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Respiratory Therapist Intubation Practice in Pediatric ICUs: A Multicenter Registry Study

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BACKGROUND: Tracheal intubation by respiratory therapists (RTs) is a well-established practice that has been described primarily in adult and neonatal patients. However, minimal data exist regarding RTs' intubation performance in pediatric ICUs. The purpose of this study was to describe the current landscape of intubations performed by RTs in pediatric ICUs. METHODS: A multicenter quality improvement database, the National Emergency Airway Registry for Children (NEAR4KIDs) was queried from 2015 to 2018. We performed a retrospective analysis of prospectively collected data on subject demographics, indication for intubation, difficult airway history and feature presence, provider discipline, medications, and device. Intubation outcomes included first-attempt and overall success rates, adverse events, and oxygen desaturation (ie, S_{pO_2} < 80%). Overall intubation success was defined as intubation achieved in ≤ 2 attempts. RESULTS: There were 12,056 initial intubation encounters from 46 ICUs, with 109 (0.9%) first attempts performed by RTs. Nine (20%) ICUs reported at least one intubation encounter by RTs. The number of intubations performed by RTs at individual centers ranged from 1 to 46 (RT participation rate: 0.3% to 19.6%). RTs utilized video laryngoscopy more often than other providers (53.2% for RTs vs 28.1% for others, *P* < .001). RTs' first attempt success (RT 60.6% vs other 69.2%, *P* = .051), overall success (RT 76.2 % vs other 82.4%, *P* = .087), and oxygen desaturation S_{pO_2} < 80% (RT 16.5% vs other 16.9%, *P* = .91) were similar to other providers. Adverse events were more commonly reported in intubations by RTs versus by other providers (22.9% vs 13.8%, *P* = .006). CONCLUSIONS: RTs infrequently intubate in pediatric ICUs, with success rates similar to other providers but higher adverse event rates. RTs were more likely to use video laryngoscopy than other providers. RTs' intubation participation, success, and adverse event rates varied greatly across pediatric ICUs. *Key words: endotracheal intubation; respiratory therapist; respiratory care practitioner; RT; pediatric critical care; airway management; intubation.* [Respir Care 0;0(0):1–●. © 0 Daedalus Enterprises]

Introduction

Tracheal intubation is a common procedure in pediatric ICUs to initiate invasive mechanical ventilation, enable inter- or intrafacility transport, facilitate procedures, and protect a patient's airway.[1] Intubation in pediatric patients

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is associated with high rates of adverse events (AEs).[2-4] Critically ill pediatric patients carry an increased risk of complications during airway management due to a decreased physiologic reserve and high potential for severe cardiopulmonary deterioration, oxygen desaturation, hemodynamic compromise, and cardiac arrest.[5] More than one intubation attempt has been associated with progression to cardiac arrest.[6]

Tracheal intubation by respiratory therapists (RTs) has been described in several case series with success rates and complication rates similar to physicians.[7-12] However, recent data are limited and the existing literature consists of small, single-center studies of varying quality. Most of these investigations have been limited to neonates or adults.[7-10,12] The largest such study did include pediatric patients; however, these patients were not described as a specific subgroup.[11]

The purpose of this study was to describe RT intubation practice in pediatric critical care and compare RT outcomes with pediatric intubations by other providers using an international multicenter quality improvement database. The primary outcome was first-attempt success rate. Secondary outcomes were overall success rate, AE rate, and oxygen desaturation. We hypothesized that there would be no difference in first-attempt success rate in the intubations performed by RTs compared to those performed by physicians and advanced practice providers.

QUICK LOOK

Current knowledge

Respiratory therapists (RTs) providing tracheal intubation is a well-established practice with success and complication rates similar to those for physicians. However, available data are from single-center studies of adult and neonatal patients, and RTs providing tracheal intubation in critically ill pediatric patients has not been described.

What this paper contributes

RTs infrequently intubate in pediatric ICUs, and outcomes varied widely between centers. RT success rates were similar to those for other providers, although adverse event rates were higher during RT attempts. RTs were more likely to use video laryngoscopy, and video laryngoscopy was associated with fewer adverse events.

