

# PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

## **Level of Trainee and Tracheal Intubation Outcomes**

Ronald C. Sanders Jr, John S. Giuliano Jr, Janice E. Sullivan, Calvin A. Brown III, Ron M. Walls, Vinay Nadkarni, Akira Nishisaki and for the National Emergency Airway Registry for Children Investigators and Pediatric Acute Lung Injury and Sepsis Investigators Network

*Pediatrics* 2013;131:e821; originally published online February 11, 2013;  
DOI: 10.1542/peds.2012-2127

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://pediatrics.aappublications.org/content/131/3/e821.full.html>

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2013 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™



# Level of Trainee and Tracheal Intubation Outcomes

**AUTHORS:** Ronald C. Sanders, Jr, MD, MS,<sup>a</sup> John S. Giuliano, Jr, MD,<sup>b</sup> Janice E. Sullivan, MD,<sup>c</sup> Calvin A. Brown, III, MD,<sup>d</sup> Ron M. Walls, MD,<sup>d</sup> Vinay Nadkarni, MD,<sup>e</sup> and Akira Nishisaki, MD, MSCE<sup>g</sup> for the National Emergency Airway Registry for Children Investigators and Pediatric Acute Lung Injury and Sepsis Investigators Network

<sup>a</sup>Department of Pediatrics, Section of Pediatric Critical Care, UAMS/Arkansas Children's Hospital, Little Rock, Arkansas;

<sup>b</sup>Department of Pediatrics, Section of Pediatric Critical Care, Yale University School of Medicine, Yale-New Haven Children's Hospital, New Haven, Connecticut; <sup>c</sup>Department of Pediatrics, Division of Critical Care and Kosair Charities Pediatric Clinical Research Unit, University of Louisville and Kosair Children's Hospital, Louisville, Kentucky; <sup>d</sup>Department of Emergency Medicine, Brigham and Women's Hospital; Division of Emergency Medicine, Harvard Medical School, Boston, Massachusetts; and

<sup>e</sup>Department of Anesthesiology, Critical Care Medicine, and Pediatrics, Center for Simulation, Advanced Education and Innovation, the Children's Hospital of Philadelphia, Pennsylvania

## KEY WORDS

adverse events, ICU, outcomes, tracheal intubation, training

## ABBREVIATIONS

CI—confidence interval

IQR—interquartile range

OR—odds ratio

NEAR4KIDS—National Emergency Airway Registry for Children

PALISI—Pediatric Acute Lung Injury and Sepsis Investigators

PGY—postgraduate year

TIAE—tracheal intubation associated events

(Continued on last page)



**WHAT'S KNOWN ON THIS SUBJECT:** Provider training level is associated with lower rates of successful tracheal intubation in selected neonatal settings. However, little is known about the association of training level with tracheal intubation success and adverse events in the PICU.



**WHAT THIS STUDY ADDS:** Our results demonstrate the association of training level on the first attempt and overall success rate as well as the incidence of adverse tracheal intubation-associated events in a large-scale, prospective assessment across 15 academic PICUs.

## abstract

**BACKGROUND:** Tracheal intubation is an important intervention to stabilize critically ill and injured children. Provider training level has been associated with procedural safety and outcomes in the neonatal intensive care settings. We hypothesized that tracheal intubation success and adverse tracheal intubation-associated events are correlated with provider training level in the PICU.

**METHODS:** A prospective multicenter observational cohort study was performed across 15 PICUs to evaluate tracheal intubation between July 2010 to December 2011. All data were collected by using a standard National Emergency Airway Registry for Children reporting system endorsed as a Quality Improvement project of the Pediatric Acute Lung Injury and Sepsis Investigator network. Outcome measures included first attempt success, overall success, and adverse tracheal intubation-associated events.

**RESULTS:** Reported were 1265 primary oral intubation encounters by pediatric providers. First and overall attempt success were residents (37%, 51%), fellows (70%, 89%), and attending physicians (72%, 94%). After adjustment for relevant patient factors, fellow provider was associated with a higher rate of first attempt success (odds ratio [OR], 4.29; 95% confidence interval [CI], 3.24–5.68) and overall success (OR, 9.27; 95% CI, 6.56–13.1) compared with residents. Fellow (versus resident) as first airway provider was associated with fewer tracheal intubation associated events (OR, 0.42; 95% CI, 0.31–0.57).

**CONCLUSIONS:** Across a broad spectrum of PICUs, resident provider tracheal intubation success is low and adverse associated events are high, compared with fellows. More intensive pediatric resident procedural training is necessary before “live” tracheal intubations in the intensive care setting. *Pediatrics* 2013;131:e821–e828

Tracheal intubation is one of the most important interventions in the stabilization of critically ill or injured children. Advanced airway skills training is one of the major pillars of the Accreditation Council for Graduate Medical Education pediatric program requirements for resident and fellowship education.<sup>1</sup> The pediatric airway presents unique anatomic challenges depending on the patient age, size, and underlying condition.<sup>2</sup> These challenges, coupled with low frequency of pediatric trainee exposure to advanced airway management, make tracheal intubation procedural competency difficult to achieve. As a result, tracheal intubation in children is associated with high levels of operator stress as well as patient morbidity and mortality.<sup>3–11</sup>

