, learners subsequently incorporated the techniques into their clinical practice.[28]

What Are the Optimal Research Methods to Study Intubation in Simulation? There are two distinct patterns regarding study methodology for simulated experience with intubation. Several studies[14,16,18,22–24] have used checklists with good interrater reliability to ensure that best-practice techniques were being used. Other studies have assessed outcome measures, such as decreased time to intubation or increased numbers of successful first-pass intubations and whether certain best-practice standards had been met. Future studies of intubation should consider including both checklist-based assessments and clinically relevant outcome measures.

Cricothyrotomy

Emergent cricothyrotomy is uncommonly performed by the EP. The reported cricothyrotomy rate for failed emergent intubations is 0.2%–2.8%.[29–32] Prior to the

Table 3
Breakdown of EM Guidelines for Procedures and Resuscitations By Frequency and Risk

	Higher Frequency	Lower Frequency
Higher risk	• Intubation • Central venous access • LP • Chest tube • Dislocation reduction • Adult medical resuscitation • Adult trauma resuscitation • Procedural sedation	• Cricothyrotomy • Cardiac pacing (transvenous) • Pericardiocentesis • Vaginal delivery • Pediatric medical resuscitation • Pediatric trauma resuscitation
Lower Risk	• ED bedside ultrasound	

ED = emergency department; LP = lumbar puncture.

development of task trainers and high-fidelity mannequins, practicing cricothyrotomy was limited to random chance experience in the ED on actual patients, practice on human cadavers or on the newly dead,[33] or incorporation of mental imagery.[34]

There are several cricothyrotomy techniques, including the surgical approach,[35] Seldinger approach,[36–38] and the rapid four-step approach.[39] Studies as to which is faster or more successful are inconclusive.[36–44]

Wong et al.[45] reported a first attempt success rate of 61% for cricothyrotomy and suggest five as the minimum number of performances required to successfully perform the procedure on a mannequin. However, these results may not be generalizable to other methods (surgical technique, rapid four-step technique, or transtracheal). Moreover, it is not known whether proficiency on a task trainer translates into higher fidelity simulation scenarios. For example, anesthetists took significantly longer to perform a needle cricothyroidotomy procedure in a medium-fidelity simulator scenario compared to performing it on a mannequin alone.[46] The ACGME currently recommends three cricothyrotomy performances for EM resident trainees, but it is unclear whether this is sufficient to ensure proficiency.

Tube Thoracostomy

There are few articles that examine the use of simulation to facilitate the learning of proper chest tube placement. Traditionally, the training of chest tube placement has been accomplished using either animal or cadaver models.[47,48] Using a canine lab to train EM residents and fourth-year medical students, Homan et al.[49] found that repetition increased procedural speed and improved retention of skills. Chapman et al.[50] demonstrated that paper and computer modeling of open thoracotomy did not increase procedural accuracy. More recently, the use of simulation has been incorporated into the training of ATLS protocols,[51,52] and Berkenstadt et al.[53] found that the TraumaMan (Simulab Corp., Seattle, WA) simulator was superior to animal models for identifying anatomic landmarks.

Central Venous Line Placement

Central venous line placement (CVLP) poses many risks to patients, such as the potential for a pneumothorax, local hematoma, etc. Complications from CVLP may also be delayed (such as blood stream and central venous line infections) or unrecognized by the individual performing the procedure; thus, studies should not rely on self-reporting of complications.

Supervised instruction of CVLP in actual patients has been shown to decrease complications[54,55] In a deliberate practice model with supervised instruction of CVLP in actual patients, immediate feedback with videotape analysis was repeated until competence was attained. After institution of the training, there was a significantly decreased incidence of pneumothoraces.[54] However, a method of learning this skill without potential risk to patients is preferred.

