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Original Article

Reversal effect of sugammadex sodium on rocuronium-induced neuromuscular blockade in patients undergoing painless tracheoscopy

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Abstract: Objective: To compare the efficacy and safety of sugammadex sodium versus neostigmine for rocuronium-induced neuromuscular blockade during painless tracheoscopy. Methods: A retrospective analysis was conducted in 278 consecutive patients who underwent painless tracheoscopy under rocuronium anesthesia between January 2023 and May 2024. Patients received either sugammadex (n = 125) or neostigmine (n = 153) for muscle-relaxant reversal. Outcomes evaluated included train-of-four (TOF) recovery times (TOF ≥ 0.25, 0.75, 0.9), complete reversal rates, recovery metrics (eye-opening time, post-anesthesia care unit (PACU) stay) and complication rates. Correlations between baseline characteristics and TOF recovery times were also assessed. Results: Sugammadex significantly accelerated TOF recovery (all $P < 0.001$) and improved complete reversal rate ($P = 0.013$). Eye-opening and PACU times were reduced by 35.4% and 35.8%, respectively (both $P < 0.001$). The incidences of hypoxemia, bradycardia, and postoperative nausea and vomiting (PONV) were also decreased (all $P < 0.05$). Age, body mass index (BMI), and American Society of Anesthesiologists (ASA) class were positively correlated with TOF recovery time. Conclusion: In painless tracheoscopy, sugammadex sodium provides rapid and complete reversal of rocuronium, lowers postoperative complications, and improves perioperative efficiency.

Keywords: Sugammadex sodium, neostigmine, painless tracheoscopy, rocuronium, neuromuscular blockade reversal

Introduction

With the rapid development of diagnostic and therapeutic technologies for respiratory diseases, painless tracheoscopy has become the preferred approach for managing lung tumors, infectious diseases, airway stenosis, and other lesions, owing to its advantages of good patient tolerance and high procedural precision [1]. To maintain a clear surgical field and minimize patient movement, neuromuscular blocking agents such as rocuronium are commonly administered to achieve profound muscle relaxation [2]. However, postoperative residual neuromuscular blockade (PORC) may result in serious complications, including respiratory muscle weakness, hypoxemia, and even aspiration [3, 4]. Therefore, safe and rapid reversal of neuromuscular blockade has become a key determinant of perioperative safety during painless tracheoscopy.

The conventional reversal agent, neostigmine, increases acetylcholine concentration at the neuromuscular junction by inhibiting acetylcholinesterase. Nevertheless, this mechanism has significant limitations [5]. Evidence suggests that neostigmine has limited efficacy in reversing deep blockade and may induce cholinergic side effects such as bradycardia and bronchospasm, necessitating co-administration of atropine [6, 7]. Furthermore, its relatively slow onset may prolong the post-anesthesia care unit (PACU) stay and reduce procedural efficiency [8]. In short procedures such as painless tracheoscopy, traditional reversal strategies often fail to achieve the desired balance between rapid recovery and safety, highlighting the need for more effective neuromuscular blockade management.

Sugammadex sodium, the first selective muscle relaxant antagonist, overcomes the limitations

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of traditional agents by directly encapsulating rocuronium molecules, thereby rapidly terminating their neuromuscular blocking effect [9]. Multiple randomized controlled trials have demonstrated that sugammadex sodium can reverse profound neuromuscular blockade (TOF ratio ≥ 0.9) within 2-5 minutes, markedly reducing the incidence of PORC without inducing cholinergic side effects [10, 11]. Its superiority over neostigmine has been well-established in general anesthesia. However, painless tracheoscopy is characterized by short procedural duration, variable requirements for the depth of muscle relaxation, and a high demand for rapid patient turnover. The clinical value of sugammadex sodium in this specific setting, therefore, warrants further investigation. Current comparative evidence for painless tracheoscopy remains limited, and in particular, its applicability in terms of operational efficiency and in special populations has not yet been clarified.

This study aimed to systematically evaluate the efficacy of sugammadex sodium in reversing rocuronium-induced neuromuscular blockade during painless tracheoscopy and to provide a reference for clinical practice health economic decision-making.