The ability to manage the pediatric airway, which includes anticipating potential difficulties and choosing an appropriate approach, remains one of the most vital skills to develop when caring for critically ill children. Provider training level has been found to correlate with patient outcome during advanced airway management in selected environments including the operating room, delivery room, and NICU.<sup>7,12–14</sup> Pediatric trauma patients intubated by less experienced emergency medical personnel in the field have increased morbidity and mortality in comparison with similar patients intubated by pediatric-trained hospital personnel.<sup>15</sup> A limited number of studies from neonatal resuscitation demonstrated that resident trainee success rates are moderate at best.<sup>14,16,17</sup> Unfortunately, little is known about the provider level of training in PICUs, and its association with first attempt success, overall success, and adverse tracheal intubation–associated events (TIAEs).<sup>11,18</sup>

Previously published studies are from a single-center experience.<sup>9,11</sup> Therefore, in this study, we aim to specifically describe tracheal intubation practices

across 15 academic PICUs related to provider training level by using the National Emergency Airway Registry for Children (NEAR4KIDS) registry,<sup>11</sup> endorsed as a quality improvement project of the Pediatric Acute Lung Injury and Sepsis Investigator (PALISI) network. We hypothesized that tracheal intubation first attempt success, overall success, and adverse tracheal intubation–associated events are associated with provider training level in the PICU.

## METHODS

After institutional review board review and approval, a prospective multicenter observational cohort study was performed across 15 PICUs. All critically ill children who underwent a primary oral intubation attempt between July 1, 2010 and December 31, 2011 within the PICU environment were identified, and the clinicians who intubated them documented the intubation process per protocol guidelines. A previously developed quality improvement tool called NEAR4KIDS was endorsed by the PALISI network and used for this investigation.<sup>11</sup> After each center's institutional review board approval, each site project leader developed a site-specific compliance plan with monitoring during a run-in phase to ensure a >95% tracheal intubation encounter capture rate as well as to confirm the accuracy of the data. Two compliance officers reviewed and approved the compliance plan for each site. Following documentation of >95% compliance and data accuracy, data collection was initiated for each tracheal intubation that occurred in the PICU at each center.

In brief, a bedside clinician completed a data collection sheet whenever an urgent or emergency tracheal intubation occurred. Subsequently, the accuracy of the information was verified by a research assistant who then

entered the data through a secured password-protected Web site portal. The research assistant or research designee interviewed members of the PICU team to ensure that all advanced airway management procedures were captured. A limited dataset (deidentified) was transmitted to the NEAR4KIDS coordinating center for analysis.

## Trainee Preparation

Pediatric trainees (residents and fellows) underwent instruction in both didactic format as well as “hands on” practice in tracheal intubation on manikins according to each institution's customary educational practice. Many programs required trainees to attend the neonatal resuscitation program before their neonatology rotations which typically occurred in the first year of residency. The Pediatric Advanced Life Support course designed by the American Heart Association was also a required course before their PICU rotation. Some programs required airway management scenarios to be completed either individually or as part of a more comprehensive “mock code” session. There was no uniform educational modality applied across the PICUs in this investigation.

## Patient Selection

Patients of all ages within the PICU were eligible for NEAR4KIDS enrollment if they received primary advanced airway management (tracheal intubation, laryngeal mask placement, emergency tracheostomy, and cricothyrotomy) in the PICU. For this study, only patients who were primarily orally intubated with direct laryngoscopy were included. This included patients requiring intubation at any time point during their admission or those for whom extubation failed and who required reintubation. Primary nasal intubations, planned tracheal tube changes (change of preexisting tube),

and advanced airway management initiation outside the PICU were excluded.

### Airway Management Events

The patient and provider characteristics of airway management attempts, process of care variance (multiple attempts: intubation course requiring >2 attempts), and safety outcomes (TIAEs) were captured. The operational definitions used for data acquisition and analysis during airway management events has been described previously.<sup>11</sup> There was no predefined time limit for any specific attempt or course. At each institution, tracheal intubations were performed according to their respective standards of practice.

Tracheal intubation-associated events were further categorized into severe TIAEs and nonsevere TIAEs. Severe TIAEs included cardiac arrest, esophageal intubation with delayed recognition, vomiting with aspiration, hypotension requiring intervention (fluid and/or pressors), laryngospasm, malignant hyperthermia, pneumothorax/pneumomediastinum, or direct airway injury. Esophageal intubation with delayed recognition was defined as misplacement of the tracheal tube in the upper esophagus or hypopharynx with a lapse of time and clinical deterioration (such as oxygen desaturations) before removal of the misplaced tube. Nonsevere TIAEs included mainstem bronchial intubation, esophageal intubation with immediate recognition, vomiting with no aspiration, hypertension requiring therapy, epistaxis, dental or lip trauma, medication error, dysrhythmia, or pain and/or agitation requiring additional medication and causing delay in intubation. Mainstem bronchial intubation was considered only when it was confirmed on chest radiograph or recognized after the clinical team secured the tube. Each airway management event was followed until the patient was discharged from the PICU or death occurred.

