Effect of Procedure Simulation Workshops on Resident Procedural Confidence and Competence

ERIN M. AUGUSTINE, MD

MADELYN KAHANA, MD

Abstract

Background Pediatrics residents perform a limited number of some procedures in the clinical setting and may benefit from procedure simulation workshops.

Objective To examine (1) the number and types of procedures performed by pediatrics residents in the clinical setting, (2) the relationship between the number of procedures performed and self-reported procedural confidence and competence, and (3) the effect of a procedure simulation workshop on self-reported procedural confidence and competence.

Methods Pediatrics residents at Lucile Packard Children's Hospital at Stanford attended a half-day procedure workshop, rotating between 6 procedure simulation stations: vascular access, airway management, bladder catheterization, chest tube placement, lumbar puncture, and umbilical lines. Residents completed a survey immediately before and

after the workshop to self-assess procedural confidence and competence.

Results Seventy-two residents participated in a procedure workshop. The average number of procedures performed increased significantly from intern to junior to senior year. A positive correlation was found between number of procedures performed and preworkshop confidence ($P < .001$, $R^2 = 0.86$) and competence ($P < .001$, $R^2 = 0.88$). For each procedure assessed, completion of the procedure simulation workshop resulted in a statistically significant ($P < .001$) increase in self-perceived confidence (14%–131%; average, 48%) and competence (12%–119%; average, 50%). Statistically significant ($P < .05$) increases remained when results for interns, juniors, and seniors were examined separately.

Conclusion Procedure simulation workshops improve resident self-reported procedural confidence and competence, particularly for procedures that are least performed.

Editor's Note: The online version of this article contains the scale for estimated cumulative total number of procedures performed used in this study.

Introduction

The Residency Review Committee for Pediatrics of the Accreditation Council for Graduate Medical Education (ACGME) mandates that pediatrics residents demonstrate

Erin M. Augustine, MD, is a Pediatrics Emergency Medicine Fellow at Children's National Medical Center; and Madelyn Kahana, MD, is Professor of Pediatrics and Anesthesiology, Pediatrics Residency Program Director, and Associate Chair of Pediatrics for Education at Stanford School of Medicine.

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Corresponding author: Erin M. Augustine, MD, Children's National Medical Center, Emergency Department, 111 Michigan Avenue NW, Washington, DC 20010, 202-476-4177, eaugusti@cnmc.org.

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procedural competence. Although the definition of competence is not explicit, the requirements imply that residents should demonstrate the necessary skills for independent practice.¹

Although pediatrics residents are required to demonstrate procedural competence, multiple studies report that residents, in fact, lack these skills.^{2–7} In a 2007 report,⁴ fewer than 65% of pediatrics program directors reported that all or almost all of their residents were competent to perform the following required procedures at the completion of training: intravenous (IV) placement (48%), arterial puncture (51%), umbilical arterial catheter placement (55%), umbilical venous catheter placement (57%), intubation (60%), and venipuncture (61%). If competence is determined by procedural success in the clinical setting, multiple studies in the past decade suggest that residents are not competent. Leone et al⁶ reported that the median success rate for neonatal intubation was 33% for pediatrics interns and 40% for pediatrics junior and senior residents. Similarly, Falck et al³ found that neonatal intubation was successful on the first or second attempt for 50% of pediatrics interns, 55% of pediatrics junior residents, and 62% of pediatrics senior residents. Although

lumbar puncture is one of the most commonly performed procedures, Baxter et al² reported that only 74% of lumbar punctures performed by pediatrics residents in the clinical setting were successful.

Residents' lack of procedural competence may, in part, be a reflection of limited clinical opportunities to perform procedures^{6,8} and/or inadequate alternative procedural education. A 2007 article⁴ noted that only 40% to 70% of pediatrics residency programs have a formal method for teaching arterial puncture, bladder catheterization, peripheral IV placement, lumbar puncture, and venipuncture. Given the reported lack of procedural competence, procedure education needs to be more explicitly incorporated into pediatrics residency programs. Few studies have assessed pediatric procedural education and the ideal format for that instruction has not been established.

The objective of this study was to examine (1) the number and types of procedures performed in the clinical setting by pediatrics residents at a large, academic children's hospital, (2) the relationship between the number of procedures performed and self-reported procedural confidence and competence, and (3) the effect of a procedure simulation workshop on self-reported procedural confidence and competence.

