Air Medical Journal 38 (2019) 39–44

Contents lists available at ScienceDirect

Air Medical Journal

journal homepage: http://www.airmedicaljournal.com/

Original Research

Impact of Paralytic Agent on Postintubation Sedation

Kelsey Billups, PharmD, BCPS [1], Ashley Larrimore, MD [2,3], Junan Li, PhD [4], Howard Werman, MD [2,5], Mary Beth Shirk, PharmD, BCPS, FCCP [1,4*]

[1] Department of Pharmacy, The Ohio State University Wexner Medical Center, Columbus, OH
[2] Department of Emergency Medicine, The Ohio State University College of Medicine, Columbus, OH
[3] The Center for Emergency Medical Services, The Ohio State University Wexner Medical Center, Columbus, OH
[4] Division of Pharmacy Practice and Science, The Ohio State University College of Pharmacy, Columbus, OH
[5] MedFlight of Ohio, Columbus, OH

A B S T R A C T

Objective: The aim of this study was to evaluate the difference in the time to postintubation sedation between patients receiving etomidate and either succinylcholine or rocuronium in the prehospital setting.
Setting: Patients who received rapid sequence intubation medications from transport service personnel and were subsequently intubated were included. The critical care transport agency operates 8 helicopter- and 3 ground-based emergency medical service units.
Methods: This retrospective cohort study compared the time to the first sedative in patients intubated with etomidate and succinylcholine versus etomidate and rocuronium. Enrollment of 64 patients per arm was needed to achieve 80% power with a 2-tailed alpha of 0.05.
Results: Sixty-four and 38 patients received succinylcholine or rocuronium, respectively. The median time to postetomidate sedation was 10 (range, 5.0-16.0) and 13.5 (range, 7.0-20.8) minutes for succinylcholine and rocuronium patients, respectively ($P = .13$). Given the average duration of effect of etomidate, succinylcholine, and rocuronium, 0 (0%) succinylcholine versus 33 (86.8%) rocuronium patients were found to be at risk of wakeful paralysis.
Conclusions: This study suggests rocuronium's long duration of effect puts patients at risk for wakeful paralysis once the short effects of etomidate have subsided.

Rapid sequence intubation (RSI) is an airway management technique that results in immediate unresponsiveness and muscular relaxation. It is the most effective means of controlling an emergency airway.[1-3] Certified paramedics and nurses often use this method in the prehospital setting to intubate unresponsive patients.[1,4,5] During RSI, an induction agent produces unresponsiveness, whereas a neuromuscular blocking agent (NMBA) produces muscular relaxation. Ideal agents have a rapid onset of action and a short duration of effect. Used in the proper manner, these medications help lower the risk of pulmonary aspiration and, once administered, allow rapid control of the airway.[6,7]

Etomidate is an anesthetic agent used to induce sedation during RSI. It has a rapid onset of action (within 1 minute), a short dose-dependent duration of effect (3-5 minutes), and a minimal effect on patient hemodynamics, making it an ideal RSI agent.[8] Succinylcholine and rocuronium are NMBAs commonly used during RSI.[5,9,10] Succinylcholine has an onset of 45 seconds and a duration of effect of 4 to 6 minutes.[11,12] Although it has a favorable pharmacokinetic profile, succinylcholine causes an extracellular shift of potassium, placing certain patients at risk for hyperkalemia and cardiac arrest with the use of this agent. Such patients include those with baseline hyperkalemia, a burn or massive crush injury, persistent denervation, or myopathies.[13] Rocuronium induces paralysis in 60 seconds but has a duration of effect longer than succinylcholine, typically lasting 58 to 94 minutes when used at paralyzing doses.[11,14] After intubation in the prehospital setting, additional sedation is administered to comfort the patient, improve synchrony with mechanical ventilation, decrease patient oxygen requirements, and facilitate safe transport to a medical center for definitive care.