### Statistical Method

Statistical analysis was performed by using Stata 10.0 (Stata Corp, College Station, TX). Summary statistics were described with mean and SD for parametric variables and median with interquartile range for nonparametric variables. For categorical variables with dichotomous outcome, the contingency table method was used with  $\chi^2$  test or Fisher exact test, as appropriate. The Wilcoxon rank sum test was used for comparison of nonparametric variables. A *P* value of <0.05 was considered significant.

Multivariate logistic regression was used after adjusting for indication for elective procedure, previous history of a difficult airway, and patient age category to evaluate success of tracheal intubation at the first attempt as well as overall success. Those covariates were identified in the previous study by using the similar data collection and outcome report system.<sup>18</sup> It is speculated that a senior-level airway provider may have more difficult cases that may result in a higher incidence of TIAEs or lower likelihood of success; we evaluated this effect modification by including an interaction term. The interaction term was kept in the multivariate regression model when its coefficient was <0.1.

### RESULTS

A total of 1660 orotracheal intubation encounters were reported from July 1, 2010 to December 31, 2011 across 15 academic PICUs in the PALISI network, with a median of 88 and interquartile range (IQR) of 31 to 158 intubations per site. Median number of ICU beds was 26 (IQR, 16–30). Median number of ICU attending physicians was 9 (IQR, 6–10); median number of pediatric residents was 74 (IQR, 34–80). Ten (63%) PICUs had a pediatric critical care medicine fellowship program. Of the 1660 orotracheal intubation encounters, 395

were performed by nonpediatric physicians (eg, anesthesiologists, emergency medicine staff, and respiratory therapists). Thus, 1265 orotracheal intubation encounters performed by pediatric residents, fellows, and attendees were included for analysis.

### Patient Characteristics

The median age was 1 year (IQR, 0–7 years) with 744 (59%) boys (Table 1). The predominant diagnostic categories were respiratory-lower airway/pulmonary in 378 (33%). The most common indications for tracheal intubation were oxygenation failure, 454 (36%), or ventilatory failure, 425 (34%) (Table 1).

### Tracheal Intubation Success

Of 1265 encounters, 763 (60%) were successful on the first attempt by the initial provider (laryngoscopist), and 988 (78%) were successful overall by the initial provider (Table 2). The first tracheal intubation attempt was performed by a pediatric resident in 384 cases, a pediatric critical care fellow in 679 cases, and a PICU attending physician in 202 cases. First and overall attempt success rate varied between pediatric residents (37%, 51%), pediatric critical care fellows (70%, 89%), and PICU attending physicians (72%, 94%) (Table 2). After adjusting for patient-level covariates (previous history of difficult airway, elective intubation as indication and age), fellow participation was associated with a higher rate of first attempt success (odds ratio [OR], 4.29; 95% confidence interval [CI], 3.24–5.68, *P* < .001) in comparison with resident providers (Table 3). Pediatric critical care fellows were more likely to have overall success in patients without a previous history of a difficult airway (OR, 9.27; 95% CI, 6.56–13.1; *P* < .001). The first attempt success rate was not different across the training level within the category of pediatric residents by

**TABLE 1** Patient Characteristics for Primary Intubation Encounter in the PICU

Number of encounters	1265
Patient characteristics	
Age, y, median (IQR)	1 (0–7)
Weight, kg, median (IQR)	10.5 (5.2–24.5)
Gender, <sup>a</sup> <i>n</i> (%)	Male 744 (59) Female 514 (41)
Diagnostic categories, <sup>b</sup> <i>n</i> (%)	
Cardiac-medical	56 (5)
Cardiac-surgical	107 (9)
Neurologic (excluding TBI)	214 (19)
Respiratory-upper airway	116 (10)
Respiratory-lower airway/pulmonary	378 (33)
Sepsis/shock	112 (10)
Trauma (including TBI)	30 (3)
Other	131 (12)
Indications for tracheal intubation, <sup>c</sup> <i>n</i> (%)	
Oxygenation failure	454 (36)
Ventilatory failure	425 (34)
Therapeutic hyperventilation	39 (3)
Neuromuscular weakness	46 (4)
Impaired airway reflex	96 (8)
Elective procedure	199 (16)
Upper airway obstruction	128 (10)
Pulmonary toilet	52 (4)
Unstable hemodynamics	169 (13)
Previous history of difficult airway, <i>n</i> (%)	123 (10)

TBI, traumatic brain injury.

<sup>a</sup> Gender is missing in 7 encounters.

<sup>b</sup> Diagnostic category available in 1144 encounters.

<sup>c</sup> There may be >1 indication for each tracheal intubation.

postgraduate year (PGY) year: PGY-2 (55/160, 34%), PGY-3 (81/208, 39%), and PGY-4 (2/5, 40%) ( $P = .42$ ,  $\chi^2$  for trend, degrees of freedom ( $df$ ) = 1). However, the first attempt success rate trended toward improvement within the training level category of pediatric critical care fellows: PGY-4, 193/280 (69%); PGY-5, 155/227 (68%); PGY-6, 108/137 (79%); and PGY-7, 8/11 (73%) ( $P = .07$ ,  $\chi^2$  for trend,  $df$  = 1). The analysis for overall success as a first airway provider showed a similar effect by training level. The first attempt and overall success rate of the pediatric critical care fellow at the PGY-6 level approached that of the PICU attending.