Methods

Setting

Lucile Packard Children's Hospital at Stanford is a 312-bed, academic, free-standing children's hospital with a 74-bed neonatal intensive care unit and a 24-bed pediatric intensive care unit. There are approximately 7300 hospital admissions (average length of stay, 5.6 days), 1400 neonatal intensive care unit admissions, 1100 pediatric intensive care unit admissions, 14 060 pediatric emergency room visits, and 7650 urgent care visits annually. The residency program consists of approximately 78 total residents, 26 per training year.

Procedure Simulation Workshops

Procedure simulation workshops were implemented at Lucile Packard Children's Hospital during the 2010–2011 academic year. Before that, pediatrics residents received informal procedure education by nurses, senior residents, fellows, and faculty physicians, often immediately before or during a procedure. Formal education was provided every 2 years in Neonatal Resuscitation Program and Pediatric Advanced Life Support courses.

During the 2010–2011 academic year, residents were strongly encouraged to attend 1 of the 5 half-day procedure workshops offered between November 2010 and March 2011. The workshops took place at the Center for

What was known

Pediatrics residents' procedural skills can be enhanced through simulation.

What is new

Assessment of the effect of the number of procedures performed, and the impact of a half-day, 6-station procedure workshop using simulation on residents' self-reported procedural confidence and competence.

Limitations

Small sample, single-site study outcomes are limited to self-assessed procedural competence and confidence.

Bottom line

The procedure simulation workshops improved resident self-reported procedural confidence and competence, particularly for procedures they performed least frequently.

Advanced Pediatric and Perinatal Education at Lucile Packard Children's Hospital. Residents rotated in small groups (2–3 residents per group), spending 20 to 30 minutes at each of the 6 procedure simulation stations listed in TABLE 1. Patient simulation models and relevant equipment were available at each station. Each station was taught by a faculty physician or fellow who was selected based on strong resident teaching evaluations. Instructors taught a procedure relevant to their field. Neonatologists, for example, taught umbilical line placement. Instructors received a 5–10 minute orientation immediately before the workshop detailing the equipment available and educational structure for the workshop. After reviewing the

TABLE 1 PROCEDURE STATIONS

Procedure Stations	Procedures Reviewed
Vascular access	Arterial puncture ^a
	Venipuncture ^a
	IV placement ^a
Airway management	Bag mask ventilation
	Endotracheal intubation ^a
Bladder catheterization	Bladder catheterization ^a
Chest tube placement	Needle decompression ^b
	Chest tube placement ^b
Lumbar puncture	Lumbar puncture ^a
Umbilical lines	Umbilical artery catheterization ^a
	Umbilical vein catheterization ^a

Abbreviations: ACGME, Accreditation Council for Graduate Medical Education.

^a ACGME required procedures, sufficient training required.

^b ACGME required procedures, exposure required.

indications, contraindications, and risks of each procedure, the leader demonstrated the proper technique for each procedure with high-fidelity patient simulators. Residents subsequently took turns performing each procedure and demonstrating proper use of the equipment. Residents were given feedback and repeated the procedure until he or she was deemed competent, at the discretion of the instructor.

Surveys

Residents who attended the workshop completed 2 anonymous surveys, 1 immediately before and 1 immediately after the workshop. Each survey was 2 pages long and took approximately 5 to 10 minutes to complete. The preworkshop and postworkshop surveys were collated to compare prerespouses with postresponses for an individual resident. Residents provided their year in training; no other demographic information was collected. The surveys asked about the 11 procedures listed in TABLE 1. In the preworkshop survey, residents were asked to estimate (1) the total number of times they had performed each procedure in a clinical setting (this number included times performed in residency, medical school, and at any other time), (2) their confidence in performing each procedure (preconfidence), and (3) their competence in performing each procedure (precompetence). In the postworkshop survey, residents were asked to estimate (1) their confidence in performing each procedure (postconfidence), (2) their competence in performing each procedure (postcompetence), and (3) their before workshop competence in performing each procedure (retrospective precompetence). Retrospective precompetence refers to the assessment of before intervention competence estimated after the intervention. A comparison of retrospective preworkshop competence to postworkshop competence minimizes the change in competence due to changes in resident self-assessment standards because both are estimated at the same time, after the intervention.⁹

Residents estimated the number of times they had performed each procedure on a 1 to 6 scale (1 = 0–5 times, 2 = 6–10 times, 3 = 11–15 times, 4 = 16–20 times, 5 = 21–25 times, and 6 = more than 25 times performed) (APPENDIX TABLE provided as online supplemental information). Estimations of confidence and competence were on a 6-point Likert scale (1 = not confident or not competent; 6 = very confident or competent). The surveys were developed by the authors, and evidence for their validity has not been collected.

