

# Rapid Sequence Intubation for Pediatric Emergency Patients: Higher Frequency of Failed Attempts and Adverse Effects Found by Video Review

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**Study objective:** Using video review, we seek to determine the frequencies of first-attempt success and adverse effects during rapid sequence intubation (RSI) in a large, tertiary care, pediatric emergency department (ED).

**Methods:** We conducted a retrospective study of children undergoing RSI in the ED of a pediatric institution. Data were collected from preexisting video and written records of care provided. The primary outcome was successful tracheal intubation on the first attempt at laryngoscopy. The secondary outcome was the occurrence of any adverse effect during RSI, including episodes of physiologic deterioration. We collected time data from the RSI process by using video review. We explored the association between physician type and first-attempt success.

**Results:** We obtained complete records for 114 of 123 (93%) children who underwent RSI in the ED during 12 months. Median age was 2.4 years, and 89 (78%) were medical resuscitations. Of the 114 subjects, 59 (52%) were tracheally intubated on the first attempt. Seventy subjects (61%) had 1 or more adverse effects during RSI; 38 (33%) experienced oxyhemoglobin desaturation and 2 required cardiopulmonary resuscitation after physiologic deterioration. Fewer adverse effects were documented in the written records than were observed on video review. The median time from induction through final endotracheal tube placement was 3 minutes. After adjusting for patient characteristics and illness severity, attending-level providers were 10 times more likely to be successful on the first attempt than all trainees combined.

**Conclusion:** Video review of RSI revealed that first-attempt failure and adverse effects were much more common than previously reported for children in an ED. [Ann Emerg Med. 2012;xx:xxx.]

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## INTRODUCTION

### Background

Rapid sequence intubation (RSI) is the standard for definitive airway management in emergency medicine.<sup>1-4</sup> The administration, in rapid succession, of sedative and neuromuscular-blocking medications is designed to optimize conditions for emergency intubation while limiting the risk of patient harm. RSI is reported to be a highly successful and safe procedure among adult emergency department (ED) patients,<sup>1,2,4</sup> with one multicenter study reporting success on the first attempt for 85% of these patients.<sup>2</sup> Children are thought to be at greater risk during emergency intubation, for both failed attempts and adverse effects.<sup>1</sup> To our knowledge,

there are few studies that report pediatric-specific data for RSI in an ED, all of which have important limitations.<sup>3,5-9</sup>

In a report from the National Emergency Airway Registry, 156 children (18 years or younger) had tracheal intubation attempted in an ED setting, including 1 pediatric ED. For the 127 children who underwent RSI, 78% were tracheally intubated on the first attempt and 16% had at least 1 adverse effect (including 2% with desaturation, 7% with mainstem intubation, and 4% with esophageal intubation).<sup>3</sup> In a separate retrospective study of 143 children tracheally intubated in a pediatric ED, bradycardia was reported in 4% of patients and hypoxemia in 22%.<sup>5</sup> These studies likely underreport the frequency of both first-attempt failure and adverse effects because of voluntary self-reporting or the limitations of chart review. Our clinical experience and quality assurance efforts

### Editor's Capsule Summary

#### *What is already known on this topic*

The relative rarity of pediatric tracheal intubation challenges both training and ongoing skills retention.

#### *What question this study addressed*

What is the frequency of first-attempt success and adverse effects during rapid sequence intubation in a large tertiary care pediatric emergency department?

#### *What this study adds to our knowledge*

This review of 114 videotaped rapid sequence intubation events observed first-attempt success in 52%, oxygen desaturation in 33%, cardiopulmonary resuscitation in 2%, and a 3-minute median duration from induction to final endotracheal tube placement.

#### *How this is relevant to clinical practice*

This study demonstrates suboptimal performance for this uncommon but critical procedure.



**Figure 1.** View from ceiling-mounted video camera.

suggested that failed first attempts and adverse effects occur more commonly than reported for pediatric emergency patients undergoing RSI.

### Importance

RSI is among the most common critical procedures performed for pediatric emergency patients and should be a high priority for quality assurance efforts.<sup>9-11</sup> First-attempt success is used as a measure of the quality of the RSI process and the ease of tracheal intubation.<sup>2,3</sup> The failure of early attempts at tracheal intubation may deplete a patient's oxygen reserve, leading to physiologic deterioration of an already critically ill or injured child. An accurate description of the frequency of first-attempt success and adverse effects of RSI for children in an ED setting will allow a better risk assessment and inform targeted interventions to reduce that risk.

