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Original Article

Tips to Improve Success Rate of Intubation: A Standardized Rapid Sequence Intubation Protocol Attached to the Resuscitation Cart

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Objectives: The purpose of this study was to determine whether the implementation of a standardized rapid sequence intubation (RSI) protocol easily accessed on the resuscitation cart increased the success rate of intubation and reduced intubation-related complications in the emergency department (ED).
Methods: This work was a retrospective study of patients who were intubated in the ED between February 2006 and June 2007. The RSI protocol and a dosage cross-table were attached to the resuscitation cart beginning in January 2007. Intubated patients before and after application of the protocol were sorted into two groups: pre-intervention and post-intervention.
Results: A total of 147 patients were enrolled in the study, including 72 patients in the pre-intervention group and 75 patients in the post-intervention group. After application of the standardized protocol prompted on the resuscitation cart. The adherence rates to pre-treatment agents (69% vs. 90%; $p < 0.01$) and neuromuscular blocking agents (NMBA) (72% vs. 90%; $p < 0.01$) significantly improved. The first-attempt success rate was 57 of 72 (79%) in the pre-intervention group versus 70 of 75 (93%) in the post-intervention group ($p = 0.016$). The time to intubation did not differ significantly, but the pre-intervention group had a higher percentage of prolonged time to intubation (13% vs. 3%; $p = 0.029$). The implementation of a standardized RSI protocol did not induce significant adverse effects.
Conclusions: Our study demonstrated implementation of a standardized RSI protocol, improved clinician adherence to the RSI, increased success of first-attempt ED intubation and led to a decline in the rate of prolonged time to intubation.

Key words: *rapid sequence intubation, resuscitation cart, RSI*

Introduction

Successful airway management is a cornerstone of the practice of emergency medicine, and tracheal endotracheal (ET) intubation is the gold standard for emergency department (ED) airway management for patients requiring a definitive airway.[1] Rapid sequence intubation (RSI) is a process involving administration of weight-based doses of a sedative followed immediately by a neuromuscular blocking agent (NMBA) to facilitate ET intubation and minimize the risk of aspiration. The implementation of RSI in the ED increases the success rate of intubation and decreases complications.[2-4]

A protocol is an extension of clinical guidelines. Implementation of a protocol favorably impacts clinically pertinent outcomes, and the clinician can judge whether the protocol applies to the patient. Protocol-directed medical procedures and checklists may improve team communication and consistency of patient care.[5]

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Although RSI was introduced to our ED in early 2000, it was not routinely used. Some physicians don't use RSI due to lack of familiarity with dosages of appropriate available agents and fear of difficult bag valve mask ventilation after NMBA administrated.[2,4,6] Although 84% of ED intubations involve medications, standard RSI is the initial chosen method in only 69%.[7]

Little work has been conducted regarding how to improve the performance of RSI in ED. To standardize the performance of RSI and thereby diminish individual differences in clinical practice, we therefore developed a RSI protocol and attached the body-weight-based dosage cross-table to the resuscitation cart to minimize the complexity of dosage weight conversions. We hypothesized that the implementation of standardized RSI protocol and attached the body-weight-based dosage cross-table to the resuscitation cart could improve adherence of clinicians to the RSI and increase success rate of intubation. The aim of this study was to evaluate the adherence of clinicians to the RSI and to compare success rates of intubation and complications before and after protocol implementation.

Methods

A standardized RSI protocol was developed in October 2006 in our ED (Fig. 1). We retrospectively reviewed patients intubated in the ED and admitted to intensive care units between February 2006 and June 2007. Patients intubated before and after the application of protocol were sorted into two groups: pre-intervention and post-intervention. Clinical characteristics and performance of intubation in the two groups were compared. The primary outcomes of the study were success rate on the first attempt, protocol adherence rate and intubation related complications. This study was approved by the Institutional Review Board.

This study was conducted at a university-affiliated teaching hospital with an annual ED volume of 65,000 patients. Adult patients (aged 18 years and older) who were intubated in the ED and admitted for intensive care were enrolled in the study. The patients were flagged in a computerized search of the hospital-based databank by all intensive care unit patients with mechanical ventilation use, procedure code search of intubation and the use of endotracheal tube in the ER. The RSI does not apply to patients who present to the ED with cardiac arrest or who are noted to have had a difficult airway before intubation; these patients were therefore excluded from the study.

