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Original Contribution

Peri-intubation factors affecting emergency physician choice of paralytic agent for rapid sequence intubation of trauma patients☆

Jason R. West *, Catherine Lott, Lee Donner, Marc Kanter, Nicholas D. Caputo

Lincoln Medical and Mental Health Center, Department of Emergency Medicine, Weill Cornell Medicine of Cornell University, Bronx, NY, United States

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ABSTRACT

Introduction: No study has assessed predictors of physician choice between the succinylcholine (Succ) and rocuronium (Roc) for rapid sequence intubation (RSI) during the initial resuscitation of trauma patients in the emergency department (ED).
Methods: We retrospectively evaluated of the use of Succ and Roc for adult trauma patients undergoing RSI at a Level 1 trauma center. The primary outcome was to identify factors affecting physician choice of paralytic agent for RSI analyzed by cluster analysis using pre-intubation vital signs and early mortality. The secondary outcome was to identify factors influencing physician choice of paralytic agent using a logistic regression model reported as adjusted odds ratios (aOR).
Results: The analysis included 215 patients, including 148 receiving Succ and 67 receiving Roc. The two groups were similar in regard to age, provider level of training, mean GCS (10 vs. 10) and median ISS (27 vs. 27). Cluster analysis using peri-intubation patient vital signs and early mortality indicates that patients with predominantly abnormal vital signs and early mortality were more likely to receive Roc (74%) than those without abnormal vital signs prior to intubation or early mortality (24%). Hypoxemia prior to RSI (aOR 12.3 [2.5–60.9]) and the use of video laryngoscopy (VL) (aOR 5.5 [1.2–24.6]) were associated with the choice to use Roc.
Conclusions: Roc was more frequently chosen for paralysis in the patient cluster with predominantly abnormal peri-intubation vital signs and higher rate of early ED mortality. The use of Roc was associated with hypoxemia prior to RSI and VL.

1. Introduction

Rapid sequence intubation (RSI) is the recommended intubation method to obtain airway control in acutely-injured patients [1]. Succinylcholine and rocuronium are the most commonly used paralytic agents for RSI in the emergency department (ED) [2]. Historically, succinylcholine has been considered the paralytic agent of choice for RSI in the ED due its short duration of action [3], yet recent studies have demonstrated similar rates of first intubation attempt success when rocuronium is used at optimal doses [3,4]. Despite its duration of only 6 min, succinylcholine may be contraindicated in certain ED patient populations, such as those with hyperkalemia. Rocuronium has a duration of action up to 45 min, but the only known contraindication is drug allergy. However, the use of rocuronium by emergency providers has increased dramatically over the last 15 years, and the current rocuronium use for RSI may nearly approximate that of succinylcholine [2]. Furthermore, a recent study recommends the use of rocuronium, when used with ketamine and fentanyl, to achieve first pass success for RSI in out-of-hospital critically-injured patients [5].

While there is robust data demonstrating that succinylcholine provides optimal intubation conditions in patients undergoing RSI in non-ED settings, there is a paucity of data on the ideal paralytic use for ED patients undergoing intubation as a life-saving measure during the initial resuscitation period after acute traumatic injury. No study has assessed factors associated with the physician choice between the two paralytic agents for RSI during the initial resuscitation of trauma patients in the ED. The primary outcome was to identify factors affecting physician choice of paralytic agent for RSI analyzed by cluster analysis using pre-intubation vital signs and early ED mortality during the injured patients' resuscitation.

2. Patients and methods

2.1. Study setting and population

This was a retrospective cohort study set at an academic Level 1 trauma center (designated by the American College of Surgeons) in an

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* Corresponding author at: Lincoln Medical and Mental Health Center, 234 E. 149th Street, 2C-2, Emergency Medicine Department, 314-406-2915, Bronx, NY 10451, United States.
E-mail address: westj3@nychhc.org (J.R. West).

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urban setting with an average ED census of 170,000 visits. The study was approved by the Institutional Review Board under expedited review. Our institution has an ACGME-accredited 4-year emergency medicine (EM) residency program, and trauma intubations are performed by an EM resident under direct supervision by EM and anesthesia attendings or by an attending at their discretion. Residents have extensive training in airway management through simulation lab, critical care, and anesthesia rotations. Our department prepares RSI medication kits that contain etomidate for induction of sedation and both succinylcholine and rocuronium for paralysis. During the study period, only etomidate was available for induction of anesthesia. The paralytic agent used for RSI was guided by attending physician preference. At our institution, data on peri-intubation oxygenation, operator level of training, direct versus video laryngoscopic methods, and need for surgical airway are recorded by the EM provider performing the intubation using a standardized electronic form entered into the electronic medical record after the intubation.

