Abstract:
Procedural skills are integral to the practice of pediatric emergency medicine, but provider experience is limited by case rarity. Simulation-based medical education allows for the practice of rare procedures without compromising patient safety. Simulation-based procedural training improves provider confidence, knowledge, and performance, and may translate to better patient outcomes. However, optimal instructional designs for simulation-based training remain unclear, and educators have a plethora of didactic approaches and simulator characteristics to consider. This article reviews how simulation can be used for pediatric procedural skills training and maintenance, focusing on instructional design features, simulation modalities, and the use of simulation as an assessment tool in the era of competency-based medical education.
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Keywords:
simulation-based medical education; procedural skills training; assessment tools

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Simulation-Based Procedural Skills Training in Pediatric Emergency Medicine

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Procedural skills are integral to the practice of pediatric emergency medicine (PEM). Procedures such as intubation, cardiopulmonary resuscitation (CPR), central venous catheterization, and thoracostomy can be lifesaving but are rarely performed in children, rendering it challenging for providers to achieve and maintain competence.[1] Trainees may be especially deficient in basic resuscitation and procedural skills.[2,3] Insufficient procedural practice can increase risks of medical error and adverse events.[4]

Simulation-based medical education (SBME), which has been termed an "ethical imperative," allows for the practice of rare procedures without risk of harming patients.[4,5] Simulation-based medical education engages learners in an immersive experience with real-world relevance, while providing direct feedback and allowing time to reflect and generalize upon shared experiences.[6] Simulation-based medical education is an integral element of the

6-step framework by Sawyer et al[7] for teaching procedural skills in medicine: Learn, See, Practice, Prove, Do, and Maintain. The "Practice" and "Prove" stages of this framework use SBME for skill acquisition and demonstration of competency. Once competency is established with simulation, the trainee may, under supervision, perform procedures on patients until he or she can be entrusted to act independently.[7]

Systematic reviews on the use of simulation for pediatric education and procedural skills training have found that SBME improves provider knowledge, performance in simulated settings, behaviors with patients, and time to task completion, and may translate to improvements in patient outcomes.[5,8–11] Multiple specialties and training programs are incorporating simulation-based curricula and assessments. Educators wishing to integrate simulation-based procedural training have a plethora of approaches and tools to consider. Despite robust data on the benefits of SBME, optimal instructional design features for specific learners, learning objectives, and desired outcomes remain largely unknown.[9,12]

This article will describe how simulation can be used for pediatric emergency procedural skills training and maintenance. We will discuss specific instructional design features, simulation modalities, and the use of simulation as an assessment tool in the era of competency-based medical education.

INSTRUCTIONAL DESIGN FEATURES

Effective instructional design is integral to successful implementation of SBME. A number of best practices gleaned from the medical education literature may be applied to simulation instruction, as summarized in Table 1. In a recent meta-analysis, Cook et al[13] quantified the impact of such instructional design features, designating a number of them as SBME best practice, including repetitive practice, mastery learning, and distributed practice. This section defines and reviews instructional design features for SBME, drawing upon key literature in the context of pediatric procedural skills training.

Deliberate Practice

Deliberate practice, or "practice with purpose," focuses on learners making continuous and small but deliberate adjustments to their practice of a cognitive or procedural skill in response to immediate feedback.[5] Instructional design with deliberate practice incorporates 9 key components, as depicted in Figure 1. Classically, the relationship between learning (or performance) and deliberate practice is understood to be an ogive, or S-shaped, learning curve, such that learning becomes more effortful after a clear inflection point (Figure 2). This association is exemplified in studies of deliberate practice applied to the cognitive task of interpreting radiographs.[14,15] A deliberate practice SBME curriculum incorporates elements of repetitive practice and mastery learning, which are further described below.

TABLE 1. Features of SBME reflecting educational best practices.

Educational Best Practice	SBME Features
Active learning	Immersive/"hands-on"
Prompt feedback	Real-time, formative feedback
High expectations	Range of difficulty promotes mastery
Collaboration among students	Allows practice as team
Emphasis on time for tasks	Repetitive practice
Respect for diverse learning styles	Visual, auditory, experiential, and didactic learning combined
High student-faculty interaction	Teacher as coach/facilitator

Data from: Chickering W, Gamson ZF. Seven principles for good practice in undergraduate education. Biochem Educ 1989;17(3):140–1; and Issenberg SB, McGaghie WC, Petrusa ER, et al. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teach 2005;27(1):10–28.

For psychomotor skills, a 2011 meta-analysis found that SBME with deliberate practice was significantly more effective than traditional curricula (eg, didactic learning) for teaching procedural and surgical skills such as central venous catheterization, thoracentesis, and Advanced Cardiac Life Support.[16] In the pediatric literature, deliberate practice has been associated with improved performance in pediatric and neonatal CPR, including such skills as CPR quality, CPR timeliness, and cardiac defibrillation.[17–19] Simulation-based medical education with deliberate practice of infant lumbar puncture (LP) by pediatric interns improves key procedural process measures like number of LP attempts[20] and may translate to clinical success on the first infant LP after training.[21]

Deliberate practice does, however, have its limitations. It can be resource and time intensive, often requiring instructor-to-learner ratios nearing 1:1, rendering it more apt for structured medical training programs than for providers in practice. It