* Address for correspondence: Mary Beth Shirk, PharmD, BCPS, FCCP, Department of Pharmacy, The Ohio State University Wexner Medical Center, 410 West 10th Avenue, 368 Doan Hall, Columbus, OH 43210 Dr. Billups is now with the Indiana University Health Methodist Hospital, Indianapolis, IN
E-mail address: MaryBeth.Shirk@osumc.edu (M.B. Shirk).

1067-991X/$36.00

https://doi.org/10.1016/j.amj.2018.09.006

Longer-acting rocuronium has been associated with delays in postintubation sedation and analgesia compared with succinylcholine in the emergency department (ED).[15,16] Furthermore, doses of sedation and analgesia tend to be lower after RSI with rocuronium.[16] Delays in sedation postintubation can lead to wakeful paralysis and a sympathomimetic surge, causing increases in heart rate and blood pressure.[17] Appropriate sedation improves mechanical ventilation synchrony and decreases the work of breathing.[18] Similar trends in the timing and dosing of postintubation medications have yet to be adequately studied in the prehospital setting.

The primary aim of this study was to evaluate the difference in time to postintubation sedation between patients receiving etomidate and either succinylcholine or rocuronium in the prehospital setting. We hypothesized that there would be a significant difference in the time to first post-RSI sedative administration based on the NMBA administered as part of the RSI regimen, similar to findings in the ED setting.[15,16]

Methods

Study Design and Setting

This was a retrospective cohort study that compared the time to the first sedative in patients intubated with the RSI regimen of etomidate and succinylcholine versus those who received etomidate and rocuronium in the prehospital setting. Intubations occurred in the field, during transport, or upon arrival to the referring hospital. The critical care transport company involved in this study is an accredited air and ground organization that serves the central Ohio area. MedFlight is a not-for-profit agency that completes nearly 7,000 critical care transports each year and operates 8 helicopter- and 3 ground-based emergency medical service units. A registered nurse–paramedic team is part of all transports. Each member receives identical training on RSI and is certified to intubate and administer RSI and post-RSI medications via an approved protocol. All personnel transport patients via ground; however, not all personnel transport patients via air. Additionally, all intubations are subject to peer and medical director review, and personnel receive annual retraining on RSI technique. Medical record documentation occurs contemporaneously during transport using handheld electronic devices (Toughbooks; Panasonic Corporation, Newark, NJ) with subsequent uploading of documentation onto the agency's database.

Operational Definitions

For the purposes of this study, RSI refers to intubation facilitated by a sedative (etomidate) and a paralytic agent (succinylcholine or rocuronium). Postintubation sedative agents were medications considered sedating regardless of their analgesic, amnestic, or anxiolytic properties and were limited to agents available to personnel per the transport agency's protocol for intravenous push administration. The agency's protocol did not include the initiation of sedatives administered as a continuous infusion. These agents included midazolam, lorazepam, fentanyl, and morphine. Propofol was not available to paramedics or nurses as part of their transport formulary. Baseline vital signs included heart rate, systolic blood pressure, and respiratory rate directly before etomidate administration. Hypotension was defined as at least 1 isolated systolic blood pressure (SBP) reading less than 90 mm Hg. Patients were defined as trauma or medical patients by the nurse-paramedic team during transport. A significant event was defined as a cardiac arrest requiring advanced cardiac life support or profound hypotension with a documented SBP < 60 mm Hg. Transport time was defined as the time from the field or transferring institution departure to receiving institution arrival.

Selection of Participants

Patients were identified through a query of the transport agency's database. This query identified patients who were transported to any medical facility who were given etomidate, succinylcholine, or rocuronium between January 1, 2010, and December 19, 2016, by any provider (ie, transport agency crewmember, emergency medical services medic, other health care provider, or hospital nurse).