2.2. Study protocol

We conducted retrospective data collection adhering to the guidelines used to reduce bias inherent to retrospective study designs endorsed by the American College of Emergency Physicians [6]. The electronic medical record was searched to find trauma patients of age 18 or older who were intubated in the ED using either succinylcholine or rocuronium as a paralytic agent for RSI between January 1, 2011 and December 31st 2015. Data was retrospectively collected from the standardized intubation data entered into the electronic medical record and on patient age, presenting Glasgow Coma Scale (GCS), calculated Injury Severity Score (ISS), heart rate, ED mortality, and whether the patient had penetrating trauma, blunt trauma, trauma to the head or face, or end-stage renal disease (ESRD). Data was collected by trauma program coordinators who had been trained for and involved in continuous quality improvement database collections using a standardized data collection form. Patients were excluded if they were missing documentation or were intubated after leaving the ED. We found no previous studies on which to base a sample size calculation. The primary outcome was to identify factors affecting physician choice of paralytic agent for RSI analyzed by cluster analysis using pre-intubation vital signs and early mortality. The secondary outcome was to identify factors influencing physician choice of paralytic agent by using a multivariate logistic regression model reported as adjusted odds ratios (aOR).

2.3. Data analysis

Patients were categorized into two groups based on the paralytic used. Patient demographic data, GCS, ISS, blunt versus penetrating injury, the presence of facial or head injury, operator level of training, peri-intubation oxygenation saturation rates, presenting heart rate, presenting systolic blood pressure, the frequency of direct versus video laryngoscopy, and rates of ED mortality were compared between the two groups. The data collection form was double-checked by the study investigators, and we found no incorrect data entries among the included patients. An unpaired Student's *t*-test was used to compare the variables, and the difference between the means with 95% confidence interval (95% CI) is reported between the two groups.

A two-step cluster analysis was performed to cluster patients into groups based on the presence of pre-RSI hypoxemia (oxygen saturation <90%), tachycardia (heart rate > 100 beats per minute), hypotension (systolic blood pressure <90 mm Hg), and early ED mortality. We chose to include early ED mortality in our cluster analysis and logistic regression, because we considered the resuscitating physician's gestalt that a trauma patient is at high risk for mortality may have affected physician choice of paralytic agent. Two-Step cluster analysis was developed using the steps of 1) pre-clustering of cases using a sequential approach and 2) the clustering of cases using a hierarchical technique [7]. The patient clusters were analyzed for significant differences in the frequency of rocuronium use for RSI using a one-way analysis of variance (ANOVA).

A multivariable logistic regression analysis was performed to evaluate the association between the physician choice to use rocuronium and the available variables. We considered all confounders available in our data and intended to create a model based on relevance to the outcome (physician choice to use rocuronium). We included the following confounding variables in the model: pre-RSI hypoxemia, tachycardia, hypotension, early ED mortality, laryngoscopic device used, GCS < 8, and the presence of head or facial trauma. The goodness of fit of the model was checked by the Hosmer-Lemeshow test. The model was checked for multicollinearity by evaluating variance inflation factors among the included variables. A p-value of <0.05 was used to determine significance. All analysis was conducted using SPSS v. 23.0 (IBM, SPSS Inc., Chicago, IL).

3. Results

216 patients were identified during the 4 year period who met our inclusion criteria. One patient (who survived) was excluded because of incomplete data. 215 patients were included in our analysis. There were 148 (69%) patients in the succinylcholine group and 67 (31%) patients in the rocuronium group. The groups were similar demographically with regard to age and intubating provider levels of training and recorded severity of injury (Table 1). 53% of intubations were performed by residents. The level of training of the intubating provider did not differ between groups. The groups were similar with regard to penetrating injuries, yet the succinylcholine group had a higher rate of head and facial trauma (50% vs. 34%). The rocuronium group had a similar GCS mean (10 vs. 10) and ISS median values (27 vs. 27) to the

Table 1
Patient demographics and peri-intubation conditions of the succinylcholine and rocuronium groups.