Methods

A multicenter quality improvement database, the National Emergency Airway Registry for Children (NEAR4KIDS), was queried for all intubations recorded between 2015 and 2018. The NEAR4KIDSs database includes 46 pediatric ICUs worldwide. Institutional review board approval was obtained at each center with a waiver of informed consent. Data were prospectively collected on patient demographics, indication for intubation, difficult airway history and feature presence, provider discipline, medications, and device using a standardized form. Individual centers developed a compliance plan to ensure that > 95% of intubations were captured in the database. The compliance officer for NEAR4KIDS reviewed the plan. A secondary verification was performed at each center via review of medical records.

Each intubation encounter was a priori defined as 1 episode of complete airway management, including intubation.[4] We included only primary intubation with the first approach. We excluded intubations for endotracheal tube change. A course was defined as a single method or approach (ie, direct laryngoscopy, awake vs sedated, standard vs rapid sequence) and one set of medications. One attempt was defined as an insertion of a device (eg, laryngoscope) into the oropharynx. AEs were defined as severe and nonsevere. Severe AEs included cardiac arrest, esophageal intubation with delayed recognition, emesis with witnessed aspiration, hypotension requiring treatment, laryngospasm, malignant hyperthermia, dental trauma, and air leak (pneumothorax or pneumomediastinum). Nonsevere AEs included mainstem bronchial intubation, emesis without aspiration, hypertension requiring intervention, epistaxis, lip trauma, dysrhythmias, and pain or agitation requiring additional medication that caused a delay in intubation.[4] Oxygen desaturation was defined as $S_{pO_2} < 80\%$, and severe desaturation was defined as $S_{pO_2} < 70\%$ in intubations with the highest $S_{pO_2} > 90\%$ after pre-oxygenation. Desaturation data included only intubation attempts in which S_{pO_2} was > 90% at the beginning of the course.

Our primary outcome was first-attempt success rate. Secondary outcomes included overall success rate, AEs, and instances of oxygen desaturation. Overall intubation success was defined as a successful placement of endotracheal tube within 2 attempts. We used descriptive statistics with proportion, chi-square, or Fisher exact tests for univariate analyses with dichotomous outcomes, and we used a multivariable logistic regression to control for potential patient and practice confounders. We included the potential confounders associated with RT intubation participation at the level of $P < .10$. Sensitivity analysis was performed including only centers in which RTs performed intubation.

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Table 1. Subject Demographics and Intubation Characteristics

	Intubation by Non-RTs	Intubation by RTs	*P*
Age category			.15
Infant (< 1 y)	5,523 (46)	48 (44)	
Young child (1–7 y)	3,557 (30)	36 (33)	
Child (8–17 y)	2,391 (20)	25 (23)	
Adult (≥ 18 y)	476 (4)	0 (0)	
Gender*			
Male	6,615 (55)	67 (61)	.20
Female	5,327 (45)	42 (39)	
Admission diagnosis			.02
Respiratory	5,493 (46)	45 (41)	
Cardiac	2,184 (18)	14 (13)	
Neurological	2,151 (18)	32 (29)	
Shock	1,040 (9)	8 (7)	
Trauma/traumatic brain injury	280 (2)	0 (0)	
Other/missing	799 (7)	10 (9)	
Indication for tracheal intubation			
Respiratory	7,442 (62)	63 (58)	.34
Neurological	1,285 (11)	25 (23)	< .001
Shock/hemodynamic instability	1,610 (13)	19 (17)	.23
Procedural	1,910 (16)	10 (9)	.053
Therapeutic hyperventilation	157 (1)	1 (1)	> .99
Difficult airway characteristics			
History of difficult airway	1,646 (14)	14 (13)	.78
Presence of difficult airway feature(s)	3,836 (32)	31 (28)	.41
Device			< .001
Direct laryngoscope	8,468 (71)	51 (47)	
Video laryngoscope	3,363 (28)	58 (53)	
Other/missing	116 (1)	0 (0)	

Data are presented as *n* (%). Intubation by Non-RTs: $n = 11,947$; Intubation by RTs: $n = 109$.
* Gender: $n = 12,051$.
RT = respiratory therapist

The overall analyses used an $\alpha = 0.05$ as statistical significance. Analyses were performed with SPSS 24 (IBM, Armonk, New York) and STATA 15.0 (StataCorp, College Station, Texas).