This project was reviewed by Stanford University's Institutional Review Board and was found to be exempt.

Data Analysis

Matched variables were compared using paired *t* tests. Unmatched variables were compared using unequal variance *t* tests. Correlations between variables were assessed

using ordinary least squares regressions. Comparisons were considered statistically significant if $P < .05$. No correction for multiple comparisons was made. Data analysis was performed using Microsoft Excel (XP, Redmond, WA) and Stata (Version 11; StataCorp, College Station, TX).

Results

Seventy-two of the 78 residents (92% participation rate) in the pediatrics residency program participated in one of the procedure workshops. Six residents did not participate because of scheduling conflicts or clinical responsibilities. The total number of participants included 25 interns (35%), 25 junior residents (35%), and 22 senior residents (31%). All residents completed preworkshop and postworkshop surveys (100% completion rate).

The estimated total number of procedures performed by year in residency is shown in TABLE 2. Interns performed each of the procedures assessed an average total of ≤ 10 times. Seniors similarly performed an average total of ≤ 10 arterial punctures, bladder catheterizations, needle chest decompressions, chest tube placements, umbilical artery catheter placements, umbilical vein catheter placements, and venipunctures. In contrast to interns, seniors estimated performing 6 to 15 IV placements, 6 to 15 intubations, 11 to 20 bag mask ventilations, and 16 to 25 lumbar punctures. Unequal variance *t* tests demonstrated statistically significant ($P < .05$) differences between procedure number and year in residency as noted in

TABLE 2.

Ordinary least-squares regressions demonstrated a statistically significant positive correlation between number of procedures performed and preworkshop confidence for interns ($P < .001$, $R^2 = 0.77$), juniors ($P < .001$, $R^2 = 0.83$), seniors ($P < .001$, $R^2 = 0.89$), and all residents combined ($P < .001$, $R^2 = 0.86$). Ordinary least-squares regressions demonstrated a statistically significant positive correlation between number of procedures performed and preworkshop competence for interns ($P < .001$, $R^2 = 0.80$), juniors ($P < .001$, $R^2 = 0.83$), seniors ($P < .001$, $R^2 = 0.90$), and all residents combined ($P < .001$, $R^2 = 0.88$).

Resident self-assessed procedural confidence and competence are shown in TABLE 3. For each procedure, preworkshop to postworkshop confidence increased by 14% to 131% (average, 48%), preworkshop to postworkshop competence increased by 12% to 119% (average, 50%), and retrospective preworkshop to postworkshop competence increased by 12% to 59% (average, 30%). Paired *t* tests demonstrate statistically significant ($P < .001$) differences between (1) preconfidence and postconfidence, (2) precompetence and postcompetence,

TABLE 2		NUMBER OF PROCEDURES PERFORMED, PREWORKSHOP CONFIDENCE, AND PREWORKSHOP COMPETENCE BY YEAR IN RESIDENCY									
Procedure	Interns (n = 25)			Juniors (n = 25)			Seniors (n = 22)			Precomp, Mean	Preconf, Mean
	No, ^a Range (Mean)	Preconf, ^a Mean	Precomp, ^a Mean	No, ^a Range (Mean)	Preconf, Mean	Precomp, Mean	No, ^a Range (Mean)	Preconf, Mean			
Arterial puncture	0-10 (1.2)	1.8	1.7	0-5 (1.0)	1.7	1.6	0-10 (1.1)	2.1	2.0		
Bag mask ventilation ^b	0-10 (1.4)	3.5	3.2	0-10 (1.9)	3.4	3.4	11-20 (3.3)	4.6	4.4		
Bladder catheterization	0-10 (1.3)	2.8	2.7	0-10 (1.3)	2.7	2.8	0-10 (1.1)	2.7	2.8		
Needle chest	0-5 (1.0)	1.3	1.4	0-5 (1.0)	1.6	1.6	0-5 (1.0)	1.9	1.9		
Chest tube	0-5 (1.0)	1.3	1.3	0-5 (1.0)	1.4	1.6	0-5 (1.0)	1.4	1.3		
IV placement	0-10 (1.6)	2.6	2.5	6-10 (2.0)	3.2	3.1	6-15 (2.1)	2.8	2.9		
Intubation ^c	0-10 (1.2)	2.3	2.2	0-10 (1.8)	3.1	3.1	6-15 (2.7)	3.3	3.6		
Lumbar puncture ^d	0-10 (1.9)	3.8	3.7	11-20 (3.4)	4.5	4.4	16-25 (4.3)	4.9	4.8		
UAC placement ^e	0-10 (1.2)	2.2	1.9	0-10 (1.6)	3.1	3.0	0-10 (1.7)	2.7	2.6		
UVC placement ^e	0-10 (1.2)	2.4	2.0	0-10 (1.6)	3.1	3.0	0-10 (1.7)	2.8	2.6		
Venipuncture	0-10 (1.4)	2.3	2.2	0-10 (1.9)	3.4	3.2	0-10 (1.8)	3.0	3.0		
Average ^f	0-10 (1.3)	2.4	2.3	0-10 (1.7)	2.8	2.8	6-10 (2.0)	2.9	2.9		