Characteristics	Succinylcholine $n = 148$	Rocuronium $n = 67$	Difference (95% CI)
Age (mean)	38	38	−0.6 (−5.6 to 4.5)
ISS[a] (median) (IQR)	27 (27;32)	27 (27;32)	–
GCS[b] (median) (IQR)	10.5 (7;15)	9 (6;14)	–
GCS (mean)	10	10	−0.8 (−0.5 to 2)
Penetrating injury (%)	30 (20%)	20 (30%)	10% (−2.8 to 23)
Head or facial injury (%)	74 (50%)	23 (35%)	−15% (−29 to 1)
Mortality	1 (0.7%)	7 (10.4%)	9.8% (2.3 to 17.2)
Operator training level			
Attending	37 (24.8%)	17 (25.3%)	0.5% (−11 to 14)
EM PGY[c] 4	10 (7.3%)	7 (8.9%)	0.15% (−6 to 12)
EM PGY 3	27 (18.7%)	12 (17.9%)	−0.8% (−12 to 11)
EM PGY 2	44 (28.8%)	18 (28.3%)	−0.5% (−13 to 13)
EM PGY 1	30 (19.4%)	13 (20.7%)	0.7% (−12 to 11)
Oxygen saturation			
O2[d] Pre-RSI (median) (IQR)	99% (96;100)	97 (93;100)	–
O2 at Confirmation (median) (IQR)	99% (91;100)	90 (85;91)	–
Hypoxemia[e] Pre-RSI	2 (1.4%)	15 (22.4%)	21% (10.8 to 31)
Hypoxemia at confirmation	25 (16.9%)	23 (34.3%)	17.4% (4.5 to 30)
Heart rate			
Heart rate (median) (IQR)	93 (79;112)	91 (74;118)	–
Tachycardia[f]	54 (36.5%)	30 (44.8%)	8.3% (−5.9 to 22.5)
Laryngoscopic device			
Direct	145 (98%)	62 (92.5%)	−5.4% (−1.2 to 12)
Video	3 (2.0%)	5 (7.5%)	5.4% (12 to −1.3)

[a] ISS = Injury Severity Score.
[b] GCS = Glasgow Come Scale; IQR = Interquartile range.
[c] EM PGY = Emergency resident post-graduation year.
[d] O2 = peripheral oxygen saturation.
[e] Hypoxemia = oxygen saturation < 90%).
[f] Tachycardia = heart rate > 100.

succinylcholine group. The presence of tachycardia at the time of RSI was more frequent in the rocuronium group (44.8% vs. 36.5%) (mean difference of 8.3%; 95% CI - 5.9 to 22.5). Pre-RSI hypoxemia was higher in patients receiving rocuronium (22.4% vs. 1.4%). Oxygenation at the time of confirmation of intubation was lower in the rocuronium (median 90% vs. 99%). Video laryngoscopy was used more frequently among those receiving rocuronium (7.5% vs. 2%). None of the patients included in our analysis had end-stage renal disease.

Mortality was higher in the rocuronium group (10.4%) than in the succinylcholine group (0.7%) (difference of 9.8%; 95% CI 2.3–17.2). Only 8 patients died in the ED in our study, and only one of these 8 had head or facial injury. The mechanism of injury of the 8 patients who died were due to gunshot wound in 4 patients, stab wound in 2 patients, fall in one patient, and being struck by a vehicle in one patient. The patient who died in the ED with a head and facial injury was struck by a vehicle and presented without hypoxemia but has a GCS of 3 on arrival and an ISS of 51. All patients with ED mortality died within the first hour of resuscitation after both initial injury and ED presentation. All but one patient (requiring surgical airway) were intubated successfully. Table 1 includes the patient demographics, operator level of training, peri-intubation conditions, laryngoscopic device used, and the mortality incidence between the two groups.

The two-step cluster analysis identified 3 clusters of patients: 1) those without pre-RSI hypoxemia, tachycardia, hypotension, or early ED mortality 2) those with tachycardia and a low risk of ED mortality, but not pre-RSI hypoxemia or hypotension and 3) those who predominantly had pre-RSI hypoxemia, tachycardia, hypotension, and a high risk of ED mortality. Each cluster had 120, 68, and 27 patients, respectively. The number of patients receiving video laryngoscopy in each cluster was 6, 2, and 0, respectively. The one-way ANOVA between the clusters for the outcome of the use of rocuronium indicate there were significant differences between the groups ($p < 0.001$). The results of the cluster analysis are reported in Table 2.