Results

Of 12,056 initial intubation encounters between January 2015 and September 2018, 109 (0.9%) were performed by RTs. Table 1 presents the subject demographics, indications, and approaches. A higher proportion of intubations by RTs (23% by RTs vs 11% by non-RTs, $P < .001$) took place in children with neurological indication), and a lower proportion of intubations were performed by RTs (9% by RTs vs 16% by non-RTs, $P = .053$) for a procedure. Intubation attempts by RTs utilized video laryngoscopy significantly more often (53% by RTs vs 28% by non-RTs, $P < .001$).

Intubation Outcomes

RTs' performance was similar to that of other providers: first-attempt success rate (60.6% for RTs vs 69.2% for others, $P = .051$), overall success rate (76.2% for RTs vs 82.4% for others, $P = .09$), and oxygen desaturation (ie, $S_{pO_2} < 80\%$) rate (16.5% for RTs vs 16.9% for others, $P = .91$) (Table 2). When compared to individual providers, the RT first-attempt success rate was lower than that of pediatric critical care medicine attending physicians (60.6% vs 77.6%, $P < .001$), pediatric critical care medicine physicians or pediatric emergency medicine fellows (60.6% vs 71.8%, $P = .01$), and subspecialist/physician assistant/other provider (60.6% vs 72.0%, $P = .01$). There was no significant difference in the first-attempt success rate between RTs and nurse practitioners (60.6% vs 62.3%, $P = .81$) or hospitalists (60.6% vs 56.5%, $P = .77$). RTs had a higher first-attempt success rate than resident physicians (60.6% vs 47.8%, $P = .01$). RT attempts were significantly associated with higher rates of AEs (RT 22.9% vs 13.8%, $P = .006$) and severe AEs (RT 11.0% vs 5.6%, $P = .02$). After adjusting for subject characteristics (ie, neurological indication, procedural indication) and device (ie, video laryngoscope use), an RTs intubation attempt was independently associated with higher odds of AEs; the odds ratio for any AE was 2.21 (95% CI 1.39–3.50, $P = .001$) (Table 3).

Variance Across ICUs

Nine of 46 pediatric ICUs (20%) reported at least one intubation encounter performed by RTs. The number of intubation attempts by RTs per center ranged from 1 to 46 (RT participation rate per center: 0.3% to 19.6%). Three centers reported 10 or more intubation attempts by RTs, with first-attempt success rates of 56.0%, 71.7%, and 73.3%; overall success rates of 80.0%, 82.6%, and 86.7%; and AE rates of 36.0%, 10.9%, and 33.3%, respectively (Table 4).

Subgroup Analysis: Intubations Performed by Respiratory Therapists

Among intubations performed by RTs (no. = 109), there was no difference in intubation outcomes across the different subject age groups (see the supplementary materials at http://www.rcjournal.com). A small number of intubations performed in children with a history of difficult airway ($n = 14$) had a significantly higher first-attempt success rate (86% vs 57%, $P = .044$), and a significantly lower AE rate (0% vs 26%, $P = .037$). There were no differences in primary and secondary outcomes in children with difficult

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Table 2. Tracheal Intubation Outcomes