Materials and methods

Study design

This retrospective study included a total of 278 patients who underwent tracheoscopy under rocuronium anesthesia at Xi'an Honghui Hospital and Xi'an International Medical Center Hospital from January 2023 to May 2024. Based on the agent used for neuromuscular blockade reversal, patients were assigned to either the sugammadex sodium group (Research Group, n = 125) or the neostigmine group (Control Group, n = 153). The study protocol was approved by the Medical Ethics Committee of Xi'an International Medical Center Hospital.

Inclusion and exclusion criteria

Inclusion criteria: age ≥ 18 years, American Society of Anesthesiologists (ASA) classification I-III, receipt of rocuronium-induced neuromuscular blockade, absence of severe hepatic or renal insufficiency (estimated glomerular filtration rate eGFR ≥ 30 mL/min/1.73 m^2 or non-Child-Pugh C grade), and no history of drug allergy. Exclusion criteria: pregnancy, lactation, intraoperative hemodynamic instability requiring emergency intervention, use of other muscle relaxants during the operation, or emergency conversion to open surgery during the operation.

Data collection and monitoring methods

Baseline characteristics (age, sex, body mass index [BMI], ASA classification, and preoperative hemoglobin), intraoperative findings (surgery duration, total rocuronium dose, and anesthesia duration), neuromuscular recovery outcomes (time to recovery of TOF ratio to ≥ 0.25, 0.75, and 0.9, and complete reversal rate), postoperative recovery outcomes (awakening time, length of PACU stay, heart rate [HR] and mean arterial pressure [MAP] at extubation, and serum calcium level 2 hours after surgery), and complications (hypoxemia, bradycardia, postoperative sore throat, nausea, and vomiting) were retrieved from the electronic medical record system and anesthesia records.

Monitoring of neuromuscular recovery

Neuromuscular function was continuously monitored with a TOF-Watch SX acceleromyograph at the adductor pollicis muscle. The recorded data inlcuded the time from administration of the reversal agent to the first recovery of the TOF ratio to ≥ 0.25, ≥ 0.75, and ≥ 0.9, as well as the complete reversal rate, defined as a TOF ratio ≥ 0.9 with no residual signs of neuromuscular blockade within 24 hours postoperatively.

Collection of postoperative awakening and recovery indicators

Postoperative awakening-related outcomes included recovery time, defined as the interval from cessation of anesthetic administration to eye opening and appropriate response to verbal command, and length of PACU stay, defined as the interval from PACU admission until meeting the discharge criteria (Aldrete score ≥ 9). Hemodynamic indices at extubation, including HR and MAP, were recorded at the time of tube removal. In addition, venous blood samples were obtained 2 hours after surgery, and serum calcium ion concentrations were measured using an automated biochemical analyzer.

Table 1. Comparison of baseline data between the two groups

	Research Group (n = 125)	Control Group (n = 153)	t/χ^2	P
Age (years)	57.90±12.23	57.20±11.15	0.499	0.619
Sex				
Male/Female	68/57	90/63	0.549	0.459
Surgery time (min)	21.03±4.83	20.40±6.44	0.905	0.366
BMI (kg/m^2)	24.66±3.01	25.35±3.39	1.775	0.077
ASA Classification				
I/II/III	31/66/28	45/69/39	1.648	0.439
Preoperative Hemoglobin (g/L)	132.14±15.52	129.78±14.37	1.314	0.190

Note: BMI: Body Mass Index, ASA: American Society of Anesthesiologists.