ED intubations were performed by ED attending physicians and at least second-year residents of emergency medicine in the all study period. All physicians needed to attend the airway management course before ED rotation. Once intubation was indicated, the intubators assessed the patient and determined the drug to be used before intubation. All patients were intubated by conventional direct laryngoscopy.

After successful intubation, a standardized procedure note including performer, numbers of attempts, the size of endotracheal tube and complications should be written in the medical chart by the intubator.

Before implementation of our cart-disposed RSI protocol in ED, the intubators evaluated the patient's airway conditions and determined whether intubation was indicated, the types of medication for intubation, and the dosage of drugs. The nurse who administered medications must understand drug dosage calculations and performed a complicated weight-dosage-concentration conversion process for drug administration. These may cause variety of medication applied, poor adherence to RSI and unnecessary delay.

To ameliorate the varieties and complexity of RSI, we implement a standardized RSI protocol with difficult airway assessment and a combination of lidocaine, etomidate and rocuronium since October 2006. Additionally, a laminated document with a weight-based dosage table for each drug and RSI protocol were attached to the resuscitation cart. We aimed to produce better understanding of the RSI protocol and reduce complexity of drug administration and concentration conversion.

Difficult airway including difficult bag valve mask ventilation and difficult laryngoscopy intubation were quickly assessed by MONAS and LEMON score.[8-10] The patient with a difficult airway was excluded from the standardized RSI protocol (Fig. 1), and consultation with an anesthesiologist for oral flexible fiber-optic intubation, awake intubation or even surgical airway was considered.

If there was no contraindication (e.g., difficult airway), the intubator estimated the patient's body weight, and the nurse prepared drugs with the preset dosage according to estimated body weight. The table-based dosage schedule including lidocaine, etomidate and rocuronium was easily found on the resuscitation cart table surface (Table 1). The ED team performed RSI with the standardized protocol unless the intubators decided to use medication on their own.

The patient's characteristics (age, coexisting comorbidities, vital signs and oxygen saturation before and after intubation, Glasgow Coma Scale before intubation and laboratory data) were recorded from the medical records. Outcome data were as follows: success rate of intubation on the first attempt, time to successful intubation, length of mechanical ventilation, mortality and immediate complications