	Intubation by Non-RTs	Intubation by RTs	*P*
Total intubation attempts	11,947	109	
First-attempt success rate	8,271 (69.2)	66 (60.6)	.064
Non-RT who performed intubation			
Pediatric critical care medicine attending	1,760 of 2,268 (77.6)	NA	<.001
Pediatric critical care medicine or pediatric emergency medicine fellow	4,119 of 5,734 (71.8)	NA	.01
Pediatrics/emergency medicine resident	634 of 1,327 (47.8)	NA	.01
Nurse practitioner	775 of 1,245 (62.3)	NA	.81
Hospitalist	26 of 46 (56.5)	NA	.77
Subspecialist/physician assistant/other	955 of 1,325 (72.0)	NA	.01
Overall success rate	9,848 (82.4)	83 (76.1)	.11
Adverse events*			
Any adverse event	1,651 (13.8)	25 (22.9)	.006
Severe adverse event	671 (5.6)	10 (11.0)	.02
Nonsevere adverse event	1,124 (9.4)	16 (14.7)	.061
Oxygen desaturation < 80%	2,022 (16.9)	18 (16.5)	.91
Oxygen desaturation < 70%	1,357 (11.4)	13 (11.9)	.85
Individual adverse event			
Esophageal intubation, immediate recognition	547 (4.6)	8 (7.3)	NA
Esophageal intubation, delayed recognition	53 (0.4)	1 (0.9)	NA
Vomit with aspiration	59 (0.5)	2 (1.8)	NA
Vomit without aspiration	77 (0.6)	0 (0)	NA
Mainstem intubation	308 (2.6)	4 (3.7)	NA
Dental trauma	40 (0.3)	0 (0)	NA
Lip trauma	73 (0.6)	2 (1.8)	NA
Laryngospasm	30 (0.3)	1 (0.9)	NA
Pneumothorax, pneumomediastinum	15 (0.1)	0 (0)	NA
Airway injury	7 (0.1)	0 (0)	NA
Epistaxis	13 (0.1)	1 (0.9)	NA
Hypotension requiring intervention	368 (3.1)	7 (6.4)	NA
Hypertension requiring medication	15 (0.1)	0 (0)	NA
Dysthymia	141 (1.2)	2 (1.8)	NA
Pain agitation	28 (0.2)	0 (0)	NA
Cardiac arrest, patient survived	133 (1.1)	3 (2.8)	NA
Cardiac arrest, patient died	18 (0.2)	0 (0)	NA

Data are presented as *n* (%). A *P* value was not calculated for individual tracheal intubation adverse events to avoid an alpha error due to multiple comparisons.
*Note that one intubation may have more than one adverse event. Therefore, the sum of the severe and nonsevere adverse events will not be equal to all adverse events.
RT = respiratory therapist
NA = not applicable

airway features versus those without (all $P > .05$). When compared to direct laryngoscopy, RT attempts with video laryngoscopy were associated with significant decreases in severe AE (20% versus 3.4%, $P = .004$ and any AE (35% vs 12%, $P = .004$) but no significant difference for first-attempt success rate (59% vs 63%, $P = .66$), overall success rate (82% vs 71%, $P = .15$), nonsevere AE (20% vs 10%, $P = .17$), or oxygen desaturation < 80% (18% vs 16%, $P = .77$).

Sensitivity Analysis of 9 Centers Where RTs Intubated

The RT first-attempt success rate was lower compared to pediatric critical care medicine attendings (60.6% vs 76.0%, $P = .002$), pediatric critical care medicine or pediatric emergency medicine fellows (60.6% vs 72.1%. $P = .01$), and subspecialists/physician assistant/other provider (60.6% vs 73.1%, $P = .02$) (see the supplementary materials at http://www.rcjournal.com). There were no differences between RTs and nurse practitioners (60.6% vs 63.8%, $P = .56$). Overall success was lower for RTs compared to other providers (76.1% vs 84.3%, $P = .02$). Any course AEs (22.9% vs 12.6%, $P = .002$), severe AEs (11.0% vs 5.8%, $P = .03$), and nonsevere AEs (14.7% vs 8.0%, $P = .01$) were higher in RT attempts compared to other providers. There were no differences for desaturation < 80% (16.5% vs 18.4%, $P = .62$) or desaturation < 70% (11.9% vs 12.5%, $P = .86$). Mutivariable logistic regression

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analysis revealed that RT intubation attempts were associated with an increased risk of AEs compared to other providers (odds ratio 2.03, 95% CI 1.26–3.30, $P = .004$) and a reduced risk of AEs when video laryngosopy was used (odds ratio 0.43, 95% CI 0.33–0.56, $P < .001$). There were no statistically significant associations for patient category or indication for intubation.