To be included, patients must have been administered a dose of etomidate with succinylcholine or etomidate with rocuronium by personnel employed by the transport agency. Patients identified by the agency database query were then randomly selected and screened against inclusion and exclusion criteria until enough patients were included to reach the predetermined power calculation (see later). The following patients were excluded: patients less than 18 years of age, patients who were pregnant or incarcerated at the time of transport, patients intubated before transport agency personnel arrival, patients given a defasciculating paralytic before RSI, patients who did not receive a paralytic with RSI, patients who did not receive sedation post-etomidate because of a significant event, or patients with data pertinent to the primary outcome that was missing. Institutional review board approval was granted by expedited review at The Ohio State University.

Data Collection and Processing

Data including age, weight, sex, Glasgow Coma Scale, and baseline (before etomidate administration) vitals were collected. Transport details such as transport type (ie, scene or interfacility transfer); reason (ie, trauma or medical illness); mode (ie, ground or air); and times of arrival to patient, transport agency departure, arrival to receiving institution, and transition of care to the receiving institution were also collected. Sedative and paralytic agents administered peri- and postintubation by the transport team, time of administration, time of intubation, and paralytic dose were collected. Finally, the occurrence of hypotension or cardiac arrest post-etomidate administration was also collected. Data were collected by a single research team member (KB) using a standardized data collection form, and 10% of patient charts were independently reviewed by a second team member (MBS) for documentation accuracy and completeness.

Outcome Measures

The primary outcome of this study was the time between the administration of etomidate for RSI and the first post-etomidate sedative. This time interval was compared between patients receiving succinylcholine and those receiving rocuronium for RSI. If no post-etomidate sedative was given, the time of transition of care was used as a surrogate measure. Secondary end points included a comparison between groups of the number of sedative doses per minute and the incidence of hypotension between etomidate administration and the transition of care. Because multiple pharmacologic classes of sedatives and multiple agents within each class were available to our transport teams, we used the number of sedative doses per unit of time as a simplified method to reflect the cumulative amount of sedation.

Primary Data Analysis

Because of the lack of published literature, the Cohen method was used for sample size determination. We assumed there existed a medium effect size difference ($d = 0.5$ [$d = (\text{mean}_a - \text{mean}_b)/\sigma$]) in the time from etomidate for RSI to the first post-etomidate sedative between the succinylcholine and rocuronium groups.[15,19] Sixty-four patients per group were estimated to be required to reach 80% power at a significance level of .05 (2 tailed).

Demographic and clinical characteristics were summarized using descriptive statistics. Categoric data were presented as count and frequency. Continuous variables were

analyzed using unpaired Student *t*-tests (for data normally distributed, presented as mean ± standard deviation) or unpaired Mann-Whitney *U* tests (for data not normally distributed, presented as median [interquartile range (IQR)]) where appropriate. The difference in the incidence of hypotensive episodes between groups was evaluated using the Fisher's exact test. Potential associations between the incidence of hypotensive episodes and patient characteristics as well as other clinical parameters in each group were evaluated using univariate and multivariate logistic regression analyses. A *P* value < .05 was regarded as statistically significant. SAS9.3 (SAS Institute, Cary, NC) was used in all statistical analyses.

Results

A total of 464 transports were eligible for inclusion; 407 received etomidate with succinylcholine, and 57 received etomidate with rocuronium. Once screened against exclusion criteria, 102 transports were included in the final analysis; 64 patients received succinylcholine, and 38 patients received rocuronium for RSI (Fig. 1). The mean dose of RSI paralytic was consistent with the agency protocol at 1.50 ± 0.09 mg/kg and 0.95 ± 0.11 mg/kg for those receiving succinylcholine and rocuronium, respectively. Baseline characteristics were similar between groups, except that those who received succinylcholine were more likely to be scene runs, to be transported from the trauma scene, and to receive a long-acting paralytic for transport (Table 1).