### Goals of This Investigation

The goal of our study was to accurately and thoroughly describe the process, success, and safety of RSI for patients in a busy pediatric ED. Using video review, we specifically sought to determine the frequencies of first-attempt success and adverse effects for patients undergoing RSI in a pediatric ED.

## MATERIALS AND METHODS

### Study Design

We performed a retrospective, observational study, using video review as the primary method of data collection. Our

institutional review board approved our protocol before study commencement.

### Setting

We conducted our study in the ED of a tertiary care children's hospital, which is the major regional provider of emergency care to children and has approximately 90,000 annual visits. In this ED, critically ill or injured patients are managed in one of 4 resuscitation bays by a designated team, which includes emergency physician and nurse team leaders, a pediatric or emergency medicine resident, several bedside nurses, and a respiratory therapist. The physician team leader is either board certified in pediatric emergency medicine or a second- or third-year fellow in pediatric emergency medicine. For critically injured patients, the team also includes a general surgery resident, a surgical fellow or attending surgeon, and providers from anesthesiology and critical care. During the study period, no standard protocol for the practice of RSI was in place and video-assisted laryngoscopy was not routinely performed.

Since 2000, each of the ED resuscitation bays has had a ceiling-mounted digital camera, which records audio and video continuously. Video recording was instituted for peer review and quality assurance activities, and consent to review these videos is included in our ED's general consent for care. These cameras give a fixed view from above the foot of the patient's bed (Figure 1). Digital videos were automatically stored on a secure drive and deleted 60 days after the patient's visit.

### Selection of Participants

All children undergoing RSI in our ED between April 1, 2009, and March 31, 2010, were eligible for inclusion. We defined RSI as the administration, in rapid succession, of sedative and neuromuscular-blocking medications to facilitate tracheal intubation.<sup>1</sup> We excluded children intubated with other methods (sedative only or no medications because of cardiac arrest) and any who arrived tracheally intubated and did not require reintubation in the ED. If a patient received RSI during

separate ED visits, each visit was included as a unique encounter if it occurred during the study period.

### Data Collection and Processing

Using electronic tracking resources, we identified all patients evaluated in the resuscitation area during the study period. A study investigator then reviewed the medical records of these patients to determine whether RSI was performed in the ED. We ascertained subject capture through a review of separate patient lists, including ED deaths and admissions to an ICU or operating room within our institution. For patients who underwent RSI in the ED, the corresponding video was downloaded from the secure drive with a proprietary software program (VideoSphere; March Networks, Ottawa, Ontario, Canada). The software's video display included a time readout in hours, minutes, and seconds. Videos were reviewed separately from patient care and deleted after data collection.

Our methods generally conformed to published guidelines for both observational and chart review studies.<sup>12,13</sup> Three investigators (B.K., A.R., M.M.), all board certified in pediatric emergency medicine and experienced with video review, selected the data elements of interest, which were defined through consensus and use of the relevant literature. We collectively reviewed the medical and video/audio records of the first 5 study subjects to design and refine the data abstraction form. Each of 3 investigators collected data on one third of the remaining patients. When an investigator was involved in a subject's clinical care, all data for that subject were collected by one of the other investigators.

Video review was the primary source for all study data; if a data point was unavailable or unclear from the video, it was obtained from the medical record or consensus review. If not recorded in the medical record, the data element was considered missing for that subject.

To allow an assessment of the reliability of video review, a second investigator (A.R. or M.M.) reviewed videos and collected data on 12% of subjects. For dichotomous data, we calculated both the percentage of agreement between reviewers and a corresponding  $\kappa$  statistic (95% confidence interval [CI]). For continuous data elements and discrete elements of sufficient range, we used Kendall's  $\tau$  to assess the correlation of paired observations.