While there have been descriptions of simulation-based training for CVLP, data confirming efficacy are limited. Britt et al.[56] studied simulation-based training for subclavian and internal jugular venous line placement using the CentralLineMan partial task simulator (Simulab Corp.) and found that despite this training, only 4 of 11 residents were successful in their initial line on an actual patient without assistance. In contrast, Velmahos et al.[57] studied the effect of a 3-hour training session using partial task simulators for CVLP and found that the study group scored significantly higher in the repeat test, achieved a higher score on the checklist, required fewer attempts to find the vein, and showed a trend toward less time to complete the procedure. Low-fidelity models have also been used to teach central venous access,[58,59] but further evaluation is needed to determine if they are effective.

Cardiac Pacing

The steps involved in transvenous pacemaker insertion require both cognitive and technical skill. The American College of Physicians, the American College of Cardiology, and the American Heart Association released a joint statement outlining the minimum standard for performing temporary transvenous pacing.[60] To demonstrate competence, a minimum of 10 supervised transvenous pacemaker procedures was recommended, with requisite knowledge of hemodynamic monitoring with balloon flotation devices. For credentialing, the performance of a minimum of 25 procedures was recommended. In contrast, the ACGME EM guidelines suggest that trainees perform cardiac pacing six times in residency with no distinction provided between transcutaneous and transvenous approaches.[2] In response to a survey assessing the training and practice of temporary transvenous pacemaker insertion, most house officers reported that they had respectively observed and performed two temporary pacing procedures under supervision before being left unsupervised, and 50% were unhappy with their training in the procedure.[61]

Pericardiocentesis

Several mannequin-based simulators on the market today are equipped with the capacity to perform pericardiocentesis. However, although there are simulation studies assessing improved subjective levels of confidence in learners, there is no study evaluating simulation as a teaching tool to enhance competence.[62,63]

Lumbar Puncture

Lumbar puncture (LP) is a frequently performed procedure in the ED. In one study, however, incoming interns had performed an average of 2.2 LPs during medical school, with 17% having never performed the procedure.[64] One-third of internal medicine residents reported being uncomfortable performing a LP unsupervised.[65] When asked, most patients report discomfort with the idea of students performing their first LP on them,[66,67] and more than half of patients never wanted a student performing an LP on them.[67]

The traditional model of learning and practicing procedures on actual patients is not ideal, especially when simulated procedural task trainers are available.[64,68–71] Patients report being more accepting of students performing an LP on them after simulator training.[72]

Vaginal Delivery

Simulation training in obstetrics and gynecology (OB/GYN) is described by Jude et al.[73] with respect to third-year medical students' comfort with delivery on the Noelle obstetrics simulator (Gaumard Scientific, Coral Gables, FL). The authors reported that medical students who received simulation training were more comfortable with defining the stages of labor, as well as with attempting delivery with an attending or resident and performing a full delivery independently.

Other simulation-based articles in the OB/GYN literature have demonstrated improved knowledge base in the management of shoulder dystocia[74–76] and breech delivery,[76,77] eclamptic seizure,[76] and postpartum hemorrhage.[76] Teamwork,[78] surgical laparoscopic techniques,[79] and multidisciplinary simulation scenarios involving anesthesiologists and obstetricians have also been described.[80]

Ultrasound

Emergent ultrasound proficiency is becoming a necessary skill.[81–84] The Society for Academic Emergency Medicine (SAEM) recommends that an ultrasound training curriculum consist of 40 hours of didactic instruction and 150 ultrasound examinations.[85] Simulators may be used to assess resident performance on image recognition skills and to perform ultrasound-guided procedures such as central venous catheter placement[54,86,87] and peripheral nerve blocks.[88,89]

Recommendations

Ia. Simulation-based training should prioritize procedures infrequently encountered in clinical practice and commonly performed procedures that possess a potential risk to a patient when performed by the less skilled practitioner.

Ib. There is marked variability in degree of validation of simulation-based training depending on the specific procedure. Significant research opportunities to study the impact of simulation-based teaching will likely be procedure specific.

Focus for Future Research

1. Airway

Simulation has considerable traction in testing airway devices as well as teaching procedural competence. Mannequin training appears to enhance dexterity and help prevent technical and cognitive errors. Future research should focus on establishing timelines for periodic education and the role of simulation-based experiential learning to enhance existing curricula, to prevent knowledge decay, and to reinforce safe practices. Study methods should use uniform best practices to ensure consistency between studies to allow comparisons.