No difference in time to post-etomidate sedation between those who received succinylcholine and rocuronium was able to be detected within the sample size limits of the study. The median time to sedation was 10 (IQR = 5.0-16.0) and 13.5 (IQR = 7.0-20.8) minutes for succinylcholine and rocuronium patients, respectively (*P* = .13). Because the primary outcome's distribution was skewed, the difference in the primary outcome was analyzed using an unpaired Mann-Whitney *U* test. Table 2 describes the timeliness of sedation post-etomidate in each group. Given the average duration of effect of all 3 agents, the bold text highlights patients who may have been without sedation while paralyzed (0 [0%] succinylcholine vs. 33 [86.8%] rocuronium patients).[8,12,14]

Hypotension occurred in 31.3% of succinylcholine patients and 36.8% of rocuronium patients (*P* = .66). Multivariate logistic regression analyses found older age, male sex, and ground transport were associated with a greater likelihood of hypotension (Table 3). After adjusting for the duration of transport agency care, there was no difference in the number of sedative doses per minute post-etomidate between succinylcholine and rocuronium patients (0.032 [IQR = 0.019-0.049] vs. 0.030 [IQR = 0.021-0.048], *P* = .60).

Further post hoc analyses showed that patients transported by air received post-etomidate sedation more quickly than those transported by ground (10 [IQR = 5-16] vs. 20 [IQR = 14-28.5] minutes, respectively; *P* = .003). Additionally, patients who were transported from the scene received post-etomidate sedation more quickly than those transported as an interfacility transfer (10 [IQR = 5-14.75] vs. 14 [IQR = 7-21.25] minutes, respectively; *P* = .028). Characteristics associated with the use of a long-acting paralytic post-intubation for transport (n = 82, 80.3%) included trauma patients (*P* = .005), scene responses and air transports (*P* = .026 and *P* = .002, respectively), and younger age (*P* = .022). Fourteen (17.1%) of these patients received succinylcholine for RSI followed by a long-acting paralytic for transport before their first post-etomidate sedative. The median time to the first sedative for the succinylcholine patients receiving and not receiving a long-acting paralytic before the first sedative was 13 (IQR = 11-13) and 7 (IQR = 5-11.75) minutes, respectively (*P* = .002).

For patients intubated with succinylcholine, fentanyl (n = 32, 50%) or morphine (n = 24, 37.5%) were the first sedative agents administered. For patients intubated with rocuronium, morphine (n = 20, 52.6%), fentanyl (n = 13, 34.2%), lorazepam (n = 1, 2.6%), or simultaneous fentanyl/midazolam (n = 1, 2.6%) were the first sedatives administered. Eight (12.5%) succinylcholine and 3 (7.9%) rocuronium patients did not receive a sedative agent before having their care transitioned to the receiving hospital. The median time between etomidate administration and the transition of care was 42 (IQR = 22.3-56) minutes for succinylcholine (n = 8) and 15 (IQR = 11-59) minutes for rocuronium (n = 3) patients.