We collected data on patient characteristics, the RSI process, and the intubating providers. As a proxy for severity of illness, we obtained each patient's 24-hour Pediatric Risk of Mortality score (PRISM II).<sup>14</sup> PRISM II is routinely calculated for all patients admitted to our institution's pediatric ICU. For study patients not admitted to the pediatric ICU, we calculated the PRISM II score with standard methods.<sup>15</sup> Diagnostic category was based on the primary diagnosis assigned to the subject on discharge from the ED. Indication for tracheal intubation was defined by consensus review with a modification of a published scheme.<sup>16</sup> We defined physician type for the provider performing the first attempt at intubation, using a combination of training level (postgraduate year) and discipline. Physician

types were pediatric resident, emergency medicine resident, pediatric emergency medicine fellow, pediatric ICU fellow, pediatric emergency medicine attending physician, and providers from anesthesiology. Using video review, we collected various time data from the RSI process, including the decision to perform RSI, the administration of associated medications, and the initiation and duration of laryngoscopy.

### Outcome Measures

Our primary outcome was first-attempt success, measured as the number of patients with successful tracheal intubation on the first attempt at laryngoscopy. We defined a tracheal intubation attempt as a single insertion of a laryngoscope blade into a subject's mouth, with the intent of inserting an endotracheal tube into the trachea, whether or not endotracheal tube placement was attempted.<sup>2-4,17-19</sup> We defined successful intubation as the placement of an endotracheal tube distal to the glottis, which we judged to have occurred through a combination of video evidence of clinical confirmation, particularly end-tidal CO<sub>2</sub> measurement, and the patient's clinical course after intubation.

Our secondary outcome was the occurrence of adverse effects, measured as the number of patients with video evidence of 1 or more adverse effects during RSI.<sup>2,16</sup> An adverse effect was deemed to be associated with RSI if it occurred between administration of the first RSI sedative and the securing of the final endotracheal tube. We included among adverse effects episodes of physiologic deterioration, specifically oxyhemoglobin desaturation, bradycardia, hypotension, and the performance of cardiopulmonary resuscitation (CPR). Oxyhemoglobin desaturation, bradycardia, and hypotension were defined by video evidence of the resuscitating team's recognizing or addressing the episode, as continuous vital sign data were unavailable. For desaturation, we required the team to verbalize a desaturation to less than 90% and, if the intubation attempt was unsuccessful, to stop the attempt and initiate bag-valve-mask ventilation. For bradycardia and hypotension, the team needed to verbalize the onset of either during RSI. For primary data collection, we did not review the written record to identify additional episodes of physiologic deterioration not evident on video review.

We attempted to identify the following adverse effects with only video review: nonairway intubation, inadequate paralysis (vocalization, biting, or general movement at the first attempt), vomiting, and endotracheal tube obstruction. The following adverse effects were identified with the aid of the medical record: mainstem bronchial intubation (confirmatory chest radiograph), aspiration (foreign material visualized in the airway or a combination of vomiting and new infiltrate on chest radiograph), pneumomediastinum, pneumothorax, and dental/oral injury.

To determine the magnitude of potential discrepancies between video review and written documentation, a trained research assistant blinded to all primary study data collected data from the written record for 3 study outcomes: first attempt

success, the occurrence of oxyhemoglobin desaturation, and the performance of CPR during RSI. Data sources for this review included the nursing record of the resuscitation and physician procedure notes.

### Primary Data Analysis

The unit of analysis was the patient visit, not the provider or attempt number. We included the first 5 subjects in the analysis, whose data were collected by consensus review. We tabulated all data and generated descriptive statistics for outcomes and data elements of interest.

We explored the association between physician type and first-attempt success. For this analysis, pediatric emergency medicine attending physicians and providers from anesthesiology were combined into one physician type (attending physician). We calculated the first-attempt success of each physician type; we report first-attempt success (as a percentage with 95% CI) for all trainees combined and the attending physician type. We also report the unadjusted odds ratio (95% CI) for the first-attempt success of the attending physician type compared with all physician trainees.

We used multivariable logistic regression to explore further the association between physician type (attending physician versus trainee) and first-attempt success, adjusting for covariates with demonstrated or potential associations with success: patient age (years), type of resuscitation (medical versus trauma), PRISM II score, and the presence of inadequate paralysis at the first attempt. For this step in our analysis, we report an adjusted odds ratio (95% CI) for first attempt success, again between the attending physician type and all trainees.