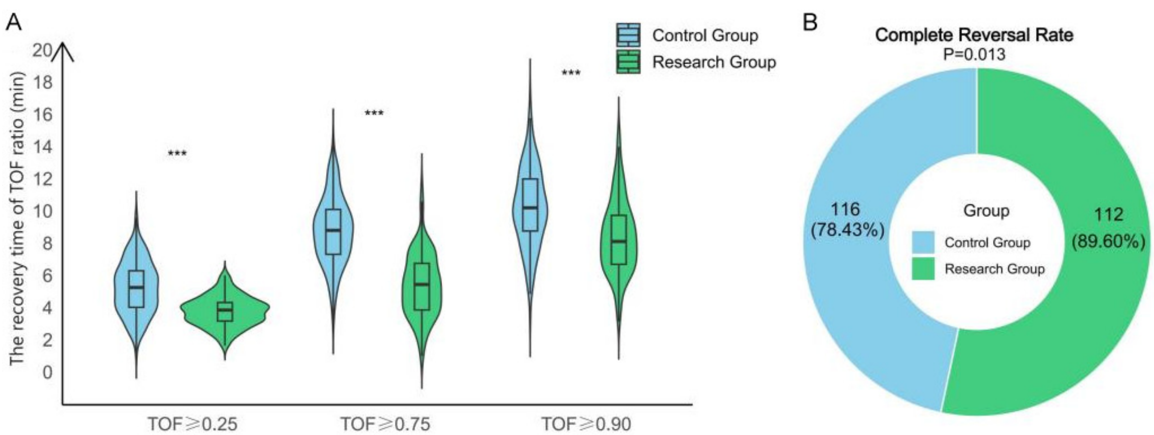


Figure 1. Comparison of reversal effects of neuromuscular blockade between the two groups. A. TOF ratio recovery to 0.25, 0.75, and 0.9 in both groups. B. Complete reversal rate in both groups. Note: TOF: Train-of-Four, ***P < 0.001.

Statistical analysis methods

The sample size was calculated based on the primary outcome measure (time to TOF ratio recovery to ≥ 0.9). Assuming a two-tailed α of 0.05 and a test power of 0.9, and using pre-experimental data (mean recovery time in the neostigmine group: 10±3 minutes), at least 110 patients per group were required to detect a 30% difference between groups. Finally, 278 eligible patients were included. Continuous variables were expressed as mean ± standard deviation, and independent sample t-tests were used for intergroup comparison. Categorical variables were expressed as frequencies (percentages), and chi-square tests were used for intergroup comparisons. Correlations between TOF recovery time and baseline variables were assessed using Pearson's test (continuous variables) or Spearman's test (ordinal variables). Statistical analyses were performed using SPSS 26.0, and the significance level was set at two-sided P < 0.05.

Results

Baseline data

No significant differences were observed between the sugammadex group and the neostigmine group in terms of age, sex distribution, surgery time, BMI, ASA classification, or preoperative hemoglobin level (P > 0.05) (**Table 1**).

Reversal of neuromuscular blockade

The times to TOF ratio to recover to ≥ 0.25, 0.75, and 0.9 were significantly shorter in the sugammadex Group than those in the sugammadex group (all P < 0.001). The complete reversal rate was also significantly higher in the sugammadex group (P = 0.013) (**Figure 1**).

Postoperative awakening and recovery

Compared to the neostigmine group, the sugammadex group demonstrated significantly

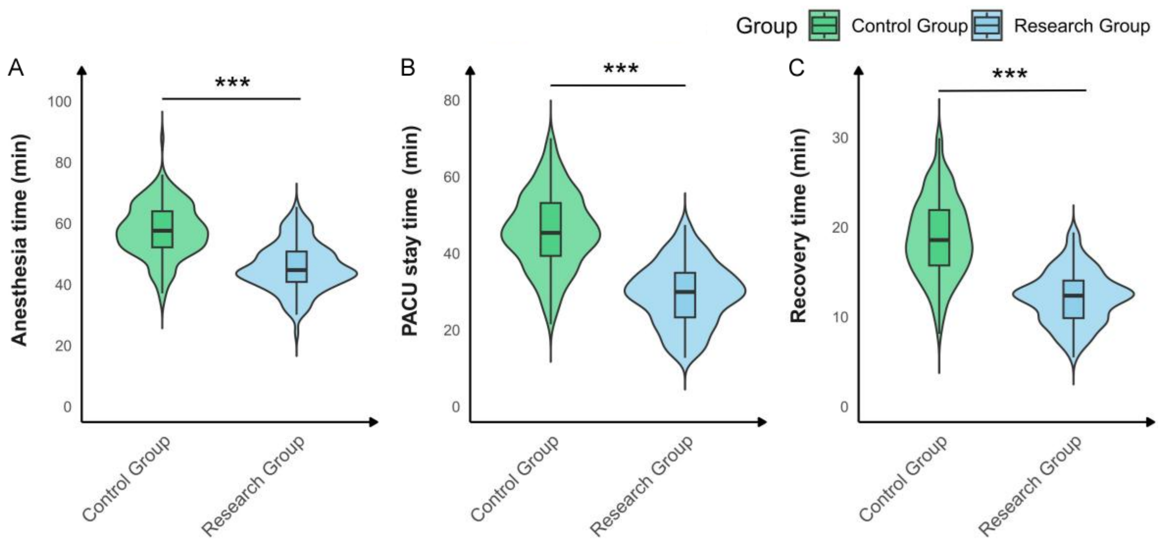


Figure 2. Comparison of postoperative awakening and extubation indicators between the two groups. A. Anesthesia time; B. PACU stay duration; C. Emergence time. Note: PACUL: Post-anesthesia Care Unit, ***P < 0.001.