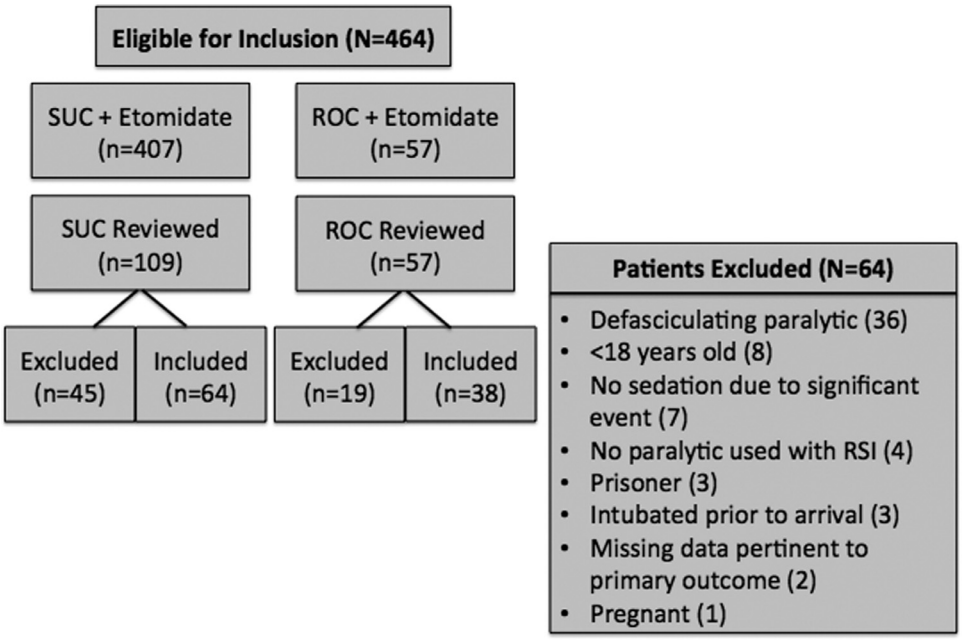

Figure 1. Exclusion criteria. The figure provides details regarding the exclusion criteria that were met and the number of run reports reviewed. Reports were reviewed until power was reached or, in the case of rocuronium, all available patients in the designated study period had been included or excluded. ROC = rocuronium; SUC = succinylcholine.

Table 1
Patient Demographics

	Succinylcholine (n = 64)	Rocuronium (n = 38)	*P* Value
Age (years)			
Median (IQR)	51.5 (31.0-70.3)	54.0 (48.0-69.0)	.28[b]
Sample size[a]	64	33	
Age > 90 years, n (%)	0 (0.0)	2 (5.3)	.13[c]
Weight (kg)			
Median (IQR)	80.1 (68.2-91.1)	71.2 (68.2-90.9)	.23[b]
Male sex, n (%)	39 (60.9)	21 (55.3)	.68[c]
Glasgow Coma Scale[d]			
Median (IQR)	9.0 (6.0-14.0)	10.5 (6.3-14.0)	.52[b]
Sample size[a]	51	34	
Heart rate (beats per minute)[d]			
Median (IQR)	109.5 (88.0-120.0)	108.0 (89.5-120.0)	1[b]
Sample size[a]	58	35	
Systolic blood pressure (mm Hg)[d]			
Median (IQR)	128.5 (112.0-149.0)	120.5 (101.0-157.0)	.66[b]
Sample size[a]	54	34	
Respiratory rate (breaths/min)[d]			
Median (IQR)	24.0 (16.8-30.0)	25.0 (10.5-32.8)	.82[b]
Sample size[a]	56	34	
Etomidate dose (mg/kg)			
Median (IQR)	0.30 (0.28-0.31)	0.29 (0.26-0.30)	.36[b]
Paralytic dose (mg/kg)			
Mean (SD)	1.496 (0.094)	0.948 (0.114)	—
Sample size[a]	63	38	
Scene transport, n (%)	42 (65.6)	12 (31.6)	.0011[c]
Air transport, n (%)	58 (90.6)	29 (76.3)	.08[c]
Trauma transport, n (%)	40 (62.5)	11 (28.9)	.0019[c]
Transport time (min)			
Median (IQR)	25.5 (19.8-34.3)	30.0 (20.0-39.3)	.28[b]
Postintubation rocuronium or vecuronium for transport, n (%)	57 (89.1)	25 (65.8)	.0085[c]

IQR = interquartile range; SD = standard deviation.
[a] The exact sample size for patients with specific data variables.
[b] Two-sided Mann-Whitney *U* test.
[c] Two-sided Fisher's exact test.
[d] Immediately before etomidate administration.

Table 2
Frequency Table of Sedation and Paralysis

	Succinylcholine[a] (n = 64), n (%)	Rocuronium[b] (n = 38), n (%)
Sedative given between 0 and 4 minutes	11 (17.19)	5 (13.16)
Sedative given between 5 and 9 minutes	17 (26.56)	**7 (18.42)**
Sedative given between 10 and 19 minutes	26 (40.63)	**14 (36.84)**
Sedative given between 20 and 29 minutes	2 (3.12)	**6 (15.79)**
Sedative given at or after 30 minutes	8 (12.5)[c]	**6 (15.79)**[d]

The bold text highlights patients paralyzed without sedation based on each medication's duration of effect. Etomidate's average duration of effect is 4 minutes, ranging from 3 to 5 minutes.[8]
[a] Succinylcholine's average duration of effect is 5 minutes, ranging from 4 to 6 minutes.[12]
[b] Rocuronium's average duration of effect is 76 minutes, ranging from 58 to 94 minutes.[14]
[c] Ranging from 38 to 71 minutes.
[d] Ranging from 30 to 59 minutes.