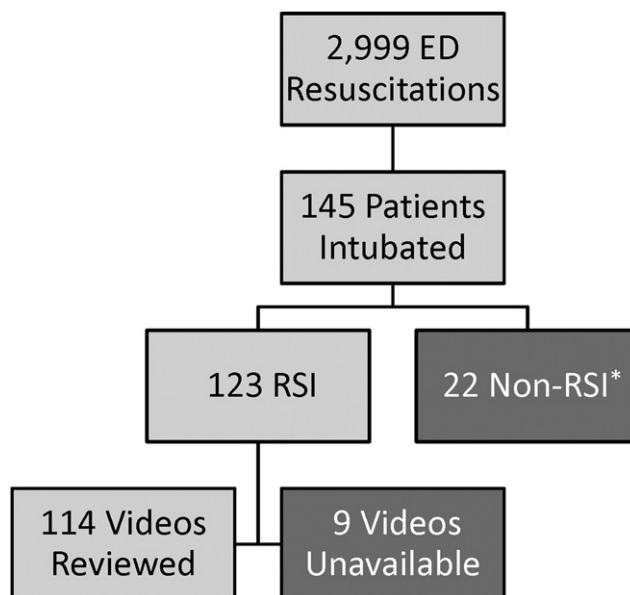
SAS software was used for all calculations (version 9.2; SAS Institute, Inc., Cary, NC).

## RESULTS

### Characteristics of Study Subjects

We reviewed the medical records of 2,999 patients who were managed in the ED resuscitation area during the 12-month study period. We identified 145 patients who underwent intubation, 123 of whom met our definition of RSI (4% of all patients reviewed) and made up our study sample. Of these 123 patients, 122 were identified through the initial chart review and 1 from a list of pediatric ICU admissions. We obtained videos for 114 of 123 subjects (93%); 9 videos were unavailable for review because of automated deletion from the secured drive (Figure 2). Few data elements were missing for study subjects: presence of a cervical collar (1 subject), PRISM II score (3 subjects), any airway assessment (1 subject), difficult airway examination (1 subject), patient positioning for tracheal intubation (1 subject), the performance of preoxygenation (3 subjects), and the time a clear decision to tracheally intubate was made (12 subjects).

Characteristics of the study sample are summarized in Table 1. Only 2 patients were older than 18 years: a 48-kg 23-year-old with special health care needs and a 22-year-old patient with alcohol intoxication. A third of subjects were younger than 12



**Figure 2.** Study subjects. \*For these 22 patients, 21 were in cardiopulmonary arrest and no meds were given for intubation and 1 patient received sedation only prior to intubation.

months, and a third weighed less than 10 kg. Two subjects had a syndrome with associated craniofacial abnormalities; no other child had a known anatomic abnormality of the mouth, throat, larynx, or trachea. The leading indications for tracheal intubation were a failure of oxygenation (22 subjects) or ventilation (20 subjects), followed by head injury (17 subjects), seizure (16 subjects), apnea caused by infection (12 subjects), and altered mental status (11 subjects). None of the 114 subjects died in the ED; 5 died during the corresponding hospitalization.

A second reviewer collected data for 14 subjects (12% of the sample). For first-attempt success, our primary outcome, agreement between reviewers was 100% and the  $\kappa$  statistic was 1.0. Reviewer agreement was 93%, with a  $\kappa$  of 0.85 (95% CI 0.57, 1.0), for both the occurrence of desaturation and for episodes of bradycardia during RSI. Agreement was 100% and the  $\kappa$  statistic was 1.0 for the identification of the provider performing the first attempt. For most time points, including the times of first sedative administration, first laryngoscopy, and the final securing of the endotracheal tube, Kendall's  $\tau$  was at least 0.97.

Tracheal intubation was successful on the first attempt for 59 of 114 study subjects (52%; 95% CI 43% to 61%). Twenty-five subjects (22%) were tracheally intubated on the second attempt, and 30 (26%) required 3 or more attempts. All but 1 subject were tracheally intubated by the fifth attempt (1 required 9 attempts) in the ED. Direct laryngoscopy was used for all but 1 subject, who was tracheally intubated on the first attempt with a video laryngoscope, used during a brief trial of the equipment in the ED. No rescue methods, eg, laryngeal mask airways, were used for any subject and no surgical airways were performed.