Discussion

In this investigation, RTs infrequently intubated critically ill children in pediatric ICUs. Intubation attempts by RTs utilized video laryngoscopy more often than attempts by other providers. First-attempt and overall intubation success rates were not significantly different compared to other providers, although RTs had a lower success rate in the sensitivity analysis of the 9 centers where RTs intubate. RTs had a lower first-attempt success rate than pediatric critical care medicine physicians and subspecialists but a similar success rate compared to nurse practitioners in both the primary analysis and the sensitivity analysis. Intubations performed by RTs had significantly more adverse AEs. This finding remained significant after adjusting for subject and practice differences between intubations by RTs and by other providers, but absolute differences in specific AEs were small, including esophageal intubation, oxygen desaturation, and direct airway injury. RT intubation practice also varied significantly across centers. Among intubations performed by RTs, video laryngoscopy use was associated with lower occurrence of AEs, without any differences in first-attempt or overall success rate.

Table 3. Multivariable Analysis of Association of Adverse Events and the RT Participation as Laryngoscopists

Variable	Odds Ratio (95% CI)	*P*
RT intubation attempt	2.21 (1.39–3.50)	.001
Admission diagnosis		
Respiratory	1.18 (0.94–1.49)	.15
Cardiac	1.17 (0.92–1.50)	.21
Neurological	0.83 (0.64–1.08)	.17
Shock	1.34 (1.02–1.76)	.038
Trauma	0.82 (0.52–1.30)	.40
Other/missing	Reference	
Neurological indication	1.14 (0.95–1.38)	.16
Procedural indication	0.56 (0.46–0.67)	< .001
Video laryngoscopy (vs direct laryngoscopy)	0.49 (0.43–0.56)	< .001

no. = 11,940 intubation attempts.
RT = respiratory therapist

Prior studies of RT intubation practices revealed variable definitions of intubation attempts and have not consistently reported physiologic AEs, making direct comparisons with our study difficult. In a series of 933 intubations of adults, children, and neonates, Thalman et al[11] described a success rate of 92.3% within 3 attempts, although an attempt was not clearly defined. The complication rate was 12% and included tooth/jaw damage, vomiting/aspiration, and other, although physiologic events were not described as AEs. Other studies did not explicitly define an intubation attempt and focused on intubation-related complications but not physiologic AEs.[10,12]

Our investigation indicated that RT outcomes are in line with recent international data evaluating intubation outcomes in pediatric ICU subjects.[2,13] A multicenter study in England reported a first-attempt success rate of 64.3% and an AE rate of 22.3%, similar to the results for RTs in our study.[2] An early report from the NEAR4KIDS database using data from July 2010 to March 2013 revealed a first-attempt success rate of 60.0%, a result almost identical to our reported success rate for RTs.[13]

In our study, intubations by RTs were associated with a higher occurrence of adverse AEs. This unexpected finding may be related to variable RT intubation skill level across sites, differences in training structure and clinical opportunities, or selection bias. The center in which RTs did the largest proportion of intubations also had a low AE rate in our report, which suggests that properly trained RTs who receive adequate opportunities can perform intubation

Table 4. Tracheal Intubation Performed by RTs at Individual ICUs

ICU	A	B	C	D	E	F	G	H	I
Total intubations, no.	235	197	176	308	344	356	817	33	11
Attempts by RTs, %	46 (20)	25 (13)	15 (9)	7 (2)	7 (2)	4 (1)	3 (.3)	1 (3)	1 (9)
First-attempt success rate	33 (72)	14 (56)	11 (73)	1 (14)	4 (57)	2 (50)	0 (0)	1 (100)	0 (0)
Overall success rate	38 (83)	20 (80)	13 (87)	1 (14)	6 (86)	2 (50)	2 (67)	1 (100)	0 (0)
Any adverse event	5 (11)	9 (36)	5 (33)	1 (14)	3 (43)	0 (0)	0 (0)	1 (100)	1 (100)
Nonsevere adverse event	4 (9)	6 (24)	3 (20)	1 (14)	1 (14)	0 (0)	0 (0)	0 (0)	1 (100)
Severe adverse event	1 (2)	3 (12)	3 (20)	1 (14)	3 (43)	0 (0)	0 (0)	1 (100)	0 (0)

Data are presented as no. (%).
RT = respiratory therapist

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safely in critically ill children. Similarly, larger pediatric ICUs had lower rates of AEs, suggesting that increasing the number of intubations performed by RTs may result in a reduction in AEs.[14] We were unable to determine the amount or type of training RTs in our study received; however, prior data have indicated that RT intubation training varies widely across centers.[15,16] Surprisingly, in the subanalysis of RT intubation attempts, we found a higher RT first-attempt success rate and lower incidents of AEs in subjects with a history of difficult intubation, which lies in contrast to findings for other providers in this registry.[4,17] The low rate of AEs is likely a chance finding related to the small sample size; however, it is possible this was due to increased vigilance during intubation of a patient with a known difficult airway or the RT selected to intubate was known to be skilled at airway management.