### Adverse Tracheal Intubation Associated Events

Two hundred seventy adverse TIAEs (21%) out of 1265 tracheal intubations were reported (Table 2). The most frequently reported nonsevere TIAE was the immediate recognition of esophageal intubation, 125 events (10%). The most frequently reported severe TIAE was hypotension, observed in 46 encounters (4%) (Table 4). Encounters with pediatric critical care fellows as the first airway providers, compared with pediatric residents, were associated with significantly fewer incidences of TIAEs (OR, 0.42; 95% CI, 0.31–0.57;  $P < .001$ ) (Table 5).

**TABLE 2** Success Rates and TIAEs by initial airway provider

	Resident ( <i>n</i> = 384)	Fellow ( <i>n</i> = 679)	PICU Attending ( <i>n</i> = 202)	Total ( <i>N</i> = 1265)
First attempt success, <i>n</i> (%)	141 (37)	477 (70)	145 (72)	763 (60)
Overall success, <i>n</i> (%)	196 (51)	603 (89)	189 (94)	988 (78)
Any TIAEs, <i>n</i> (%)	117 (30)	108 (16)	45 (22)	270 (21)
Any Severe TIAEs, <i>n</i> (%)	25 (6)	37 (6)	19 (9)	81 (6)

## DISCUSSION

Our prospective multicenter observational study across the PALISI network investigated the association of the provider level of training with tracheal intubation success as well as adverse tracheal intubation–associated events by using the NEAR4KIDS registry with high compliance. Pediatric residents were successful in 37% of the first attempts and in 51% of the overall attempts (including repeated attempts). First attempt and overall success rates were lower for pediatric residents in comparison with fellows, and the difference remained significant even after adjustment for patient-level factors. The incidence of TIAEs was also significantly higher in tracheal intubations attempted by resident providers, even after adjustment for patient-level factors. The association of trainee laryngoscopist training level on tracheal intubation–associated morbidity and mortality in this patient population was previously unknown. Our results demonstrate the association of training level on the first attempt and overall success rate as well as the incidence of adverse TIAEs in a large-scale, prospective assessment across 15 academic PICUs.

An association of the level of training with tracheal intubation outcomes was reported in the delivery room and NICU ~10 years ago. Similar to our findings in the PICU, Falck et al<sup>16</sup> reported 449 intubations performed by pediatric residents in the delivery room and NICU between 1998 and 2001. PGY-3 pediatric resident trainees demonstrated a higher likelihood of successful intubations in comparison with PGY-1 level trainees by using logistic regression model analysis. Their first attempt and overall success rates ranged from 35% and 50% (PGY-1), 33% and 55% (PGY-2), to 45% and 62% (PGY-3), respectively, for pediatric residents. These reported rates may have overestimated the actual success because they included intubations at labor

**TABLE 3** Multivariate Analysis for First Attempt and Overall Tracheal Intubation Success Performed by Pediatric Resident or Pediatric Critical Care Fellow

	First Attempt Success <sup>a</sup>		Overall Success <sup>b</sup>	
	OR (95% CI)	P	OR (95% CI)	P
Fellows (vs residents)	4.29 (3.24–5.68)	<.001	9.27 (6.56–13.1)	<.001
Previous history of difficult airway	1.71 (0.27–11.0)	.57	4.47 (0.72–27.9)	.11
Fellows and previous history of difficult airway (interaction)	0.58 (0.21–1.62)	.30	0.26 (0.09–0.74)	.01
Elective intubation	1.06 (0.75–1.49)	.74	1.10 (0.74–1.64)	.64
Age <sup>c</sup>				
Infant (<1 y)	Reference		Reference	
1–7 y	1.14 (0.84–1.54)	.40	1.03 (0.72–1.47)	.90
≥ 8 y	1.08 (0.77–1.51)	.64	1.09 (0.73–1.64)	.67

Analysis includes first course of each encounter when pediatric resident or pediatric critical care fellow were the first laryngoscopists ( $n = 1063$ ).

<sup>a</sup> Logistic regression Pseudo  $R^2 = 0.081$ ,  $P < .0001$ .

<sup>b</sup> Logistic regression Pseudo  $R^2 = 0.167$ ,  $P < .0001$ .

<sup>c</sup> Comparison with infants (<1 y).

and delivery for meconium aspiration. In those cases, tracheal placement of the endotracheal tube was not confirmed. Taking this into consideration, the resident success rates in our multicenter cohort are similar to their report. In a more recent study from a single academic institution in Canada, Bismilla et al<sup>17</sup> reported an the overall success rate of endotracheal intubation in neonates of 63% by all pediatric residents and 69% by all pediatric neonatal fellows. Respiratory therapists were successful in 100% of cases. It is noteworthy that

their NICU respiratory therapists have an established training program for airway management that includes 3 days of intensive didactic sessions, 1 year of experience assisting tracheal intubations, and 10 supervised intubations. They are also required to perform a certain number of intubations annually to maintain their competence.<sup>17</sup> In contrast, their residents did not have any specific airway management training other than Neonatal Resuscitation Program recertification every 2 years and clinical rotations in level III NICUs for a total of 5

months. Their neonatal fellows also did not have any specific training curriculum besides the mandatory neonatal resuscitation program.<sup>17</sup> Our PICU fellow overall success rate was much higher (89%). This may be due to a larger number of tracheal intubation opportunities for pediatric critical care fellows throughout their training, and/or larger airways and different patient populations. In our data, fellows were the primary airway providers in 41% of the encounters, whereas Bismilla et al<sup>17</sup> reported that fellows accounted for only 26% of the intubations.