**Table 1.** Demographic and health characteristics.\*

Demographics	Result
Age, y	2.4 (0.4, 10.1)
Weight, kg	13 (5.7, 38)
Sex, female	54 (47)
<b>Presenting characteristics</b>	
Medical resuscitation (nontrauma)	89 (78)
Cervical collar (n=113)	21 (19)
Hypoxemic or supplemental oxygen (n=108) <sup>†</sup>	52 (48)
<b>Vital signs on arrival<sup>†</sup></b>	
Normal pulse rate and blood pressure	66 (58)
Abnormal pulse rate	42 (37)
Hypotension	14 (12)
Abnormal pulse rate and hypotension	8 (7)
<b>Clinical characteristics</b>	
PRISM II (n=111)	6 (2, 12)
<b>Diagnostic category<sup>§</sup></b>	
Neurologic	39 (34)
Respiratory (lower tract)	29 (26)
Trauma <sup>  </sup>	21 (18)
Shock	13 (11)
Other	12 (11)
<b>Disposition from the ED</b>	
<b>ICU</b>	
Pediatric	90 (79)
Neonatal	13 (11)
Cardiac	2 (2)
Operating room <sup>¶</sup>	6 (5)
Transfer to outside facility <sup>#</sup>	3 (3)

\*Data are presented as number of patients (% of 114, unless indicated) or median (IQR).

<sup>†</sup>First oxyhemoglobin saturation less than 90% (written record) or receiving supplemental oxygen on arrival (video review).

<sup>‡</sup>Based on first recorded vital signs and age-based normals (pediatric advanced life support).

<sup>§</sup>"Neurologic" included seizures and altered mental status. "Respiratory—lower tract" included asthma, pneumonia, and bronchiolitis. "Trauma" included head injuries. "Shock" included any form of shock, including metabolic, septic, cardiogenic, and hypovolemic. "Other" included upper airway obstruction (3), burns/asphyxia (4), intoxication (4), and intra-abdominal process (1).

<sup>||</sup>Seven traumatically injured patients had a diagnostic category other than "trauma."

<sup>¶</sup>One subject was discharged to the floor after postoperative extubation and the other 5, to the pediatric ICU.

<sup>#</sup>One subject, a 22-year-old woman tracheally intubated for alcohol intoxication, was transferred to the nearest adult facility and 2, to the local burn center.

Seventy subjects (61%; 95% CI 52% to 70%) experienced at least 1 adverse effect during RSI, and 35 (31%; 95% CI 23% to 40%) experienced more than 1. The most common adverse effects were physiologic deterioration (primarily oxyhemoglobin desaturation), right mainstem intubation, and nonairway intubation (Table 2). The depth of desaturation was available for 29 of the 38 subjects with an episode identified during RSI. Among these 29 subjects, 22 (76%) had desaturation to below 80% and 10 (29%) to less than 60%. Two subjects with a perfusing rhythm became pulseless after physiologic deterioration during RSI; each received chest compressions and intravenous epinephrine. Both children were tracheally intubated on the third attempt, had a subsequent return of spontaneous circulation, and survived to hospital discharge. We

**Table 2.** Adverse effects during RSI.

Physiologic Deterioration	No. (% of 114)
Any episode	45 (39)
1 episode	23 (20)
2 or more episodes	22 (19)
Desaturation	38 (33)
Bradycardia	5 (4)
Hypotension	4 (4)
CPR*	2 (2)
<b>Other adverse effects</b>	
Right mainstem tracheal intubation <sup>†</sup>	34 (30)
Left hemithorax opacification <sup>†</sup>	5 (4)
<b>Nonairway tracheal intubation<sup>§</sup></b>	
Detected	20 (18)
Undetected	1 (1)
Inadequate paralysis (first attempt)	11 (10)
Vomiting	8 (7)
Dental/oral injury	1 (1)

RSI, Rapid sequence intubation.

\*Patients with a perfusing rhythm who became pulseless and required chest compressions during RSI.

<sup>†</sup>Final radiologist impression of the confirmatory radiograph.

<sup>‡</sup>On confirmatory chest radiograph. Presumes complete atelectasis of the left lung in association with right mainstem intubation.

<sup>§</sup>An endotracheal tube placed outside the airway. "Detected" indicates misplacement identified by clinical confirmation. "Undetected" indicates misplacement not immediately recognized; this patient was tracheally reintubated after the secured endotracheal tube was found to be supraglottic on the confirmatory radiograph.

did not identify any occurrences of aspiration, pneumothorax, or pneumomediastinum for any subject.