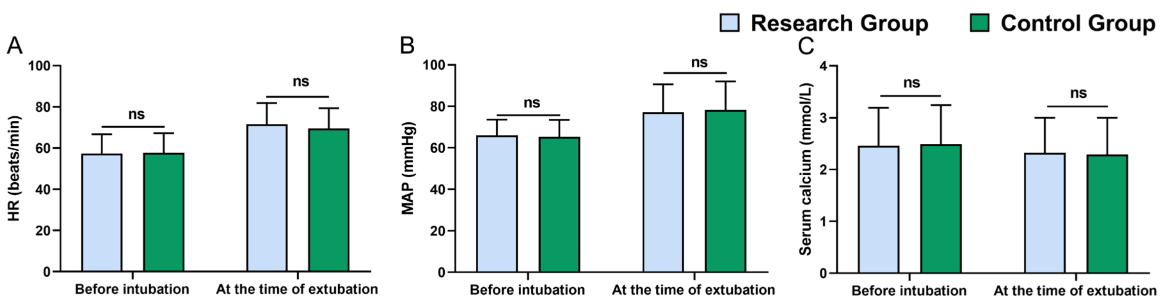


Figure 3. Comparison of hemodynamics and serum calcium concentration between the two groups before intubation and at the time of exbutation. A. Heart rate (HR); B. Mean arterial pressure (MAP); C. Serum calcium concentration. Note: HR: Heart Rate, MAP: Mean Arterial Pressure, ^{ns}P > 0.05.

shorter anesthesia duration, recovery time, and PACU stay (all P < 0.001) (**Figure 2**).

Hemodynamics and serum calcium

No statistical differences were observed between the two groups in preoperative HR, MAP or serum calcium levels. Similarly, HR and MAP at extubation, as well as serum calcium concentrations 2 hours after surgery, did not differ significantly between the groups (all P > 0.05) (**Figure 3**).

Postoperative complications

In terms of postoperative complications, the incidences of hypoxemia, bradycardia, and nausea and vomiting were significantly lower in the Research Group than those in the control group (P < 0.05). There was no significant difference in the incidence of postoperative sore throat between the two groups (P > 0.05) (**Table 2**).

Correlation between baseline characteristics and TOF recovery

Correlation analyses were performed to assess the relationship between baseline characteristics and the time to TOF recovery to ≥ 0.9. In the Research Group, age (r = 0.205, P = 0.022), BMI (r = 0.379, P < 0.001), and ASA classification (r = 0.260, P = 0.003) showed significant positive correlation with recovery time. Surgery duration, preoperative hemoglobin, and sex showed no significant association with recovery time (all P > 0.05). In the Control Group, the correlations were more pronounced. Recovery

Table 2. Comparison of the incidence of postoperative complications between the two groups

	Research Group (n = 125)	Control Group (n = 153)	t	P
Hypoxemia	5 (4.00)	16 (10.46)	4.108	0.042
Bradycardia	7 (5.60)	26 (16.99)	8.536	0.004
Postoperative Sore Throat	10 (8.00)	21 (13.73)	2.276	0.131
Nausea and Vomiting	7 (5.60)	24 (15.69)	7.064	0.008

time demonstrated strong positive associations with age (r = 0.380, $P < 0.001$), BMI (r = 0.474, $P < 0.001$), and ASA classification (r = 0.435, $P < 0.001$), with higher correlation coefficients compared to the Research group. Similarly, surgery duration, preoperative hemoglobin, and sex showed no significant associations (all $P > 0.05$). Details are shown in **Figure 4**.

Reversal effects of sugammadex sodium in different populations

Across all stratifications by age (< 65 years vs. ≥ 65 years), BMI (< 24 kg/m^2 vs. ≥ 24 kg/m^2), and ASA classification (I, II, or III), the time to TOF recovery to ≥ 0.9 was significantly shorter in the Research Group compared to the Control Group ($P < 0.05$). Similarly, in both age and BMI subgroups, the complete reversal rate was significantly higher in the Research Group than in the Control Group ($P < 0.05$). Subgroup analysis by ASA classification revealed no significant difference in the complete reversal rate between groups among patients with ASA grade I ($P > 0.05$). However, among patients with ASA II or III, the Research Group demonstrated a significantly higher complete reversal rate compared to the Control Group ($P < 0.05$). See **Table 3** for details.