Abbreviations: n, number of participants; No, number of procedures; preconf, preworkshop confidence; precomp, preworkshop competence; UAC, umbilical arterial catheter; UVC, umbilical venous catheter.

^aNo is the range of estimated lifetime cumulative total number of procedures performed and the mean-scaled number of procedures based on the scale in APPENDIX TABLE; preconf is the mean preworkshop confidence based on a 6-point Likert scale; and precomp is the mean preworkshop competence based on 6-point Likert scale.

^bStatistically significant difference in mean-scaled number of procedures between interns and juniors ($P = .04$), interns and seniors ($P < .001$), and juniors and seniors ($P = .002$).

^cStatistically significant difference in mean-scaled number of procedures between interns and juniors ($P = .01$), interns and seniors ($P < .001$), and juniors and seniors ($P = .03$).

^dStatistically significant difference in mean-scaled number of procedures between interns and juniors ($P < .001$), interns and seniors ($P < .001$), and juniors and seniors ($P = .02$).

^eStatistically significant difference in mean-scaled number of procedures between interns and seniors ($P = .005$).

^fStatistically significant difference in mean-scaled number of procedures between interns and juniors ($P < .001$), interns and seniors ($P < .001$), and juniors and seniors ($P = .03$).

TABLE 3 RESIDENT PREWORKSHOP (PRE) AND POSTWORKSHOP (POST) CONFIDENCE AND COMPETENCE

Procedure	Confidence				Competence								
	Pre	Post	Pre/Post	P	Pre	Retro Pre	Post	Pre/Retro Pre		Pre/Post		Retro Pre/Post	
	Mean		%Δ		Mean			%Δ	P	%Δ	P	%Δ	P
Arterial puncture	1.8	3.2	78	<.001	1.8	2.2	3.3	22	<.001	83	<.001	50	<.001
Bag mask ventilation	3.8	4.6	21	<.001	3.6	3.5	4.4	-3	.32	22	<.001	26	<.001
Bladder catheterization	2.8	4.1	46	<.001	2.8	3.1	4.0	11	.08	43	<.001	29	<.001
Needle chest	1.6	3.7	131	<.001	1.6	2.2	3.5	38	<.001	119	<.001	59	<.001
Chest tube	1.3	3.0	131	<.001	1.4	1.9	2.9	36	<.001	107	<.001	53	<.001
IV placement	2.9	4.0	38	<.001	2.8	3.2	4.0	14	.005	43	<.001	25	<.001
Intubation	2.9	4.2	45	<.001	2.9	3.3	4.1	14	.006	41	<.001	24	<.001
Lumbar puncture	4.4	5.0	14	<.001	4.3	4.3	4.8	0	.99	12	<.001	12	<.001
UAC placement	2.7	3.9	44	<.001	2.5	2.9	3.8	16	<.001	52	<.001	31	<.001
UVC placement	2.8	3.9	39	<.001	2.5	2.9	3.8	16	<.001	52	<.001	31	<.001
Venipuncture	2.9	4.2	45	<.001	2.8	3.4	4.0	21	<.001	43	<.001	18	<.001
Average	2.7	4.0	48	<.001	2.6	3.0	3.9	15	<.001	50	<.001	30	<.001

Abbreviations: %Δ, percentage of change; P, significance; retro pre, retrospective preworkshop competence; UAC, umbilical arterial catheter; UVC, umbilical venous catheter.

and (3) retrospective precompetence and postcompetence for all procedures assessed. Statistically significant differences ($P < .05$) remained when each procedure was examined separately for interns, juniors, and seniors. Preworkshop competence was significantly ($P \leq .006$) less than retrospective preworkshop competence for 8 of 11 procedures (73%).