Focused review of the written record revealed marked variation in the documentation of important aspects of the RSI process, as well as notable discrepancies with findings from video review. The nursing record of the resuscitation (n=83) and the physician procedure note (n=67) were the sources that most frequently contained documentation of the number of attempts. In the nursing record, first-attempt success was 64% (53 of 83) and in the procedure note 58% (39 of 67), representing absolute differences from video review of 12% and 6%, respectively. The written records of 108 subjects either referenced or specifically included physiologic data collected during RSI. Oxyhemoglobin desaturation during RSI was documented for 20 (19%) of these subjects, a difference of 21% compared with video review. Of the 38 subjects observed on video review to experience desaturation during RSI, 20 (53%) had no corresponding documentation in the written record. Only 1 of the 2 subjects who underwent CPR during RSI had documentation in the written record that CPR was performed.

Characteristics of the RSI process are reported in Table 3 and important intervals in Table 4. Nearly one quarter of subjects received less than 3 minutes of preoxygenation. The median time from a verbalized decision to tracheally intubate to final endotracheal tube insertion was 11.8 minutes (interquartile range 8.3, 17.6). In almost 25% of subjects, the duration of laryngoscopy on the first attempt, during which the patient was

**Table 3.** Characteristics of the RSI process.\*

Arrival Assessment	No. (%)
Airway adjuncts used <sup>†</sup>	12 (11)
Airway assessed <sup>†</sup>	40 (35)
Difficult airway examination performed <sup>§</sup>	11 (10)
<b>Preparation</b>	
Patient positioned for tracheal intubation <sup>  </sup>	80 (71)
Preoxygenation >3 min <sup>¶</sup>	86 (77)
<b>RSI sedative</b>	
Etomidate	104 (91)
Other <sup>#</sup>	10 (9)
<b>RSI paralytic</b>	
Succinylcholine	87 (76)
Rocuronium	18 (16)
Vecuronium	9 (8)

\*Data are presented as number of patients (% of 114, unless indicated).  
<sup>†</sup>Oral or nasopharyngeal airway.  
<sup>‡</sup>Any general airway examination as a part of the initial assessment, including statement of "airway clear," n=113.  
<sup>§</sup>Any component of a specific difficult airway examination,<sup>1</sup> n=113.  
<sup>||</sup>Any positioning, including raising the bed, pulling the patient up in the bed, or placing a shoulder roll, n=113.  
<sup>¶</sup>Recommended minimum duration for adequate preoxygenation,<sup>1</sup> n=111.  
<sup>#</sup>Ketamine (3), midazolam (2), lorazepam (2), thiopental (2), and fentanyl (1).

apneic and not receiving oxygen or ventilation, was more than 1 minute.

A physician trainee (resident or fellow) performed the first attempt for 84% (96 of 114) of the sample and was in the first 3 years of postgraduate training for 46%. First-attempt success varied by physician type (Figure 3). A physician trainee successfully tracheally intubated 43 of 96 subjects (45%; 95% CI 35% to 55%) on the first attempt; attending providers were successful on the first attempt for 16 of the remaining 18 subjects (89%; 95% CI 67% to 97%). The unadjusted odds ratio for first-attempt success by an attending physician compared with a trainee was 9.9 (95% CI 2.2 to 45.3). After adjusting for patient age, resuscitation type, PRISM II score, and inadequate paralysis, attending providers were still 10 times more likely to be successful on the first attempt (adjusted odds ratio 10.2; 95% CI 2.1 to 50.9).

For the 9 eligible subjects whose videos were unavailable for review, we performed a sensitivity analysis for our main outcomes, using the written record for a select number of data elements. For these subjects, the median age was 4.3 years and 7 (78%) were medical resuscitations. Seven of 9 subjects were tracheally intubated on the first attempt (78%), with attempt number unclear for 1 patient. Four patients had documentation of an adverse effect in association with RSI: 3 with right mainstem intubation by confirmatory radiograph and 1 with an episode of oxyhemoglobin desaturation. None of the 9 patients had documentation of pulseless arrest in the ED, and all survived to hospital discharge. According to findings from the written record, the inclusion of these subjects in our study sample would not have meaningfully changed the results for the primary or secondary outcomes.

**Table 4.** Timing of the RSI process (median time in minutes or seconds; n=114 unless indicated).

Interval	Median (IQR)
Arrival to decision, min*	15.7 (6.3, 32.6)
Decision to sedative, min <sup>†</sup>	7.4 (3.8, 10.7)
<b>Sedative to final ETT placement, min</b>	3.2 (1.9, 7.5)
Sedative to laryngoscopy, s <sup>‡</sup>	90 (66, 132)
Laryngoscopy to final ETT, s	72 (30, 246)
Final ETT placement to securing, min <sup>§</sup>	3.6 (2.9, 4.3)
Duration of first attempt, s <sup>  </sup>	36 (24, 54)

ETT, Endotracheal tube.