In the multivariable logistic regression model to identify variables associated with the physician choice to use rocuronium instead of succinylcholine, only pre-RSI hypoxemia and use of video laryngoscopy were associated with the use of rocuronium (Table 3). The adjusted odds ratios (aOR) for pre-RSI hypoxemia and use of video laryngoscopy were 12.3 (95% CI 2.5–60.9; $p = 0.002$) and 5.5 (95% CI 1.2–24.6; $p = 0.025$), respectively. There was no multicollinearity detected between variables included in the model. According to the Hosmer-Lemeshow goodness of fit test ($p = 0.492$), the model fit the data well.

4. Discussion

This is the first study to assess peri-intubation factors associated with physician choice of paralytic agent for RSI during the initial resuscitation of trauma patients in the ED. The most important finding of our study is that patients with abnormal vital signs prior to intubation or early ED mortality were more likely to receive rocuronium. Additionally, we found that the use of rocuronium was associated with hypoxemia prior to intubation and the use of video laryngoscopy. This study invites the question of why ED providers were more likely to give rocuronium to patients who were more sick, as there is no clear physiologic or pharmacologic reason why this would be a superior choice of paralytic agent.

We attribute the wide confidence intervals in our logistic regression analysis to be due to our inclusion of a heterogeneous trauma population. Because we did not account for factors such as the Mallampati score or other indicators of difficult airway [8,9] aside from head of facial trauma, it is unclear why providers choosing rocuronium for paralysis were more likely to use video laryngoscopy. Video laryngoscopy in trauma patients has been associated with longer intubation times, but not mortality [10]. Video laryngoscopy has not been demonstrated to be superior to direct laryngoscopy to achieve first endotracheal tube pass success in trauma patients [10,11], unless there are multiple predictors of difficult airway [11]. In this study, very few patients underwent video laryngoscopy, and in cluster 1 (those without pre-RSI hypoxemia, tachycardia, hypotension, or early ED mortality) 6 patients underwent video laryngoscopy, while zero of the patients in cluster 3 (those who predominantly had pre-RSI hypoxemia, tachycardia, hypotension, and a high risk of ED mortality) underwent video laryngoscopy. The rocuronium group in our study had similar mean GCS and median ISS scores. Both study groups had high ISS scores >25, corresponding to severely-injured patients with high mortality rates [12].

Physicians performing the intubation documented a portion of our study variables themselves, and it is possible that measurement bias was introduced. The primary outcome of our study was physician choice to use rocuronium, and we believe it is unlikely that this would be misrepresented or documented erroneously in the medical record. The use of only etomidate for induction increases the generalizability of our data to trauma patients receiving etomidate during RSI in the ED, yet it is possible that our results may have been different using a different induction agent. Although we addressed the selection bias between the two paralytic agents using peri-intubation physiological factors via cluster analysis, there may have been other unaccountable factors influencing physician choice of paralytic agent not detected in this

Table 2
Cluster analysis of patients by pre-RSI vital signs and early ED mortality for the evaluation of the outcome of physician choice to use rocuronium.

Cluster	1	2	3
n (% of total)	$n = 120$ (55.8%)	$n = 68$ (31.6%)	$n = 27$ (12.6%)
Pre-RSI vital signs			
Hypotension[a]	0 (0%)	0 (0%)	18 (66.7%)
Tachycardia[b]	0 (0%)	68 (100%)	16 (59.3%)
Hypoxemia[c]	0 (0%)	0 (0%)	17 (63%)
Early ED mortality[d]	0 (0%)	2 (2.9%)	6 (22.2%)
Outcome			
Rocuronium	29 (24.2%)	18 (26.5%)	20 (74.1%)

[a] Hypotension = Systolic blood pressure < 90 mm Hg.
[b] Hypoxemia = Oxygen saturation < 90%.
[c] Tachycardia = heart rate > 100.
[d] Early ED mortality = died during initial emergency department resuscitation.