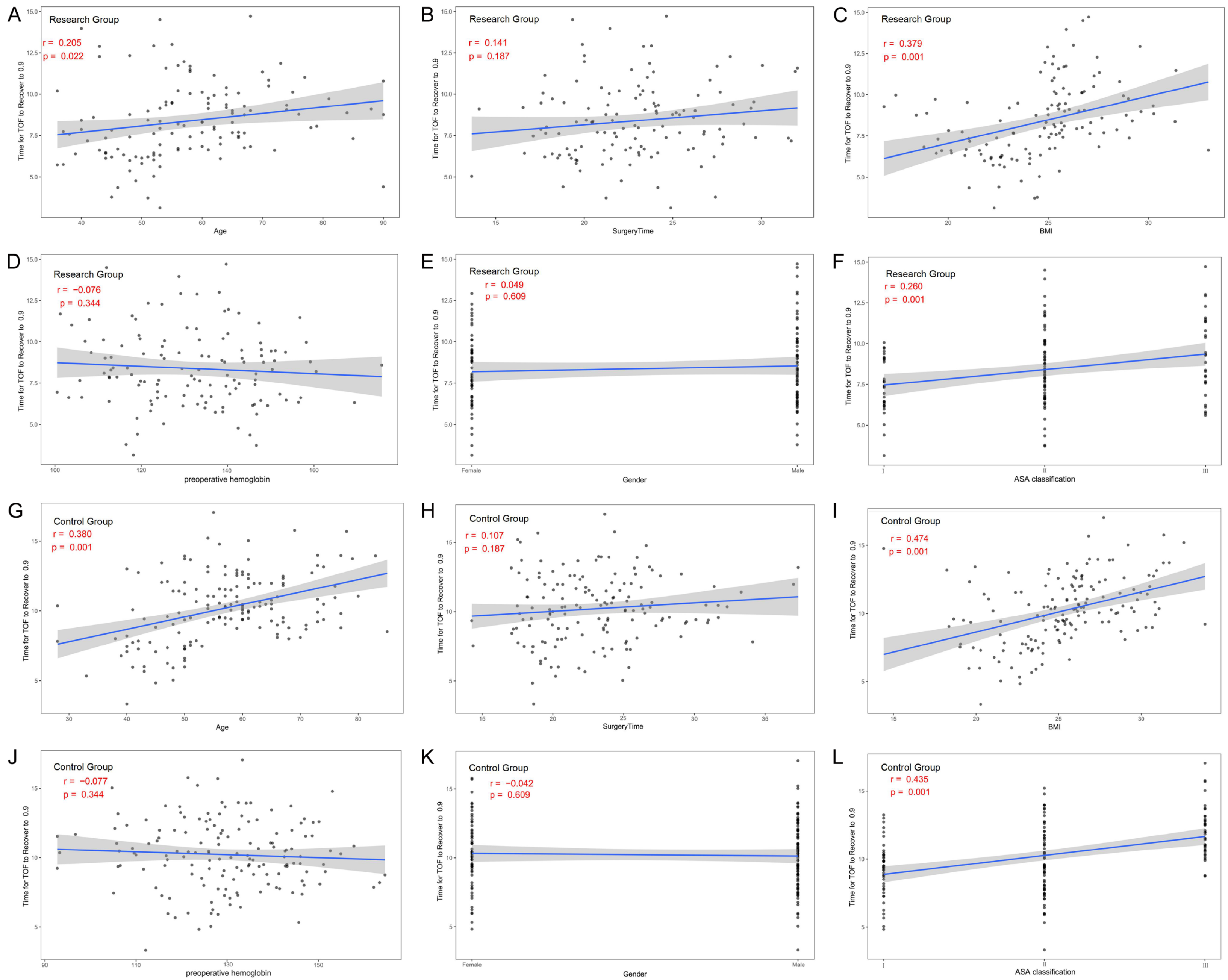
Reversal effects under different rocuronium doses