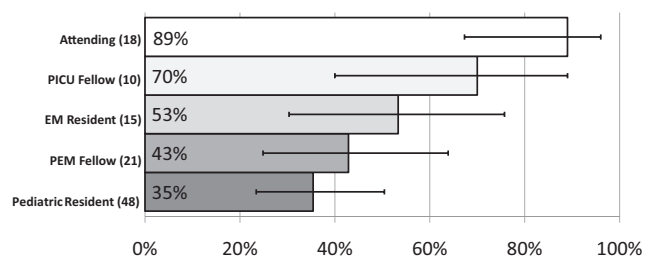
\*Verbalized decision to intubate, n=102 for time of decision. Results are shown only for 102 subjects with full data.

<sup>†</sup>First sedative medication used for RSI. Visual evidence of administration was used if no clear statement of administration was made. Results are shown for the 102 subjects with full data.

<sup>‡</sup>First insertion of the laryngoscope blade after administration of the RSI paralytic medication.

<sup>§</sup>Represents the time required for clinical confirmation, including auscultation and end-tidal CO<sub>2</sub> monitoring, and taping or otherwise securing the final ETT.

<sup>||</sup>Insertion of the laryngoscope blade to removal.



**Figure 3.** First-attempt success by physician type (n=subjects per type). "Attending" is comprised of both attending physicians from Pediatric Emergency Medicine and providers from Anesthesiology. First attempt success was 88% (6 of 7 subjects) for PEM attendings and 91% (10 of 11 subjects) for providers from Anesthesiology. Two study subjects, whose first attempts were performed by a neonatology fellow and an otolaryngology resident, respectively, are not included in this figure. 95% confidence intervals for the first attempt success of each physician type are indicated by the "error" lines: Attending (67%, 97%), PICU Fellow (40%, 89%), EM Resident (30%, 75%), PEM Fellow (25%, 64%), and Pediatric Resident (23%, 50%).

## LIMITATIONS

Our study has several limitations. First, the investigators who reviewed videos for data collection were not blinded to the study's objectives, which could have biased our determination of adverse effects especially. However, we used standard definitions from the relevant literature, and both measures of interreviewer agreement were high for adverse effects. Second, we relied on previously recorded videos from the resuscitation area and could not confirm clinical findings with direct observation, which also could have affected our determination of adverse effects. Because our definition of physiologic deterioration required verbalization or action by the care team, we assume that we still

underreported occurrence of these episodes. Third, we were unable to completely quantify the severity and duration of physiologic deterioration. We reported the depth of oxyhemoglobin desaturation for subjects with data available, and for three quarters of those measured, saturation decreased to below 80%. Moreover, even “mild” or brief episodes put a critically ill patient at risk for further deterioration. Fourth, data collection was limited to the ED. We did not attempt to assess whether an episode of deterioration complicated a patient’s subsequent course. Fifth, our study was conducted at a single academic pediatric center, which limits generalizability of our findings to other ED settings.

## DISCUSSION

RSI is a critical and often lifesaving procedure that, although infrequently performed in the pediatric ED, all emergency physicians must be able to perform successfully and safely. To our knowledge, we present data from the first detailed, video-based evaluation of pediatric RSI in the ED. For patients in a pediatric ED, we found a higher frequency of both failed first attempts and adverse effects than previously reported in association with RSI. Two children had physiologic deterioration during RSI severe enough to require CPR.

There are several potential reasons why we found a lower frequency of first-attempt success than was found in previous studies. First, we strictly defined a tracheal intubation attempt, thereby capturing brief attempts that might otherwise have been unreported, eg, those quickly aborted because of inadequate paralysis. We chose to count even brief attempts because any laryngoscopy can increase vagal tone and lead to bradycardia, laryngospasm, vomiting, and oral trauma. In addition, every attempt contributes to the total duration of laryngoscopy, during which the patient is apneic and not receiving oxygenation or ventilation. Second, our use of video review revealed more frequent first-attempt failure and episodes of physiologic deterioration than was documented in the written record. The discrepancies between video review and written records in our study highlight the limitations of the methodologies used by previous studies, which almost certainly underestimated the above outcomes. Third, a higher proportion of first attempts in our study was performed by pediatric trainees, who have been reported to be less proficient with tracheal intubation than counterparts in other disciplines.<sup>3,20</sup> Physician trainee experience with critical procedures such as tracheal intubation, especially for pediatric trainees, has declined dramatically in the last 15 years.<sup>11,18</sup> In the National Emergency Airway Registry study, only 10% of tracheal intubations were attempted by pediatric residents, which may partially explain their higher percentage of first-attempt success.<sup>3</sup>