2. Cricothyrotomy, tube thoracostomy, cardiac pacing, and pericardiocentesis

The correlation of successful simulation performance and success in the clinical setting via these training methods has not yet been definitively shown. Future research should focus on the development and evaluation of: 1) hybrid models to enhance realism and 2) in situ simulation as a proxy for clinical performance.

3. CVLP

Future studies should employ explicit instructional training methods in the psychomotor domains and evaluate the effects of incorporating the elements of the best evidence medical education (BEME) review and deliberate practice.

4. LP

While there is face validity that LP simulation training should improve performance and increase patient safety, confirmatory data are lacking. Future studies should compare simulated LP training and traditional training methods. Currently available LP task trainers should be studied for validity.

5. Ultrasound

Simulation-based ultrasound training needs to be validated as a method of enhancing operator performance in the clinical setting, and the necessary amount of training required for proficiency needs to be defined.

6. Vaginal delivery

Current simulation literature focuses on difficult deliveries and complications of deliveries. Limited research exists with respect to teaching routine vaginal delivery. EM research should focus on vaginal delivery instruction using birthing simulators. The consensus group recommended precipitous and difficult vaginal deliveries as high-priority areas of training.

7. Other questions

- What is an acceptable minimum competence training program for each procedure?
- How many repetitions are truly necessary to attain competence?
- How much fidelity is enough?

Recommendations

Ic. The group recommended further study regarding the use of optimal simulation modalities for specific procedures.

Focus for Future Research

1. Which procedures are best suited for task trainers?

Procedural task trainers may be best suited for a single specific procedure. Since lower-fidelity modalities allow focus on skill acquisition, this may be most appropriate for early learners until they are ready to progress through more complex scenarios where the procedure is part of the overall patient management.

2. What is the ideal use of high-fidelity simulation in procedural training?

As higher fidelity simulation offers cognitive stimuli that enhance perceived realism, it may be best suited for complex tasks, such as resuscitation, or for ''whole procedure'' practice, since the procedure becomes a component of the overall management of the patient. One of the most powerful factors in increasing cognitive fidelity is the incorporation of a patient's ''voice.'' Is it possible to develop a sufficiently ''high'' fidelity environment by combining several ''lower'' fidelity products (i.e. task trainers)?

Further study using a modified Delphi process to evaluate what procedures may be better suited for high-fidelity versus low-fidelity simulation was recommended by the group.

II. THE ROLE OF VIRTUAL REALITY IN EMERGENT PROCEDURAL TRAINING

While few procedures commonly performed in EM have been developed into virtual reality systems, there are examples within the surgical specialties where virtual reality is becoming standard practice. EPs can learn from these successful virtual reality models when designing and testing models for procedures.

General surgery,[90–93] OB/GYN,[94] urology,[95] neurosurgery,[96] vascular surgery,[97,98] orthopedic surgery,[99] otolaryngology,[100] and gastroenterology[101,102] have demonstrated the potential usefulness of virtual reality training. The models that have shown the most promise for improving procedural competency are those that use screen-based video technology as integral parts of the actual procedure, such as endoscopic surgical techniques. Since these procedures are based on video screen output, this is optimal for technology that allows graphical representation of what the operator sees in response to procedural manipulation.

Recommendations

II. Virtual reality simulation has been most successful for procedures that are already screen-based.

Focus for Future Research

1. Which procedures in EM are most amenable to education and practice using virtual reality technology?

Potential EM procedures that may translate well into computer screen–based virtual reality environments include fiber-optic laryngoscopy, fiber-optic–assisted intubation, and bedside ultrasonography.

2. Can competency training in virtual reality environments translate into clinically meaningful improvements in patient care outcomes?

A challenge in simulation education and research is demonstrating that improved performance in simulated environments leads to improved patient care. When designing studies to test educational effectiveness of virtual reality simulators, evaluation of patient-centered outcomes should be considered.