Subgroup analysis based on rocuronium dosage (≤ 0.6 mg/kg vs. > 0.6 mg/kg) revealed distinct patterns in TOF recovery time and complete reversal rates. Under both dosage conditions, the Research group achieved significantly shorter TOF recovery times to 0.9 compared to the Control group (all $P < 0.05$). Notably, within both groups, patients who received > 0.6 mg/kg required significantly longer TOF recovery times than those who received ≤ 0.6 mg/kg (all $P < 0.01$). Regarding complete reversal rates, no significant difference was observed between the two groups in the ≤ 0.6 mg/kg subgroup ($P > 0.05$). However, at doses > 0.6 mg/kg, the Research group achieved a significantly higher complete reversal rate compared to the Control group ($P < 0.05$). Importantly, the Control group showed a dose-dependent decline in complete reversal rates, with patients receiving ≤ 0.6 mg/kg exhibiting significantly higher rates than those receiving > 0.6 mg/kg ($P < 0.01$). Data are shown in **Table 4**.

Discussion

As a novel selective antagonist of neuromuscular blocking agents, the clinical utility of sugammadex sodium has been extensively validated in general anesthesia [12]. Welliver et al. [13] reported that its reversal efficiency for rocuronium is more than three times higher than that of traditional agents. Notably, its rapid onset and safety profile may be particularly advantageous in short-duration procedures such as painless tracheoscopy [14]. By directly comparing sugammadex sodium with neostigmine for the reversal of rocuronium-induced neuromuscular blockade, this study confirms the superior efficacy of sugammadex sodium in accelerating recovery, improving perioperative safety, and optimizing management in specific patient subgroups. These findings provide important evidence to guide muscle relaxation strategies for painless tracheoscopy.

Our findings demonstrated that the times to TOF recovery to ≥ 0.25, ≥ 0.75, and ≥ 0.9 were significantly shorter in the sugammadex group compared to the neostigmine group, and that the complete reversal rate was markedly higher. These findings are consistent with the unique pharmacologic mechanism of sugammadex. Unlike neostigmine, which indirectly increases acetylcholine levels at the neuromuscular junction by inhibiting acetylcholinesterase, sugammadex encapsulates rocuronium molecules through steric binding, thereby directly terminating neuromuscular blockade and over-


A
Research Group
r = 0.205
p = 0.022
Time for TOF to Recover to 0.9
Age
B
Research Group
r = 0.141
p = 0.187
Time for TOF to Recover to 0.9
SurgeryTime
C
Research Group
r = 0.379
p = 0.001
Time for TOF to Recover to 0.9
BMI
D
Research Group
r = −0.076
p = 0.344
Time for TOF to Recover to 0.9
preoperative hemoglobin
E
Research Group
r = 0.049
p = 0.609
Time for TOF to Recover to 0.9
Female
Male
Gender
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Research Group
r = 0.260
p = 0.001
Time for TOF to Recover to 0.9
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Control Group
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r = −0.077
p = 0.344
Time for TOF to Recover to 0.9
preoperative hemoglobin
K
Control Group
r = −0.042
p = 0.609
Time for TOF to Recover to 0.9
Female
Male
Gender
L
Control Group
r = 0.435
p = 0.001
Time for TOF to Recover to 0.9
ASA classification

Figure 4. Correlation analysis of baseline characteristics and TOF recovery. (A-F) Correlation between TOF ratio recovery to ≥ 0.9 and age (A), operative time (B), BMI (C), preoperative hemoglobin level (D), sex (E), and ASA classification (F) in the Study group. (G-L) Correlation between TOF ratio recovery to ≥ 0.9 and age (G), operative time (H), BMI (I), preoperative hemoglobin level (J), sex (K), and ASA classification (L) in the Control group. Note: TOF: Train-of-Four, BMI: Body Mass Index, ASA: American Society of Anesthesiologists.