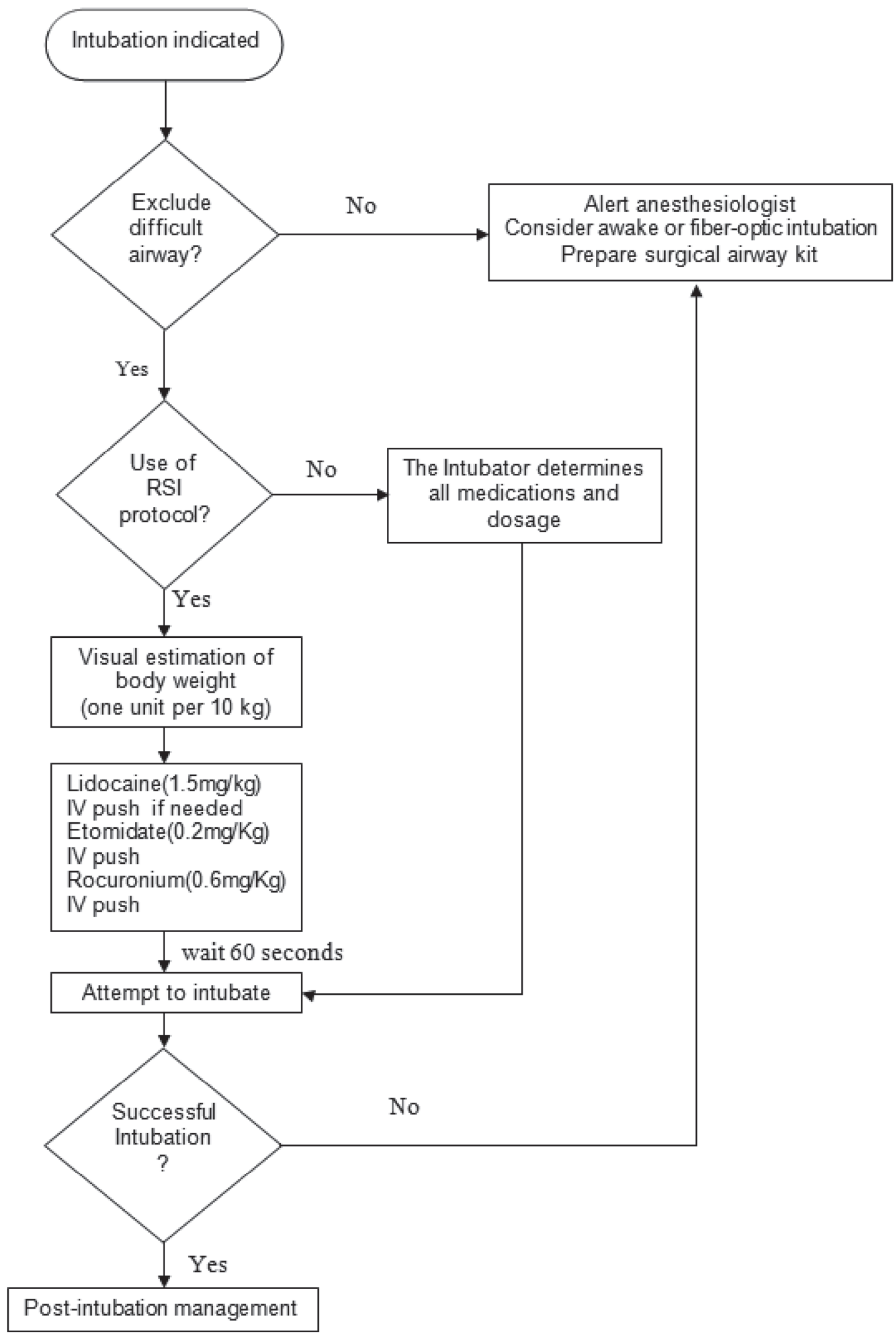

Fig. 1. Standardized RSI protocol.

Table 1. Laminated document with body weight-based dosage table attached on the resuscitation cart

	40 kg	50 kg	60 kg	70 kg	80 kg	90 kg	100 kg
Xylocaine (100 mg/5 ml)[a] (1.5 mg/kg)	60 mg (3 c.c.)	75 mg (3.75 c.c.)	90 mg (4.5 c.c.)	105 mg (5.25 c.c.)	120 mg (6 c.c.)	135 mg (6.75 c.c.)	150 mg (7.5 c.c.)
Etomidate (20 mg/10 ml)[a] (0.2 mg/kg)	8 mg (4 c.c.)	10 mg (5 c.c.)	12 mg (6 c.c.)	14 mg (7 c.c.)	16 mg (8 c.c.)	18 mg (9 c.c.)	20 mg (10 c.c.)
Rocuronium (50 mg/5 ml)[a] (0.6 mg/kg)	25 mg (2.5 c.c.)	30 mg (3 c.c.)	36 mg (3.6 c.c.)	42 mg (4.2 c.c.)	48 mg (4.8 c.c.)	54 mg (5.4 c.c.)	60 mg (6 c.c.)

[a] Each ampule contained.

after intubation. We defined cardiovascular disease as coronary artery disease, cardiac dysrhythmia, valvular heart disease or congestive heart failure. Asthma, chronic obstructive pulmonary disease and bronchiectasis were classified as lung disease. Chronic kidney disease was defined as kidney damage or a glomerular filtration rate of less than 60 mL/min/1.73 m^2 for three or more months according to the Kidney Disease Outcomes Quality Initiative of the National Kidney Foundation.[11] The chart review followed published guidelines on retrospective chart review methods in emergency medicine to ensure accurate data abstraction and to limit the biases inherent to such studies.[12] If multiple values were available for laboratory data, the first values obtained after arrival in the ED were used. We used the rapid emergency medicine score (REMS), one of the scoring systems for the assessment of the severity of illness in the initial phase of ED patients' care, as a predictor of in-hospital mortality. The six components for REMS (blood pressure, respiratory rate, pulse rate, Glasgow coma scale, peripheral oxygen saturation and patient age) were obtained from the ED triage charts.[13]