The relationship between number of procedures performed before the workshop and the percentage of increase from preworkshop to postworkshop confidence and competence was compared using ordinary least-squares regressions. A statistically significant negative correlation was found between the number of procedures performed and the percentage increase in both confidence ($P = .008$, $R^2 = 0.57$) and competence (pre/post $P = .002$, $R^2 = 0.67$; retrospective pre/post $P = .003$, $R^2 = 0.65$). Procedures least performed before the workshop were associated with larger increases in confidence and competence after the workshop.

Discussion

Our study found that pediatrics residents report performing a limited number of some procedures in the clinical setting and that this experience correlates with self-perceived procedural confidence and competence. Procedure simulation workshops significantly improve resident self-assessed confidence and competence, particularly for procedures least performed.

Limited and decreasing procedural opportunities in the clinical setting have been reported previously. Leone et al⁶ reported that graduating residents participated in > 30 neonatal intubations throughout residency training in 1994–1996 and that number had declined to < 20 in 1999–2002. Gozzo et al,⁸ examining whether residents missed procedural opportunities because of nonparticipation, found a significantly smaller percentage of procedures attempted by residents (32%) compared with nonresident practitioners. Decreasing procedural opportunities have been attributed to duty hour restrictions, limited intensive care rotations, and the presence of increasing numbers of other clinical personnel, such as nurse practitioners, physician assistants, fellows, and attending hospitalists.

We report a positive relationship between procedural experience in the clinical setting and self-reported procedural confidence and competence. Although the minimum clinical experience necessary to be considered competent at various procedures has not been established for pediatrics residents, the anesthesia literature suggests that a minimum of 40 intubation attempts are required for a 90% success rate.^{5,7} That number is more than double the average total

number of intubations and other procedures senior residents reported performing in this study.

Lack of procedure competence and opportunity has the potential to become a self-perpetuating cycle. As more pediatrics residents graduate without procedural competence, a larger number of trainees may rely on fellowship training to hone these skills. That may translate into added reductions in procedural opportunities for residents.⁴

We showed that procedure simulation workshops significantly improve resident self-reported procedural confidence and competence for all procedures assessed and all levels of training. Among other studies that evaluated resident procedure workshops, Tofil et al¹⁰ reported that a pediatric intensive care unit simulation course that used high-fidelity pediatric simulators improved pediatrics residents' confidence in intubation and intraosseous line placement. In that study, however, video review of performance by pediatric critical care physicians using checklists showed a discordance between objective performance and self-assessment. In a study of simulation workshops for central venous catheter placement, Barsuk et al¹¹ found that internal medicine residents who completed a workshop reported significantly more confidence and required fewer attempts to place a central line in intensive care patients compared with residents who had not attended the workshop. Mendaratta-Lala et al¹² reported that a simulation-based ultrasound course improved radiology resident knowledge and confidence and resulted in an increase in skills for ultrasound-guided procedures, but the results were not statistically significant. Keddis et al¹³ found that a simulation-based workshop significantly increased internal medicine resident confidence in identifying anatomic structures using ultrasound.

One of our most surprising findings was that preworkshop competence was less than retrospective preworkshop competence for most procedures (8 of 11 procedures; 73%). This difference suggested that resident self-evaluation standards had changed because of the workshop or that residents had underestimated their procedural competence before the workshop. As multiple comparisons were made, these results may be due to chance; however, this is less likely as the significant differences were $P \leq .006$.

Our study has several limitations. One limitation was that the number of procedures performed in a clinical setting was an estimated value. Resident procedure logs were not used to obtain this number because they would not have included procedures performed before residency training. Although the number is an estimate, it does

increase as expected with training year. Another limitation of the study was that the effectiveness of the workshop was based solely on resident self-assessment, and the accuracy of physician self-assessment is thought to be poor.¹⁴ Furthermore, as confidence and competence were measured immediately after the workshop, it is not known whether these improvements were short lived or persistent over time. The validity of our survey has not been studied, and our data analysis did not include a correction for multiple comparisons. Although multiple comparisons have the potential to lead to spurious associations, that is less likely given our preworkshop to postworkshop comparisons had P values $<.001$. A final limitation was that this was a single-center study at a large, academic center and may not be generalizable. A planned direction of study is to assess procedure simulation workshops at multiple institutions using more objective measures of procedural competence at multiple time intervals after the intervention.

Conclusion

Pediatrics residents report performing a limited number of some procedures in the clinical setting. The number of procedures performed is positively correlated to self-perceived confidence and competence. Procedure simulation workshops significantly increase resident self-reported confidence and competence based on measurements made immediately before and after the workshops. These increases are most notable for procedures least performed in the clinical setting.

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