Table 3
Occurrence of Hypotension

	Odds Ratio	*P* Value	95% CI
Univariate			
Age (increasing by 1 year)	1.02	.054	1.00-1.05
Sex (male vs. female)	2.63	.036	1.10-6.67
Transport type (interfacility transfer vs. scene)	2.45	.037	1.06-5.87
Transport mode (ground vs. air)	3.70	.023	1.22-12.2
Group (ROC vs. SUC)	1.28	.56	0.55-2.99
Multivariate			
Age (increasing by 1 year)	1.03	.043	1.002-1.06
Sex (male vs. female)	5.00	.0034	1.82-16.1
Transport mode (ground vs. air)	4.35	.028	1.22-16.9

CI = confidence interval; ROC = rocuronium; SUC = succinylcholine.
Univariate and multivariate analysis of all patients and factors associated with the occurrence of hypotension.

Discussion

Our study was not able to show a difference in the time to post-etomidate sedation when comparing patients intubated with rocuronium in the prehospital setting with those who were intubated with succinylcholine. This could be because of limitations in our ability to achieve our estimated sample size in the rocuronium group or because no difference exists. However, it is of interest that a statistically significant difference was found within the succinylcholine group when comparing those receiving with those not receiving a long-acting paralytic before the first post-etomidate sedative dose. Although our primary end point was the time to the administration of the first sedative, Table 2 takes into account the pharmacokinetic properties of each NMBA and suggests patients intubated with rocuronium are more likely to remain paralyzed without timely concomitant sedation post-RSI in the prehospital setting. In the current study, the duration of this wakeful paralysis state ranged from 1 to 55 minutes in patients paralyzed with rocuronium.

Our study is the first to evaluate post-intubation sedation as a primary outcome in patients intubated in the prehospital setting. The primary objective of Elofson et al[10] was to evaluate the use of NMBAs in the prehospital setting; they included post-intubation sedation as an exploratory analysis. These authors found a difference in the time to the first sedative dose when comparing patients who at any time received a long-acting NMBA (n = 42) with those who did not (n = 9). Several additional differences exist when compared with the current study. The Elofson study included patients who received etomidate or midazolam for RSI induction. These medications possess different durations of effect, which may confound appropriate timeliness of post-intubation sedation.[8,20] Patients were treated for trauma injuries, and only those transported from the scene were included. Care was provided by 8 different emergency medical service agencies, likely possessing different protocols and medical direction, and patients were brought to a single tertiary care ED. Finally, midazolam was the only sedative agent considered for the primary outcome. Of patients who did not receive midazolam post-intubation (n = 12), 50% to 55% received a sedating opioid.[10] In the current study, benzodiazepines and opioids were available to transport agency personnel through the post-intubation care protocol and were considered appropriate first sedative agents.

Although our study was unable to show a statistical difference in the time to post-etomidate sedation during prehospital care, others have demonstrated differences in other patient care settings. Watt et al[15] and Korinek et al[16] performed retrospective, cohort studies in which both found greater delays in post-intubation sedation when rocuronium was used for RSI compared with succinylcholine. However, both of these studies took place in an academic ED, an environment that differs greatly from the prehospital setting. An academic ED has a higher patient-to-provider ratio requiring delegation of care and also provides medical management using medical residents in training versus fully trained, experienced transport personnel. Finally, in the prehospital setting, there is strong emphasis placed on the safety of both the provider and patient during high-risk air and ground transport.