An intubation attempt was defined as introduction of the laryngoscope into the mouth regardless of whether an ET tube was inserted successfully or not. The period of RSI recorded by the nurse during intubation was defined as the time from administration of the first drug to definite records of confirmation of tracheal placement with bilateral auscultation of the chest. We defined prolonged intubation as failure to intubate after 10 minutes by a operator.[14]

Immediate complications of RSI were defined as clinical events occurring during intubation or within 15 minutes after intubation and were described as follows.[15] A cardiac arrest was defined as loss of pulse during or immediately after intubation. Blood pressure drop was the difference between blood pressure pre- and post-intubation. Hypotension was defined as systolic blood pressure below 90 mmHg immediately following intubation. Bradycardia was defined as heart rate less than 60 beats per minute that could not be explained by other etiology. Right mainstem intubation was considered to have occurred if the chest radiograph indicated that the tip of the ET tube was in a right mainstem bronchus.

Statistical analyses were performed using the Statistical Package for Social Science for Windows (SPSS, Chicago, IL), version 17.0. Continuous variables were expressed as mean ± SD or median (interquartile range) depending on the normality of the distribution. Normally distributed variable was compared by student's t test, and non-normally distributed variables were compared by Mann Whitney U tests. Categorical variables were expressed as absolute number and percentage and were compared with the χ^2 or Fisher's exact tests. All reported p values are two-sided, and an alpha level of 0.05 indicated statistical significance.

Results

The study included 182 patients who were intubated in the ED and admitted to the intensive care unit. We excluded 23 patients with cardiac arrest and 12 patients evaluated as having difficult airways. The pre-intervention group (before implementation of our standardized RSI protocol) included 72 patients, and the post-intervention group (after implementation of the RSI protocol) included 75 patients.

Table 2 lists the results of univariate analysis of demographic information, comorbidities, laboratory data and the severity score between the two groups. There were no significant differences.

Fig. 2 showed the adherence to drug administration rate before and after implementation of the RSI standardized protocol prompted on the resuscitation cart. The adherence rate of each RSI medication, including pre-treatment agents, sedative agents, and NMBAs, were 69 vs. 90 %, 93 vs. 93% and 72 vs. 90%, respectively. After application of the standardized protocol prompted on the resuscitation cart, the adherence rates to pre-treatment agents and NMBA during RSI significantly improved ($p < 0.01$).

Table 3 demonstrates the period of RSI, success rate of first attempt, physiological change during intubation, early complications and mortality in both groups. Overall, 86% patients (127/147) were successfully intubated on first attempt. The first-attempt success rate of the post-intervention group was signif-

Table 2. Demographic data and clinical characteristics of patients intubated in the ED before (pre-intervention group) and after application of the RSI protocol (post-intervention group)

Clinical variables	Number of cases (%)		*p* value
	Pre-intervention group n = 72	Post-intervention group n = 75	
Age (yr), mean ± SD	68 ± 16	71 ± 13	0.139
Males	47 (65)	44 (59)	0.383
Previous or coexisting conditions			
Hypertension	38 (53)	45 (60)	0.409
Cardiovascular disease	30 (42)	38 (51)	0.322
Lung disease	15 (24)	17 (23)	0.843
Cerebrovascular accident	16 (22)	16 (21)	1
Diabetes	28 (39)	31 (41)	0.867
Malignancy	14 (19)	15 (20)	1
Chronic kidney disease	20(28)	25 (33)	0.480
Vital sign at intubation, mean ± SD			
Temperature (°C)	37.3 ± 1.5	37.1 ± 1.3	0.241
Heart rate (min)	113 ± 27	108 ± 26	0.162
Pulse oxygen saturation (%)	84.6 ± 16.6	81.7 ± 14.2	0.246
Glasgow coma scale	10 ± 4	11 ± 4	0.293
Systolic blood pressure (mmHg)	143 ± 39	145 ± 44	0.758
Diastolic blood pressure (mmHg)	83 ± 27	84 ± 25	0.428
Mean arterial pressure (mmHg)	106 ± 29	104 ± 31	0.647
Laboratory values at admission			
White blood cell (× 1000/mm^3), mean (IQR)[a]	11.9 (7.4 to 13.4)	13.2 (8.1 to 17.5)	0.192
Creatinine (mg/dL), mean(IQR)	1.8 (0.8 to 2.0)	2.2 (1.0 to 2.4)	0.229
Potassium (mmol/L), mean ± SD	3.9 ± 0.9	4.1 ± 0.9	0.286
Sodium (mmol/L), mean ± SD	136 ± 9	134 ± 15	0.604
REMS[b]	12 ± 4	12 ± 4	0.874
Inotropic agent before intubation (%)	11 (15%)	11 (15%)	1