III. INSTRUCTIONAL THEORY AND SKILL ACQUISITION

Medical procedures involve a complex combination of cognitive decision-making and technical skills that require sufficient time to practice, learn, and master. With increasing concerns about patient safety and resident work hour restrictions, the need for instructional models for mastering procedural skills beyond the traditional Halstedian apprenticeship model (“see one, do one, teach one”) is evident.

Many frameworks for adult learning have been described.[103–106] For adults to be willing to learn, they need to know why a particular subject or skill is relevant. Additionally, lessons need to be applicable to the learners’ work or responsibilities, as well as to their accumulated life experiences and knowledge.[107–109] Learning is “a set of processes associated with practice or experience leading to relatively permanent changes in behavior, or the capability for movement.”[110] Three domains form a hierarchy of learning: affective, psychomotor, and cognitive.[111] The psychomotor domain may be further divided into five subcategories: imitation, manipulation, precision, articulation, and naturalization.[112,113] Based on these educational/instructional theories,[114–118] multiple authors have since described motor learning[113,119,120] and methods of teaching medical procedural skills.

Acquisition of expert performance and maintenance of skills requires deliberate practice.[113] Simulation is an opportunity for structured, deliberate practice of a skill that provides ample practice time and quality feedback.[113] Simulation-based practice, if conducted following the principles of deliberate practice, approximates a dose–response relationship.[121] Detailed, immediate formative feedback that is derived directly from the trainee’s performance, combined with opportunities to improve performance, are crucial to the learning process.[122–125]

Many studies have also examined the effects of practice on learning. Massed practice, where all practice time is completed with little or no rest between practice sessions, is time-effective, but can also lead to fatigue and decreased performance and learning. Distributed practice requires spacing of practice sessions over time with longer intervening rest periods. This allows for cognitive preparation and mental rehearsal of tasks between sessions to more deeply encode the behavior and consolidate learning,[126] which results in better performance, as well as increased retention and transferability of skills. Part practice, in contrast to whole practice, breaks down a task into multiple smaller parts and is advocated as a method of learning portions of larger tasks.[127]

The BEME systematic review describes the right conditions necessary for effective simulation instruction (Table 4). The three most important elements are: 1) provision of feedback during the learning experience,

Table 4
BEME Systematic Review—Important Features and Aspects of Simulators That Will Lead to Effective Learning[125]

1. Provide feedback during the learning experience with the simulator.
2. Learners should repetitively practice skills on the simulator.
3. Integrate simulators into the overall curriculum.
4. Learners should practice with increasing levels of difficulty.
5. Adapt the simulator to complement multiple learning strategies.
6. Ensure the simulator provides for clinical variation.
7. Learning on the simulator should occur in a controlled environment.
8. Provide individualized (in addition to team) learning on the simulator.
9. Clearly define outcomes and benchmarks for the learner to achieve using the simulator.
10. Ensure the simulator is a valid learning tool.
BEME = best evidence medical education.

2) repetitive practice, and 3) incorporation of simulation into the overall curriculum.[125] Procedural skill decay refers to the loss of some or all of the skills necessary to perform a procedure after a period of nonuse. Different terms have been used to describe this process including: knowledge decay/retention, skill decay/ retention, and skill durability.[128] This concept is important especially in EM, because EPs are expected to maintain competency in a wide variety of procedures, even those rarely performed.

Cardiopulmonary resuscitation knowledge and skills can decay as early as 2 weeks or as late as 14 months after training.[129–131] Skill retention for shoulder dystocia was retained at 6 and 12 months after initial training.[75] Anesthesiologists' training for unanticipated difficult airways was preserved for 6 to 8 weeks; however, repetition was required every 6 months.[132]

Factors influencing skill decay and retention that are germane to EM include[133] retention interval, degree of overlearning,[134,135] speed versus accuracy, conditions of retrieval, instructional strategies and training methods,[136] and individual differences.

Recommendations

IIIa. Instructional theory should be incorporated or emphasized to maximize skill acquisition.