We were unable to show differences in the secondary outcome of sedative doses per minute post-etomidate. However, previous literature has identified a relationship between RSI paralytic and the amount of sedative administered post-intubation. Korinek et al[16] evaluated sedation and analgesia infusion rates 30 minutes after RSI between patients who received succinylcholine and rocuronium for intubation in the ED. These authors found patients intubated with succinylcholine had higher rates of both propofol and fentanyl infusions compared with patients intubated with rocuronium. This study determined patients intubated with succinylcholine not only received sedation and analgesia more quickly but were also administered higher doses of these sedating medications. Korinek et al also observed a trend toward more hypotension (SBP < 90 mm Hg) in patients receiving succinylcholine for intubation ($P = .062$), suggesting a relationship between the cumulative amount of sedation and hypotension. In the current study, we found no difference in the incidence of hypotension between patients receiving succinylcholine and rocuronium ($P = .66$). This lack of difference in hypotension between arms may be because of the similar number of sedative doses per minute of transport agency care between the succinylcholine and rocuronium groups although many additional factors unable to be explored in this retrospective study contribute to the occurrence of hypotension in the prehospital setting and should also be considered.

Our post hoc analyses determined patients who were transported by air from the scene received post-etomidate sedation more quickly than ground, interfacility transports. Although only hypothesis generating, the patient care setting and patient population could explain these findings. In our study, patients transported from the scene were almost exclusively trauma patients. Paramedics and nurses may be more aware of changes in a patient's vital signs (indicating a state of wakeful paralysis) when caring for a trauma patient from the scene via high-risk, air transport. Patients who are transported as an interfacility transfer may be more likely to have already been stabilized because of a medical versus trauma complication. Although no true conclusions can be drawn, these relationships may give providers an area of future investigation.

There are important clinical implications from this study. Transport teams should be encouraged to be attentive to the kinetics of sedative agents and provide prompt sedation regardless of the paralytic used during RSI or mode (ground vs. air) and type (scene vs. interfacility) of transport. Receiving providers should understand the impact of the mode and type of transport on time to post-intubation sedation. In our study, 11 (10.8%) patients arrived to the receiving medical center without receiving any sedative after intubation. This highlights the importance of focusing on the care provided before, as well as after, arrival. Providers must also be aware that in these acutely ill patients, hypotension can lead to prerenal acute kidney injury and further complicate their care. Compared with rocuronium, succinylcholine patients received a similar number of sedative doses per minute postetomidate, likely leading to equivalent hypotensive episodes. Finally, given rocuronium's 58 to 94 minute duration of effect, patients intubated with etomidate and rocuronium are at an increased risk of wakeful paralysis compared with etomidate and succinylcholine. This raises the question as to whether, unless contraindicated, succinylcholine should always be the preferred RSI paralytic in critical care transport agency protocols.

It was estimated that 64 patients per group would have at least 80% power to detect a difference in time to postetomidate sedation between those receiving succinylcholine and rocuronium for RSI. Although we screened and included all eligible patients receiving rocuronium as far back as the transport agency's records were available, we were unable to achieve the desired 64 patients in this group. This unexpectedly small number of eligible rocuronium patients may be caused by transport agency personnel preference or bias toward the use of etomidate and succinylcholine for RSI, patients being transported and not intubated, a Glasgow Coma Scale of 3 was noted on arrival and induction agents not being used, or patients receiving etomidate without paralytic for RSI. Although other studies may have suggested a smaller sample size estimate, the more conservative Cohen method was used because previous studies were performed in the ED.[15,16] As such, this study is at risk of a type II error, not detecting a difference when one truly exits.