For tracheal intubations in the emergency department setting, Sagarin et al<sup>19</sup> reported the data from the National Emergency Airway Registry across 31 academic emergency departments of which 29 also managed children, from 1996 to 2001. A total of 5768 adult and pediatric intubations initially attempted by emergency medicine residents were evaluated over a 58-month period. The first attempt success rate was 72% (PGY-1), 82% (PGY-2), 88% (PGY-3), and 82% (PGY-4 or higher).<sup>19</sup> An association of training level and frequency of adverse events was not reported. A more recent update of their National Emergency Airway Registry suggests tracheal intubation–associated events are observed in 12% of their encounters that included both pediatric and adult patients.<sup>20</sup>

In the PICU setting, a study from a single academic tertiary PICU reported that residents were involved in 21% of tracheal intubations before an institution-specific simulation-based refresher training session was implemented.<sup>18</sup> Their first attempt success rate and overall success rate were 46% and 61%, respectively. Similar to our findings, tracheal intubation–associated events were observed in 22% of resident tracheal intubations, and all were nonsevere (esophageal intubation with

**TABLE 4** Specific TIAEs by Initial Airway Provider

	Resident ( $n = 384$ )	Fellow ( $n = 679$ )	PICU Attending ( $n = 202$ )	Total ( $N = 1265$ )
Severe TIAEs				
Cardiac arrest-died	0	4 (0.6)	1 (0.5)	5 (0.4)
Cardiac arrest-survived	3 (0.8)	10 (2)	3 (2)	16 (1)
Esophageal intubation delayed recognition	2 (0.5)	0	1 (0.5)	3 (0.2)
Emesis with aspiration	3 (0.8)	7 (1)	3 (2)	13 (1)
Hypotension <sup>a</sup>	16 (4.2)	19 (3)	11(6)	46 (4)
Laryngospasm	1 (0.3)	0	1 (0.5)	2 (0.2)
Pneumothorax pneumo-mediastinum	1 (0.3)	0	1 (0.5)	2 (0.2)
Mainstem intubation	19 (5)	23 (3)	6 (3)	48 (4)
Esophageal immediate recognition	73 (19)	38 (6)	14 (7)	125 (10)
Emesis, no aspiration	3 (0.8)	5 (0.7)	5 (2)	13 (1)
Hypertension <sup>b</sup>	1 (0.3)	1 (0.2)	1 (0.5)	3 (0.2)
Epistaxis	3 (0.8)	0	1 (0.5)	4 (0.3)
Dental/lip trauma	6 (2)	11 (2)	2 (1)	19 (2)
Medication error	0	0	2 (1)	2 (0.2)
Dysrhythmia	9 (2)	10 (2)	1 (0.5)	20 (2)

Note that each initial course may have >1 TIAE. Values shown are  $n$  (%).

<sup>a</sup> Hypotension occurred after the course is started, requiring intervention such as fluid resuscitation or pressors.

<sup>b</sup> Hypertension requiring medication.

**TABLE 5** Multivariate Analysis for Occurrence of TIAEs

	OR (95% CI)	P
Residents (reference group)	—	—
Fellow	0.42 (0.31–0.57) <sup>a</sup>	<.001
Attending physician	0.63 (0.42–0.94)	.025
Previous history of difficult airway	1.29 (0.82–2.03)	.27
Elective intubation	0.91 (0.62–1.34)	.63
Infants <1 y (reference group)	—	—
1–7 y	0.78 (0.56–1.08)	.13
≥ 8 y	1.22 (0.87–1.72)	.25

Analysis includes first course of each encounter when pediatric resident or pediatric critical care fellow were the first laryngoscopists ( $n = 1265$ ). Logistic regression Pseudo  $R^2 = 0.029$ ,  $P < .0001$ .

<sup>a</sup>  $P < .001$ .

immediate recognition, mainstem bronchial intubation, and dental/lip trauma). Of importance, the resident participation was associated with a higher incidence of TIAEs (OR, 2.22; 95% CI, 1.28–3.87;  $P = .005$ ) in their multivariate analysis adjusted for patient-level characteristics.<sup>18</sup> Although the resident involvement is similar in our study (23%), the first attempt and overall success rates in our study are 10% lower (37% and 51%). This lower rate has previously been attributed to the decline of pediatric resident tracheal intubation exposure and skill practice.<sup>14</sup>