RT intubation training varies substantially between centers, and there may be opportunities for standardized training and skill-maintenance programs.[15] Potential downsides to RT intubation programs are the need for additional education and training, intubation opportunities amid competition from other providers, and the resources required for quality assurance. Although the learning curve for RTs or advanced practice providers has not been clearly established, there are reports that approximately 25–50 intubations are required for critical care fellows to gain proficiency in pediatric intubation.[18] Thus, the limited number of intubations available for RTs is likely an obstacle for sustainable pediatric intubation programs for RTs. Centers where RTs intubate may need to limit the number of RTs who are trained to intubate to ensure adequate opportunities for skill development and skill maintenance. Particular attention should be given for RTs who are part of interfacility transport teams to ensure they are proficient in intubation. However, focusing on proficiency in video laryngoscopy may allow RTs to provide an expert service in pediatric intubation separate from critical care trainees and advanced practice providers.

Studies comparing intubation outcomes between RTs and other providers are scarce. A single-center study of a transport team compared success rates between RTs and resident physicians and reported that RTs had a higher first-attempt success rate; however, they did not report complications or AEs.[19] In our study, RTs were compared to all other providers of intubation and had a lower first-attempt success rate compared to pediatric critical care medicine attendings and fellows. Notably, advanced practice providers (ie, nurse practitioners and physician assistants) made approximately 11 times as many intubation attempts with a first-attempt success rate similar to RTs. We were unable to identify why RTs were selected to intubate; however, given the low number of RT attempts, it is probable that there is a paucity of RTs skilled in pediatric intubation, a perception that RTs lack this skill, or individual center practices that prevent RTs from providing this service.

This investigation is the first to describe the use of video laryngoscopy by RTs, and our results indicated that video laryngoscopy attempts by RTs were associated with fewer AEs than direct laryngoscopy. The reason for video laryngoscopy utilization by RTs was unable to be determined, but it may be related to local practice patterns or greater experience using this technology. A study by Grunwell et al[20] using the NEAR4KIDs database also reported that video laryngoscopy was associated with a decrease in any AEs, although not in severe AEs or in the need for multiple attempts. A Cochrane review[21] concluded that low-level evidence suggests that video laryngoscopy resulted in longer time to intubation, no difference in first-attempt success rate, no difference for Cormack view grade, and no difference for oxygen saturation or hemodynamic events. All of the trials included in this review were performed in the operating room, and their applicability to patients in the pediatric ICU may be limited.[21] Two systematic reviews and meta-analyses of critically ill adult patients in the ICU and emergency department found no benefit for video laryngoscopy for first-attempt success rate, but video laryngoscopy did result in improved laryngeal view and fewer esophageal intubations.[22,23] Thus, the benefit of video laryngoscopy for intubation is unclear, and high-quality data in children are lacking.

Limitations

This study has several limitations. The overall number of RT intubations was small and there was likely selection bias for RT intubation attempts, limiting our ability to draw definitive conclusions. Although these data are prospectively collected, the NEAR4KIDS registry does not provide information on why a certain provider or method was chosen for intubation. NEAR4KIDs data are self-reported and may be subject to recall bias. RT practice varied widely between centers, with some centers reporting a single RT attempt at intubation. All current NEAR4KIDS study sites are academic medical centers. The NEAR4KIDs database does not include intubations performed by intrafacility transport teams. Thus, this study may not be reflective of general RT intubation practice in pediatric patients.

Conclusions

RTs infrequently intubate in pediatric ICUs, with success rates similar to other providers. However, the AE rates were higher in tracheal intubations performed by RTs. RTs were more likely to use video laryngoscopy, and video laryngoscopy was associated with fewer AEs. RTs performed well when intubating a small number of children with histories of a difficult airway. RT intubation success and complication rates varied greatly across centers.

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