- Instruct the learner to improve a certain aspect of a task, since skill acquisition for procedural tasks may be best learned in parts.
- Whole practice should be mastered to prepare the trainee for actual practice situations.
- Provide immediate feedback on performance.
- Provide the learner with sufficient opportunities for repetitive practice.
- Emphasize proper technique and accuracy, rather than achieving procedural speed.

Focus for Future Research

1. How much training is enough? Future study is required to:

- Determine best practices for attaining competency, proficiency, mastery, and avoidance of skill decay.
- Develop instructional curricula and mastery guidelines for each procedure.
- Determine the amount of training required of all practitioners to sustain mastery for specific procedures.
- Determine who sets the standard for instruction and what constitutes a qualified expert. Procedure log and tracking clinical outcomes may be a potential method of determining both qualification of expertise in educators and for evaluating trainees.

2. What is the ideal balance of part vs. whole practice?

3. What is the ideal balance of block practice vs. distributive practice?

4. What instructional methods will best limit skill decay for specific procedures?

5. How often must procedures be practiced, once mastered, to limit skill decay? What is the retention interval for different procedures?

6. Does the complexity of the procedure influence the rapidity of skill decay?

7. Is overlearning necessary?

8. Does proficiency on a task trainer translate to proficiency in the clinical setting?

9. Is mastery necessarily achievable in a 3- to 4-year training program, or is a minimum acceptable level of performance more realistic?

CONCLUSIONS

Evaluative work should be conducted to determine which learning tools will maximize skill acquisition and retention. This will likely be procedure specific. Multidisciplinary collaboration is encouraged, because shared approaches may yield innovative methods for procedural training.

Simulation-based EM procedural training research should focus on incorporating instructional methods (deliberate practice, curriculum integration, repetitive practice, distributive, and part practice) to promote acquisition of motor control and achieve mastery. Providing immediate feedback and supervision commensurate with ability are critical interventions for developing technical expertise. Applying sound educational principles will be vital to the success of our simulation-based instructional endeavors.

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APPENDIX A

2008 *Academic Emergency Medicine* Consensus Conference—Technical Expertise: Procedural and Surgical Skills Consensus Group Attendees (in alphabetical order):

Halleh Akbarnia, MD, Douglas Ander, MD, Brian Bausano, MD, Lars Bjoernsen, MD, Kanwal Chaudhry, MD, Lamont Clay, MD, Joseph E. Clinton, MD, Rita Cydulka, MD, Moira Davenport, MD, Richard DiPeppe, Suzanne Dooley-Hash, MD, Todd Ellingson, MD, Leigh Evans, MD, Michael Fitch, MD, PhD, Patrice Gabler Blair, MPH, A Joseph Garcia, MD, James Gordon, MD, MPA, Jennifer Gordon, MD, Rahim Govahl, MD, Sharon Griswold-Theodoroson, MD, Jeff Graff, MD, Ronald Hall, MD, Cara Hamann, MPH, Phillip M. Harter, MD, Morris Kharasch, MD, Nalinas Khunkhlai, MD, Fred Korley, MD, Torrey Laack, MD, Richard Lammers, MD, Laeber Lestor, MD, Brian Levine, MD, David P. Lisbon, MD, William C. McGaghie, PhD, Steve McLaughlin, MD, Ernest Muy, MD, Aneesh T. Nanang, MD, Jessie Nelson, MD, Jeanne Noble, MD, Thomas Nowicki, MD, Kenneth Palm, MD, Brad Peckler, MD, J. Nelson Perret, MD, Kelly Phelps, MD, Josh Quinones, MD, Michael S. Radeos, MD, MPH, Larry Raney, MD, Michael Repplinger, MD, Skip Robey, MD, Adam Robinett, MD, Elliot Rodriguez, MD, Ajit Sachdeva, MD, David Salzman, MD, Chris Sampson, MD, Melissa Schloneger, MD, Sara Scott, MD, Michelle Sergel, MD, John Shatzer, PhD, Michael D. Smith, MD, Paul R. Sterzenski, MD, William B. Sweeney, MD, John Vozenilek, MD, Ernest Wang, MD, Eric Wilkerson, and Ernest Yeh, MD.