We found a higher frequency of adverse effects than reported in either the National Emergency Airway Registry study or, to a lesser extent, in the retrospective study by Fastle and Roback.<sup>5</sup> In the National Emergency Airway Registry study, the combination of self-reporting and convenience sampling likely resulted in falsely low estimates of both attempt failure and

adverse effects. Capture rate was not reported, and the outcomes for missed patients may have differed considerably. Also, the detection of adverse effects depended on accurate recording in the written record. As noted above, we believe that differences in methodology explain most of the observed differences between our study and the existing literature and that the true frequencies of first-attempt failure and adverse effects for children undergoing RSI in an ED are closer to our findings.<sup>10,21-24</sup>

To our knowledge, our study is the first to report a detailed description of the timing of the RSI process for ED patients, making possible an objective evaluation of published recommendations for the duration of various RSI intervals. The *Manual of Emergency Airway Management*,<sup>1</sup> a standard reference for airway management in emergency medicine, suggests that once the decision to perform RSI has been made, the entire process should take approximately 11 minutes, from preparation to final placement of the endotracheal tube. An evidence basis for this recommendation is not provided. In our study, the time from the decision to intubate to final endotracheal tube insertion was 11 minutes or less for 45% of patients and was longer than 20 minutes for 16%. The suggested duration from the administration of sedative and paralytic medications through confirmation of endotracheal tube position is approximately 60 seconds.<sup>1</sup> For a similar interval (administration of RSI sedative through final endotracheal tube placement), this mark was achieved for 3 study subjects; the median for this interval was 3 minutes and for 20 subjects was 10 minutes or more. Although Neonatal Resuscitation Program guidelines were developed for the resuscitation of neonates in a delivery room and not for children in an ED, they provide a published recommendation for the duration of laryngoscopy during emergency tracheal intubation, suggesting the “tracheal intubation procedure” should be completed within 30 seconds.<sup>25</sup> The majority of our subjects had laryngoscopy times on the first attempt alone of longer than 30 seconds, with nearly 20% of first attempts lasting more than a minute.

Our findings suggest that there may be considerable room for improvement in the practice of RSI for children in pediatric EDs, although additional studies with similar methodology need to be performed to determine the generalizability of our findings. We continue to study RSI in our ED to identify those aspects of the process that are both modifiable and associated with physiologic deterioration. Results of these investigations will inform targeted improvement efforts to improve the efficacy and safety of this lifesaving procedure for our patients. The low success rate of trainees and, in particular, pediatric residents raises the question of whether they should be performing this procedure in the ED. The answer to this question depends on whether physiologic deterioration is related to the failure of early attempts, but the data and analyses presented in this report do not address this question. In the short term, we are attempting to standardize the RSI process at our institution



through the development of a formal protocol, which will include data-driven recommendations for the timing of the process. Video laryngoscopy is now used in our ED, and its routine application may improve rates of first-attempt success, especially that of trainees.

To our knowledge, our study is the first to use video review to study pediatric RSI in the ED setting. Although video review was time consuming, this method allowed a more objective review of ED care, often repeatedly and slower than real time, offering significant advantages over operator self-report.<sup>21-23,26-28</sup> Other authors have noted the value of video review for quality assurance and peer review, specifically for resuscitations.<sup>27</sup>

In summary, video review of RSI allowed a detailed description of the success, safety, and timing of this procedure. More important, it revealed that first-attempt failure and adverse effects were much more common than previously reported for pediatric emergency patients, despite their being cared for in a high-volume, tertiary care pediatric ED. This is concerning, given that RSI is an often lifesaving procedure performed for critically ill patients, who cannot afford the potentially serious consequences of failed attempts and further deterioration. Our findings ought to motivate every institution that cares for pediatric emergency patients to review the efficacy and safety of the RSI process for their patients.

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