Table 3. Comparison of reversal effects between the two groups in different populations

Subgroup	Time for TOF Ratio to Recovery to ≥ 0.9 (min)	t	P	Complete Reversal Rate	χ^2	P
Age < 65 years old		5.160	< 0.001		4.788	0.029
Research Group (n = 91)	8.18±2.39			82 (90.11)		
Control Group (n = 113)	9.97±2.52			89 (78.76)		
Age ≥ 65 years old		4.146	< 0.001		4.465	0.035
Research Group (n = 34)	8.94±1.86			30 (88.24)		
Control Group (n = 40)	10.89±2.14			27 (67.50)		
BMI < 24 kg/m^2		3.418	< 0.001		4.661	0.031
Research Group (n = 44)	6.95±1.50			40 (90.91)		
Control Group (n = 45)	8.47±2.55			33 (73.33)		
BMI ≥ 24 kg/m^2		5.676	< 0.001		4.546	0.033
Research Group (n = 81)	9.16±2.25			72 (88.89)		
Control Group (n = 108)	10.93±2.02			83 (76.85)		
ASA classification						
I		4.166	< 0.001		0.235	0.628
Research Group (n = 31)	7.38±1.70			28 (90.32)		
Control Group (n = 45)	9.20±1.98			39 (86.67)		
II		3.266	0.001		6.259	0.012
Research Group (n = 66)	8.49±2.27			60 (90.91)		
Control Group (n = 69)	9.84±2.52			53 (74.65)		
III		5.264	< 0.001		4.689	0.030
Research Group (n = 28)	9.26±2.48			24 (85.71)		
Control Group (n = 39)	12.03±1.83			24 (61.54)		

Note: BMI: Body Mass Index, ASA: American Society of Anesthesiologists, TOF: Train-Of-Four.

Table 4. Comparison of reversal effects between the two groups under different rocuronium doses

Subgroup	Time for TOF Ratio to Recovery to ≥ 0.9 (min)	t	P	Complete Reversal Rate	χ^2	P
≤ 0.6 mg/kg		2.522	0.014		3.041	0.081
Research Group (n = 72)	7.95±2.21			67(93.06)		
Control Group (n = 88)	9.42±2.45			74 (84.09)		
> 0.6 mg/kg		5.545	< 0.001		6.205	0.013
Research Group (n = 53)	8.98±2.25*			45 (84.91)		
Control Group (n = 65)	11.20±2.09*			42(63.24)*		

Note: TOF: Train-Of-Four, *P < 0.05, compared to ≤ 0.6 mg/kg.

coming the limitations of indirect reversal [15, 16]. Donmez et al. [17] further supported these advantages, showing that in thyroid surgery, sugammadex enabled TOF recovery to 0.9 within 4 minutes without interfering with recurrent laryngeal nerve monitoring. In our study, the complete reversal rate in the neostigmine group was only 78.43%, underscoring the risk of residual blockade, whereas sugammadex sodium achieved a complete reversal rate of approximately 90%.

In addition to superior efficacy, sugammadex sodium demonstrated advantages in perioperative efficiency. Compared to the neostigmine group, anesthesia duration, recovery time, and PACU stay in the sugammadex group were reduced by 20.9%, 35.4%, and 35.8%, respectively. These benefits largely derive from its rapid onset, allowing patients to meet extubation criteria earlier and minimizing the need for prolonged anesthetic administration. Similarly, Kim et al. [18] found that sugammadex increased the rate of physiological recovery within 15 minutes after surgery by 40% and accelerated cognitive recovery, consistent with our findings. Notably, despite rapid reversal, no significant differences in HR or MAP were observed between groups during extubation, suggesting minimal cardiovascular effects. This may be attributable to its non-cholinergic mechanism, which avoids vagally mediated bradycardia and hemodynamic fluctuations often associated with neostigmine [14].

Another important clinical advantage of sugammadex is its ability to reduce postoperative residual neuromuscular blockade (PORC). Neostigmine is less effective for deep blockade and is influenced by factors such as temperature and acid-base balance [19]. In contrast, sugammadex remains effective even at higher plasma rocuronium concentrations through its "molecular encapsulation" mechanism. Lu et al. [14] demonstrated in patients with interstitial lung disease that sugammadex shortened TOF recovery to 0.9 by 75% compared to neostigmine and completely eliminated PORC. Our findings also suggest that in overweight and obese patients (BMI $\geq$ 24 kg/m^2), sugammadex achieved faster recovery and a 12.04% higher complete reversal rate than neostigmine, likely due to its pharmacokinetic independence from distribution volume and metabolism [20]. Furthermore, previous studies indicate that sugammadex maintains > 90% reversal efficiency even in patients with mild renal impairment (eGFR $\geq$ 30 mL/min) [13].