Our findings suggest that the training of pediatric residents is not sufficient before “live” tracheal intubations in the critical care setting. Our current 1 to 2 days of airway management training as a part of resuscitation training (such as Pediatric Advanced Life Support or neonatal resuscitation program) is not sufficient to provide safe intubation skills. The higher incidence of TIAEs associated with airway management initiated by pediatric residents brings into question whether the PICU is the appropriate setting to train pediatric resident intubation skills on “live patients,” given that this skill will be rarely needed in a general pediatric practice. If tracheal intubation is deemed vital to the general pediatrician’s skill set by certifying organizations such as the Accreditation Council for Graduate Medical Education and the American Board of Pediatrics,

then a focused structured setting demonstrating competence in tracheal intubation skills may be needed. This study suggests that a new approach to the instruction of tracheal intubation is needed for pediatric trainees to decrease TIAEs and to improve patient safety. One approach would be to develop and implement tracheal intubation mastery learning programs by using a mastery learning and deliberate practice approach<sup>21,22</sup>; that is, all pediatric residents have to meet a preset training goal in a simulation laboratory with intense, repeated training with feedback. This is potentially time-consuming and may be feasible for a selected group of pediatric residents who “have to” master intubation skills before graduation (for residents going to practice in a rural area, or for residents going into critical care, neonatology, or pediatric emergency medicine fellowship). From a safety perspective, only those residents who mastered the skill in the simulation laboratory would be allowed to be a laryngoscopist in this approach. Another potential approach is to use video laryngoscope as a primary intubation device to shorten the learning period. A video laryngoscope can also serve to facilitate real-time coaching by a supervisor.<sup>23,24</sup>

Our current study needs to be interpreted in the light of several limitations. Although we attempted to adjust for patient-level characteristics to evaluate

the effect of training level on a provider’s first attempt and overall success rate, it was not possible to include the severity of illness for adjustment. Therefore, it is possible that laryngoscopists (airway providers) with higher training levels (eg, fellows and attending physicians) had more challenging cases. The higher severe TIAE rates associated with PICU attending physicians may be reflective of the more challenging cases (Table 5). Underreporting of tracheal intubations with multiple attempts or TIAEs is a potential problem for “self-reported” registry data. We attempted to mitigate potential ascertainment bias or reporting bias by implementing a site compliance plan with the goal of ensuring >95% intubation capture rate and data verification by local site coordinators.

## CONCLUSIONS

Across a broad spectrum of PICU settings, resident provider tracheal intubation success is low and adverse associated events (TIAEs) are high in comparison with fellows or attending physicians. More intensive pediatric resident tracheal intubation procedural training is necessary before live tracheal intubations in the ICU setting. Further studies need to be designed to evaluate the effectiveness of innovative educational strategies in pediatric tracheal intubations.

## ACKNOWLEDGMENTS

The National Emergency Airway Registry for Children (NEAR4KIDS) Investigators: Pradip Kamat, MD, MBA, Department of Pediatrics, Emory University School of Medicine, Children’s Hospital of Atlanta (Atlanta, GA); Ana Lia Graciano, MD, Pediatric Critical Care, Children’s Hospital of Central California (Fresno, CA); Matthew S. Braga, MD, Department of Pediatrics, Dartmouth-Hitchcock Medical Center (Lebanon, NH); J. Dean Jarvis, RN, MBA, Department of Pediatrics,

Dartmouth-Hitchcock Medical Center (Lebanon, NH); David A. Turner, MD, Department of Pediatrics, Division of Critical Care, Duke Children's Hospital (Durham, NC); Ira M. Cheifetz, MD, FCCM, Department of Pediatrics, Division of Critical Care, Duke Children's Hospital (Durham, NC); Kyle J. Rehder, MD, Department of Pediatrics, Division of Critical Care, Duke Children's Hospital (Durham, NC); Craig Tucker, BS, RRT-NPS, AE-C, Respiratory Care Department, Rhode Island/Hasbro Children's Hospital (Providence, RI); Glenda Hefley, RN, MNSc, Department of Pediatrics, Section of Pediatric Critical Care, UAMS/Arkansas Children's Hospital (Little Rock, AR); Keiko Tarquinio, MD, Critical Care Medicine, Rhode Island/Hasbro Children's Hospital (Providence, RI); Simon

Li, MD, Pediatric ICU, Maria Fareri Children's Hospital (Westchester, NY); Carey Goltzman, MD, Pediatric ICU, Maria Fareri Children's Hospital (Westchester, NY); Keith Meyer, MD, Division of Critical Care Medicine, Miami Children's Hospital (Miami, FL); Anthony Lee, MD, Critical Care Medicine, Nationwide Children's Hospital, Ohio State University (Columbus, OH); Robert Tamburro, MD, Division of Critical Care Medicine, Penn State Children's Hospital (Hershey, PA); Debra Spear, RN, Division of Critical Care Medicine, Penn State Children's Hospital (Hershey, PA); Matthew Basiaga, DO, Division of Critical Care Medicine, Penn State Children's Hospital (Hershey, PA); Guillaume Emeriaud, MD, Sainte-Justine University Hospital Center (Montreal, Quebec, Canada); Jessica Leffelman,

Center for Simulation, The Children's Hospital of Philadelphia (Philadelphia, PA); Michael Apkon, MD, PhD, Department of Anesthesiology and Critical Care Medicine, The Children's Hospital of Philadelphia (Philadelphia, PA); Vicki L. Montgomery, MD, Department of Pediatrics, Division of Critical Care, University of Louisville and Kosair Children's Hospital (Louisville, KY); Laura Lee, MD, Department of Pediatrics, University of Virginia Children's Hospital (Charlottesville, VA); Ann Thompson, MD, Critical Care Medicine and Pediatrics, Pittsburgh Children's Hospital (Pittsburgh, PA); and Katherine Biagas, MD, Division of Pediatric Critical Care Medicine, Columbia University/New York Presbyterian Hospital (New York, NY).