The mean and standard deviation of variables were represented as mean ± SD.
[a] IQR = interquartile range.
[b] REMS = rapid emergency medicine score.

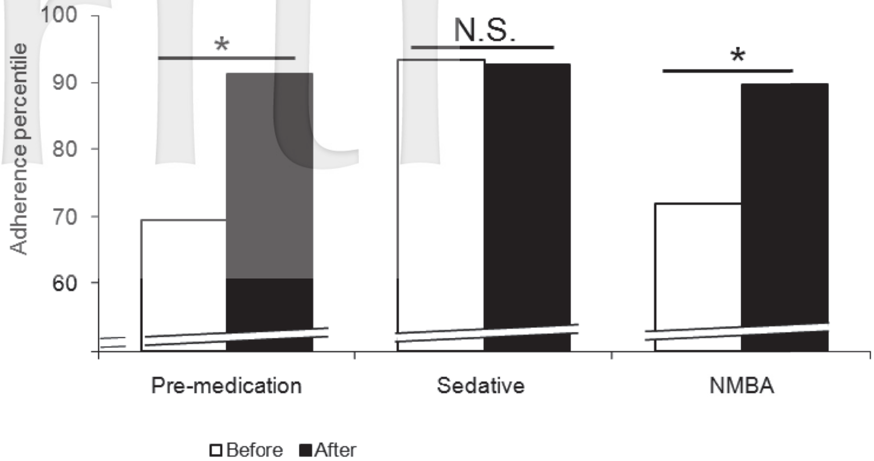

Fig. 2. Rapid sequence intubation (RSI) adherence before and after the application of the RSI protocol.
NMBA = neuromuscular blocking agents. * $p < 0.01$.

icantly higher than that of the pre-intervention group (93% vs. 79%; $p = 0.016$). The time to intubation of the pre-intervention group was 5.2 minutes, and that of the post-intervention group was 4.2 minutes. The time to intubation did not differ significantly, but the pre-intervention group had a higher percentage of prolonged intubations (13% vs. 3%; $p = 0.029$) than the post-intervention group. There were no statistical differences between the two groups in times of intubations, overall mortality, blood pressure change during intubation and early complication of intubation including hypotension, bradycardia or cardiac arrest.

Discussion

Our study showed that implementation of a standardized RSI protocol and easy accessibility on a resuscitation cart could improve adherence, success rate of first attempt ED intubation and decline of prolonged intubation. The application of ED standardized airway management protocols may improve performance and patient safety. Most of accidents and incidents are the result of human factors breakdowns such as decision-making, poor communication, failures to cross-check drugs, rather than lack of technical knowledge.[16] There is increasing awareness of the development of Crew Resource Management to promote safety behavior on the flight deck in health care system. We found our protocol could simplify the intubation process and reduce complexity of drug administration by different levels of physicians from different disciplines and different levels of nursing experience in the ED.

The first step of our protocol was a bedside evaluation of the airway. Unlike anesthesia practice, ED intubation is often performed under unexpected, chaotic and critical situations. Early identification allows for appropriate planning and a rescue strategy. Although there is no clear evidence indicating that a difficult airway can be predicted by single physical examination, it is still recommended for difficult airway evaluation before intubation.[9]