Although the authors tried to account for all confounding variables, the use of a long-acting paralytic for transport may have influenced the study findings, specifically patients receiving succinylcholine as the RSI agent and the significant difference between those receiving and those not receiving a long-acting paralytic for transport in the time to the first postetomidate sedative. The use of long-acting paralytics for transport may also have impacted sedative doses per minute between the succinylcholine and rocuronium groups. The retrospective cohort design places the study at risk for documentation inaccuracies and omissions. Several patients in both study arms were found to be missing baseline demographics such as age and vital signs. Given the study design and lack of electronic medical record access at the transferring and receiving hospitals, the authors were unable to account for all sedative medications given before and after transport agency care. Medications given before arrival but known by transport agency personnel may have affected the timeliness of postetomidate sedation. Eleven patients did not receive a sedative before arriving to the receiving medical center. Thus, their primary outcome was the time of transition of care, our surrogate measure, rather than the time of sedative given by the receiving provider.

Conclusion

When used for RSI, etomidate's short duration of effect in the face of rocuronium's long duration of effect puts patients at a higher risk for being undersedated while chemically paralyzed. Prehospital providers should remain cognizant of the fact that patients receiving etomidate for RSI induction should be given a sedative within minutes of successful intubation to prevent this untoward complication.

References

1. Lossius HM, Rùislien J, Lockey DJ. Patient safety in pre-hospital emergency tracheal intubation: a comprehensive meta-analysis of the intubation success rates of EMS providers. *Crit Care*. 2012;16:R24.
2. Okubo M, Gibo K, Hagiwara Y, et al. The effectiveness of rapid sequence intubation (RSI) versus non-RSI in emergency department: an analysis of multicenter prospective observational study. *Int J Emerg Med*. 2017;10:1.
3. Rose WD, Anderson LD, Edmond SA. Analysis of intubations. Before and after establishment of a rapid sequence intubation protocol for air medical use. *Air Med J*. 1994;13:475–478.
4. Ochs M, Davis D, Hoyt D, et al. Paramedic-performed rapid sequence intubation of patients with severe head injuries. *Ann Emerg Med*. 2002;40:159–167.
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. Wayne MA, Friedland E. Prehosptial use of succinylcholine: a 20-year review. *Prehosp Emerg Care*. 1999;3:107–109.
7. Walls RM, Brown CA, Bair AE, Pallin DJ. Emergency airway management: a multi-center report of 8937 emergency department intubations. *J Emerg Med*. 2011;41:347–354.
8. Lake Forest, IL: Hospira, Inc; 2011.
9. Hiestand B, Cudnik MT, Thomson D, Werman HA. Rocuronium versus succinylcholine in air medical rapid-sequence intubation. *Prehosp Emerg Care*. 2011;15:457–463.
10. Elofson KA, Rhoads SF, Tang A, et al. Long-acting neuromuscular blocker use during prehospital transport of trauma patients. *Air Med J*. 2013;32:203–207.
11. Hankins D. Rocuronium versus succinylcholine for rapid sequence intubation. *Air Med J*. 2012;31:16–17.
12. Lake Forest, IL: Hospira, Inc; 2010.
13. Stollings JL, Diedrich DA, Oyen LJ, Brown DR. Rapid-sequence intubation: a review of the process and considerations when choosing medications. *Ann Pharmacother*. 2014;48:62–76.
14. Irvine, CA: Teva Parenteral Medicines, Inc; 2008.
15. Watt JM, Amini A, Traylor BR, et al. Effect of paralytic type on time to post-intubation sedative use in the emergency department. *Emerg Med J*. 2013;30:893–895.
16. Korinek JD, Thomas RM, Goddard LA, et al. Comparison of rocuronium and succinylcholine on postintubation sedative and analgesic dosing in the emergency department. *Eur J Emerg Med*. 2014;21:206–211.
17. Frakes MA, Lord WR. Sedative use in patients receiving neuromuscular blocking agents from a helicopter flight team. *Air Med J*. 2006;25:173–175.
18. Patel SB, Kress JP. Sedation and analgesia in the mechanically ventilated patient. *Am J Respir Crit Care Med*. 2012;185:486–497.
19. Cohen J. A power primer. *Psychol Bull*. 1992;112:155–159.
20. Schaumburg, IL: Sagent Pharmaceuticals; 2012.