Table 3
Multivariate logistic regression analysis for physician choice of rocuronium for RSI

Variable	Adjusted odds ratio	95% CI	p-Value
Paralytic agent			
No Pre-RSI Hypoxemia[a]	Reference		
Pre-RSI Hypoxemia	12.3	2.5–60.9	0.002
Heart rate			
No tachycardia[b]	Reference		
Tachycardia	1.3	0.7–2.5	0.438
Blood pressure			
No hypotension[c]	Reference		
Hypotension	2.2	0.6–7.6	0.232
Early ED mortality			
No early mortality	Reference		
Early ED mortality	3.7	0.3–44.5	0.307
GCS[d]			
GCS 9–15	Reference		
GCS ≤ 8	1.3	0.7–2.4	0.513
Laryngoscopic device			
Direct	Reference		
Video	5.5	1.3–24.6	0.025
Presence of head or facial injury			
No head or facial injury	Reference		
Head or facial injury	0.8	0.4–1.5	0.455

[a] Hypoxemia = oxygen saturation < 90%.
[b] Tachycardia = heart rate > 100.
[c] Hypotension = systolic blood pressure < 90 mm Hg.
[d] GCS = Glasgow Coma Scale.

study due to the limitations of a retrospective analysis. Furthermore, we were unable to collect data on anatomic variables, such as predictors of difficult airway [8,9], other than the presence of facial trauma that may have affected choice of paralytic agent.

5. Conclusions

In conclusion, the resuscitating physician was more likely to choose rocuronium for paralysis during RSI in the patient cluster with predominantly abnormal peri-intubation vital signs and higher rate of early ED mortality. Furthermore, the use of rocuronium was associated with hypoxemia prior to RSI and the use of video laryngoscopy.

References

[1] Mayglothling J, Duane TM, Gibbs M, McCunn M, Legome E, Eastman AL, et al. Emergency tracheal intubation immediately following traumatic injury: an Eastern Association for the Surgery of Trauma practice management guideline. J Trauma Acute Care Surg 2012;73:333–40.
[2] Brown 3rd CA, Bair AE, Pallin DJ, Walls RM. Techniques, success, and adverse events of emergency department adult intubations. Ann Emerg Med 2015;65:363–70.
[3] Tran DT, Newton EK, Mount VA, Lee JS, Wells GA, Perry JJ. Rocuronium versus succinylcholine for rapid sequence induction intubation. Cochrane Database Syst Rev 2015;10:CD002788.
[4] Patanwala AE, Stahle SA, Sakles JC, Erstad BL. Comparison of succinylcholine and rocuronium for first-attempt intubation success in the emergency department. Acad Emerg Med 2011;18:10–4.
[5] Lyon RM, Perkins ZB, Chatterjee D, et al. Significant modification of traditional rapid sequence induction improves safety and effectiveness of pre-hospital trauma anaesthesia. Crit Care 2015:19–134.
[6] Kaji AH, Schriger D, Green S. Looking through the retrospectroscope: reducing bias in emergency medicine chart review studies. Ann Emerg Med 2014;64:292–8.
[7] Chiu T, Fang D, Chen J, Wang Y, Jeris C. A robust and scalable clustering algorithm for mixed type attributes in large database environment. Proceedings of the seventh ACM SIGKDD international conference on knowledge discovery and data mining. San Francisco, CA: ACM; 2001.
[8] Cormack RS, Rocke DA, Latto IP, Cooper GM. Failed intubation in obstetric anaesthesia. Anaesthesia 2006;61:192–3.
[9] Mosier JM, Stolz U, Chui S, Sakles JC. Difficult airway management in the emergency department: GlideScope videolaryngoscopy compared to direct laryngoscopy. J Emerg Med 2012;42:629–34.
[10] Yeatts DJ, Dutton RP, PF Hu, Chang YW, Brown CH, Chen H, et al. Effect of video laryngoscopy on trauma patient survival: a randomized controlled trial. J Trauma Acute Care Surg 2013;75:212–9.
[11] Sakles JC, Mosier JM, Chui S, Keim SM. Tracheal intubation in the emergency department: a comparison of GlideScope® video laryngoscopy to direct laryngoscopy in 822 intubations. J Emerg Med 2012;42:400–5.
[12] Palmer CS, Gabbe BJ, Cameron PA. Defining major trauma using the 2008 Abbreviated Injury Scale. Injury 2016;47:109–15.