Standardization of evidence-based practice in the care of critically ill patients is acceptable in many situations.[17] The implementation of a standardized RSI protocol in our ED which is easily accessible and viewed on the resuscitation cart table increased the adherence to pre-treatment agents and NMBA in the ED. RSI requires all clinical staffs to be familiar with patient assessment, induction agents, NMBA and post-intubation management.[18] By standardizing care, clinicians will ensure that necessary procedures and therapies are carried out in a timely manner.[5,17] Protocols might potentially create resentment among clinical staffs because procedures may be perceived as removing clinical judgment without considering all facets of the patients involved.[19] However, proposed procedural protocols have been associated with decreases in the number of errors and procedure associated complications.[5]

Patients also benefit from implementation of the RSI protocol. Compared with the pre-intervention group, the post-intervention group showed a statistically significant lower rate of prolonged intubation. Under the implementation of this standardized proto-

Table 3. Performance of intubations in patients in the ED before (pre-intervention group) and after the application of RSI protocol (post-intervention group)

	Number of cases (%)		
	Pre-intervention group n = 72	Post-intervention group n = 75	*p* value
Period of rapid sequence intubation (mins), mean (IQR)	5.2 (2.0 to 7.0)	4.2 (2.0 to 5.0)	0.096
First-attempt success (%)	57 (79)	70 (93)	0.016*
Prolonged intubations (%)[a]	9 (13)	2 (3)	0.029*
Times of intubation to extubation (days), mean (IQR)[b]	6 (2.5 to 9)	6 (3 to 8.2)	0.788
In-hospital mortality (%)	21 (29)	23 (31)	0.859
Intubation conditions, mean (IQR)[b]			
Systolic blood pressure drop (mmHg)	12 (-16 to 36)	8 (-14 to 35)	0.525
Diastolic blood pressure drop (mmHg)	9 (-6 to 23)	5 (-10 to 20)	0.301
Mean arterial pressure drop (mmHg)	10 (-7 to 28)	6 (-12 to 24)	0.364
The intubator			
Residents (%)	32 (44)	29 (39)	0.507
Complications			
Desaturation (%)	7 (10)	11 (15)	0.453
Hypotension (%)	4 (6)	6 (8)	0.746
Bradycardia (%)	3 (3)	1 (1)	0.360
Cardiac arrest (%)	0	0	1
Main bronchus intubation (%)	4 (6)	7 (9)	0.534

[a]Prolonged intubation is defined as intubation time over ten minutes.
The mean and standard deviation of variables were represented as mean ± SD.
[b]IQR = interquartile range.
*$p < 0.05$.

col, the overall success rate of intubation was 100%. The National Emergency Airway Registry study indicated that intubation using RSI had higher success rates than non-RSI techniques.[3] In the review of literature, the success rate of the first attempt of ED intubation varies from 75% to 90%, and surgical airway rates averaged less than 1%.[3] The rate of successful intubation increases with the level of experience. The NMBA administered in our RSI protocol was rocuronium, not succinylcholine. The major concern is that succinylcholine has serious side effects and is contraindicated in many medical conditions. As a standardized protocol, we needed to use medication with minimal contraindications. In addition, rocuronium can still be used to reliably create acceptable intubation conditions.[20] Theoretically, the post-intervention group with the use of rocuronium needed more time to paralyze the patients than the pre-intervention group with no NMBA (succinylcholine and rocuronium).[21] The mean time to intubation of the pre-intervention group was 5 minutes, and that of the post-intervention group was 4.2 minutes. In our experience implementation of the standardized RSI protocol in the ED setting did improve the success rate of the first attempt and significantly reduced the incidence of prolonged intubation.

Limitation

Despite its contributions, this study has certain limitations. This is a retrospective study and chart-based documentation was limited. The investigation was conducted at a single center, and the results are not necessarily applicable to other institutions with different settings. In addition, the pre-intervention group potential exists for more patients with difficult airway and this might lead to selection bias in comparison of the two groups. However, the design of our protocol is to diminish individual differences and to improve performance of intubation. The decrease number of difficult airway after implementation of our RSI protocol is reasonable and what we desire.

Conclusion

Our study documented that implementation of a standardized RSI protocol easily accessed on the resuscitation cart improved success rate of first-attempt ED intubation and led to a significant decline of prolonged intubation. Although there was no significant difference of incidence of immediate complications between the two groups, the use of an easily accessed standardized protocol improves adherence of clinicians to the RSI and increases success of intubation in the ED.

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