The analysis of postoperative complications further supported the favorable safety profile of sugammadex sodium. The incidence of nausea and vomiting was significantly lower in the intervention group, reflecting the absence of cholinergic stimulation of the gastrointestinal tract, a known adverse effect of neostigmine. Stemhagen et al. [21] reported that only 60.4% of anesthesiologists were aware of contraindications for sugammadex in patients with severe renal insufficiency, underscoring the need for enhanced clinical education. For patients undergoing tracheoscopy, reducing nausea and vomiting is particularly valuable, as these symptoms increase the risk of aspiration, particularly when the pharyngeal reflexes have not yet been fully restored after anesthesia [22].

Overall, our results demonstrate that sugammadex sodium provides more rapid and reliable reversal of rocuronium-induced neuromuscular blockade than neostigmine, shortens recovery and PACU stay, reduces PORC, and improves safety in high-risk subgroups such as obese patients and those with respiratory disease. These findings support sugammadex sodium as a preferred strategy for neuromuscular blockade management in painless tracheoscopy. Freundlich et al. [23], in their systematic review of laparoscopic surgery protocols, similarly reported that, compared to neostigmine, sugammadex reduced postoperative nausea and vomiting, consistent with our study. Moreover, the literature indicates that the rapid reversal effect of sugammadex sodium can reduce the risk of aspiration [17].

Intriguingly, Suzuki et al. [24] showed in a rat propofol model that rocuronium infusion dose-dependently prolonged emergence, while sugammadex rapidly antagonized peripheral blockade without affecting circulatory or respiratory functioning. This raises the possibility of central effects of rocuronium on emergence, warranting further investigation into the central versus peripheral actions of sugammadex and the extent of rocuronium's CNS penetration.

The correlation analysis reveals key factors influencing TOF recovery time. Both BMI and ASA classification were positively correlated with recovery in both groups, while the effect of age was more pronounced in the control group. This indicates that increased body weight and worsening physical condition may delay the clearance of rocuronium. However, through its "dose-dependent capture" mechanism, sugammadex maintained a stable reversal efficiency, with its advantages becoming more prominent under pathophysiological states. For example, among ASA III patients, the sugammadex group showed shorter TOF recovery time and a 24.17% higher complete reversal rate compared to the neostigmine group. In contrast, for ASA I patients with relatively preserved metabolic capacity, no significant difference in complete reversal rate was observed between the two groups. This suggests that for clinical practice, reversal strategies can be tailored according to the baseline characteristics of patients: for healthy young patients, neostigmine can be cautiously used under strict monitoring; for elderly, obese, and patients with comorbidities, sugammadex should be the preferred choice.

No significant association was observed between preoperative hemoglobin level and TOF recovery time, which may be related to the fact that none of the patients included in this study had severe anemia (mean hemoglobin > 120 g/L). Further verification is needed to verify this association in anemic patients. In addition, gender also had no impact on neuromuscular recovery, consistent with previous studies reporting minimal impact of sex on the pharmacokinetics of rocuronium [25]. The study by Isik et al. [26] showed that sugammadex had a milder effects on renal function markers (e.g., cystatin C) compared to neostigmine, supporting its safety in patients with chronic diseases.

This study had three notable innovations. First, it specifically focused on painless tracheoscopy, a short-duration procedure requiring rapid recovery and low complication rates, which has been underrepresented in previous studies. Second, it systematically compared the reversal effects of sugammadex and neostigmine across stratifications by age, BMI, ASA classification, and rocuronium dosage, clarifying the advantages of sugammadex in special populations (e.g., elderly, obese, and ASA III patients). Third, it revealed that sugammadex maintains stable efficacy even with increased rocuronium dosage, while neostigmine shows a dose-dependent decline in complete reversal rate, providing new evidence for individualized neuromuscular management in painless tracheoscopy. This study also has some limitations. First, as a retrospective study, it may have been at risk of selection bias. Second, some unrecorded variables, such as the depth of anesthesia and the timing of rocuronium administration, may have influenced the results. Third, the relatively small sample size in subgroup analyses limited the generalizability of the conclusions.

Conclusion

In painless tracheoscopy, sugammadex sodium enables rapid and complete reversal of rocuronium-induced neuromuscular blockade through its specific antagonistic mechanism, significantly reducing the risk of postoperative complications and improving the efficiency of perioperative management.

Disclosure of conflict of interest

None.

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