## REFERENCES

1. Accreditation Council for Graduate Medical Education. Available at: [www.acgme.org/acgmeweb/ProgramandInstitutionalGuidelines/MedicalAccreditation/Pediatrics.aspx](http://www.acgme.org/acgmeweb/ProgramandInstitutionalGuidelines/MedicalAccreditation/Pediatrics.aspx). Updated July 2007. Accessed November 8, 2012
2. Thompson A, Salonia R. Airway management. In: Fuhrman BP, Zimmerman JJ, eds. *Pediatric Critical Care*. 4th ed. Philadelphia, PA: Elsevier; 2011:1590–1613
3. Easley RB, Segeleon JE, Haun SE, Tobias JD. Prospective study of airway management of children requiring endotracheal intubation before admission to a pediatric intensive care unit. *Crit Care Med*. 2000;28(6):2058–2063
4. Gausche M, Lewis RJ, Stratton SJ, et al. Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. *JAMA*. 2000;283(6):783–790
5. Mort TC. The incidence and risk factors for cardiac arrest during emergency tracheal intubation: a justification for incorporating the ASA Guidelines in the remote location. *J Clin Anesth*. 2004;16(7):508–516 doi: 10.1016/j.jclinane.2004.01.007
6. Sagarin MJ, Chiang V, Sakles JC, et al; National Emergency Airway Registry (NEAR) investigators. Rapid sequence intubation for pediatric emergency airway management. *Pediatr Emerg Care*. 2002;18(6):417–423
7. O'Donnell CP, Kamlin CO, Davis PG, Morley CJ. Endotracheal intubation attempts during neonatal resuscitation: success rates, duration, and adverse effects. *Pediatrics*. 2006; 117(1). Available at: [www.pediatrics.org/cgi/content/full/117/1/e16](http://www.pediatrics.org/cgi/content/full/117/1/e16)
8. Eich C, Roessler M, Nemeth M, Russo SG, Heuer JF, Timmermann A. Characteristics and outcome of prehospital paediatric tracheal intubation attended by anaesthesia-trained emergency physicians. *Resuscitation*. 2009;80(12):1371–1377
9. Carroll CL, Spinella PC, Corsi JM, Stoltz P, Zucker AR. Emergent endotracheal intubations in children: be careful if it's late when you intubate. *Pediatr Crit Care Med*. 2010; 11(3):343–348
10. Nishisaki A, Marwaha N, Kasinathan V, et al. Airway management in pediatric patients at referring hospitals compared to a receiving tertiary pediatric ICU. *Resuscitation*. 2011;82(4):386–390
11. Nishisaki A, Ferry S, Colborn S, et al; National Emergency Airway Registry (NEAR); National Emergency Airway Registry for kids (NEAR4-KIDS) Investigators. Characterization of tracheal intubation process of care and safety outcomes in a tertiary pediatric intensive care unit. *Pediatr Crit Care Med*. 2012;13(1):e5–e10
12. Konrad C, Schüpfer G, Wietlisbach M, Gerber H. Learning manual skills in anesthesiology: Is there a recommended number of cases for anesthetic procedures? *Anesth Analg*. 1998;86(3):635–639
13. Mulcaster JT, Mills J, Hung OR, et al. Laryngoscopic intubation: learning and performance. *Anesthesiology*. 2003;98(1):23–27
14. Leone TA, Rich W, Finer NN. Neonatal intubation: success of pediatric trainees. *J Pediatr*. 2005;146(5):638–641
15. DiRusso SM, Sullivan T, Risucci D, Nealon P, Slim M. Intubation of pediatric trauma patients in the field: predictor of negative outcome despite risk stratification. *J Trauma*. 2005;59(1):84–90, discussion 90–91
16. Falck AJ, Escobedo MB, Baillargeon JG, Villard LG, Gunkel JH. Proficiency of pediatric residents in performing neonatal endotracheal intubation. *Pediatrics*. 2003;112(6 pt 1):1242–1247
17. Bismilla Z, Finan E, McNamara PJ, LeBlanc V, Jefferies A, Whyte H. Failure of pediatric and neonatal trainees to meet Canadian Neonatal Resuscitation Program standards for neonatal intubation. *J Perinatol*. 2010;30(3):182–187
18. Nishisaki A, Donoghue AJ, Colborn S, et al. Effect of just-in-time simulation training on tracheal intubation procedure safety in the pediatric intensive care unit. *Anesthesiology*. 2010;113(1):214–223
19. Sagarin MJ, Barton ED, Chng YM, Walls RM; National Emergency Airway Registry Investigators. Airway management by US and Canadian emergency medicine residents:

- a multicenter analysis of more than 6,000 endotracheal intubation attempts. *Ann Emerg Med.* 2005;46(4):328–336
20. Walls RM, Brown CA III, Bair AE, Pallin DJ; NEAR II Investigators. Emergency airway management: a multi-center report of 8937 emergency department intubations. *J Emerg Med.* 2011;41(4):347–354
21. McGaghie WC, Issenberg SB, Cohen ER, Barsuk JH, Wayne DB. Medical education featuring mastery learning with deliberate practice can lead to better health for individuals and populations. *Acad Med.* 2011;86(11):e8–e9
22. Barsuk JH, McGaghie WC, Cohen ER, O'Leary KJ, Wayne DB. Simulation-based mastery learning reduces complications during central venous catheter insertion in a medical intensive care unit. *Crit Care Med.* 2009;37(10):2697–2701
23. Di Marco P, Scattoni L, Spinoglio A, et al. Learning curves of the Airtraq and the Macintosh laryngoscopes for tracheal intubation by novice laryngoscopists: a clinical study. *Anesth Analg.* 2011;112(1):122–125
24. Howard-Quijano KJ, Huang YM, Matevosian R, Kaplan MB, Steadman RH. Video-assisted instruction improves the success rate for tracheal intubation by novices. *Br J Anaesth.* 2008;101(4):568–572

---

(Continued from first page)

Dr Sanders revised the data collection instruments, drafted the initial manuscript, revised the manuscript, coordinated and supervised data collection at one of the 15 sites, critically reviewed the manuscript, and approved the final manuscript as submitted; Dr Giuliano drafted the initial manuscript, revised the manuscript, coordinated and supervised data collection at one of the 15 sites, critically reviewed the manuscript, and approved the final manuscript as submitted; Dr Sullivan revised the manuscript, coordinated and supervised data collection at one of the 15 sites, critically reviewed the manuscript, and approved the final manuscript as submitted; Dr Brown revised the manuscript, supervised the central data coordinating center, monitored data completeness, validation, and compliance for the 15 sites, critically reviewed the manuscript, and approved the final manuscript as submitted; Dr Walls developed the original registry elements, mentored the NEAR4KIDS investigator team, critically reviewed the manuscript, and approved the final manuscript as submitted; Dr Nadkarni conceptualized and designed the study, reviewed and revised the data collection instruments, mentored the NEAR4KIDS investigators and PALISI investigators interface, drafted, critically reviewed and revised the manuscript, and approved the final manuscript as submitted; Dr Nishisaki conceptualized and designed the study, designed and revised the data collection instruments, directed and managed the central data coordinating center, carried out the initial analyses, drafted the initial manuscript, revised the manuscript, coordinated and supervised data collection at one of the 15 sites, critically reviewed the manuscript, and approved the final manuscript as submitted; The Pediatric Acute Lung Injury and Sepsis Investigators (PALISI) network reviewed and endorsed the study as a quality improvement research project; and The National Emergency Airway Registry for Children (NEAR4KIDS) Investigators reviewed and revised the data collection instruments, contributed data from the 15 sites, reviewed and approved the final manuscript as submitted.

[www.pediatrics.org/cgi/doi/10.1542/peds.2012-2127](http://www.pediatrics.org/cgi/doi/10.1542/peds.2012-2127)

doi:10.1542/peds.2012-2127

Accepted for publication Nov 12, 2012

Address correspondence to Ronald C. Sanders, Jr, MD, MS, Section of Pediatric Critical Care, Department of Pediatrics, UAMS/Arkansas Children's Hospital, 1 Children's Way, Slot 512-12, Little Rock, AR 72202-3591. E-mail: [rcsanders@uams.edu](mailto:rcsanders@uams.edu)

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2013 by the American Academy of Pediatrics

**FINANCIAL DISCLOSURE:** Dr Walls is a partner with the Airway Management Education Center.

**FUNDING:** This study was supported by AHRQ 1R03HS021583-01 and Endowed Chair, Critical Care Medicine, The Children's Hospital of Philadelphia.

## Level of Trainee and Tracheal Intubation Outcomes

Ronald C. Sanders Jr, John S. Giuliano Jr, Janice E. Sullivan, Calvin A. Brown III, Ron M. Walls, Vinay Nadkarni, Akira Nishisaki and for the National Emergency Airway Registry for Children Investigators and Pediatric Acute Lung Injury and Sepsis Investigators Network

*Pediatrics* 2013;131:e821; originally published online February 11, 2013;  
DOI: 10.1542/peds.2012-2127

<b>Updated Information &amp; Services</b>	including high resolution figures, can be found at: <a href="http://pediatrics.aappublications.org/content/131/3/e821.full.html">http://pediatrics.aappublications.org/content/131/3/e821.full.html</a>
<b>References</b>	This article cites 22 articles, 4 of which can be accessed free at: <a href="http://pediatrics.aappublications.org/content/131/3/e821.full.html#ref-list-1">http://pediatrics.aappublications.org/content/131/3/e821.full.html#ref-list-1</a>
<b>Permissions &amp; Licensing</b>	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: <a href="http://pediatrics.aappublications.org/site/misc/Permissions.xhtml">http://pediatrics.aappublications.org/site/misc/Permissions.xhtml</a>
<b>Reprints</b>	Information about ordering reprints can be found online: <a href="http://pediatrics.aappublications.org/site/misc/reprints.xhtml">http://pediatrics.aappublications.org/site/misc/reprints.xhtml</a>

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2013 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

