

Comparison of Sugammadex and Neostigmine for Reversal of Rocuronium-Induced Neuromuscular Blockade in Obese Patients for Lower Abdominal Surgeries

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Abstract

Introduction: Obese patients undergoing general anesthesia are at an increased risk of postoperative respiratory complications due to altered respiratory physiology and residual neuromuscular blockade. Rocuronium is commonly used to facilitate muscle relaxation during lower abdominal surgeries, necessitating effective reversal at the end of the procedure. Neostigmine has traditionally been used for this purpose but is associated with delayed recovery and cholinergic adverse effects. Sugammadex, a selective relaxant-binding agent, has emerged as a rapid and effective alternative for reversing rocuronium-induced neuromuscular blockade. This study compared the efficacy and safety of sugammadex and neostigmine in obese patients undergoing lower abdominal surgeries.

Materials and Methods: A prospective, randomized, comparative study was conducted among 100 obese patients (BMI ≥ 30 kg/m²) aged 18–65 years undergoing elective lower abdominal surgeries under general anesthesia. Participants were randomly allocated into two groups of 50 each. Group S received intravenous sugammadex (2 mg/kg), while Group N received intravenous neostigmine (50 µg/kg) with glycopyrrolate (10 µg/kg) for reversal of moderate rocuronium-induced neuromuscular blockade. The primary outcome was time to achieve a train-of-four (TOF) ratio ≥ 0.9 . Secondary outcomes included extubation time, recovery profile, postoperative complications, hemodynamic parameters, and patient and surgeon satisfaction.

Results: Baseline demographic and intraoperative characteristics were comparable between the groups. Sugammadex achieved significantly faster recovery to TOF ratio ≥ 0.9 (2.6 ± 0.8 vs. 10.4 ± 2.3 minutes; $p < 0.001$), earlier extubation (5.2 ± 1.3 vs. 12.1 ± 2.8 minutes; $p < 0.001$), shorter PACU stay (42.8 ± 8.6 vs. 58.6 ± 10.4 minutes; $p < 0.001$), and higher Modified Aldrete scores at PACU admission ($p < 0.001$). Residual neuromuscular blockade, bradycardia, and excessive salivation occurred significantly less frequently in the sugammadex group. Furthermore, successful reversal within five minutes (92.0% vs. 8.0%) and both patient and surgeon satisfaction scores were significantly higher with sugammadex (all $p < 0.001$).

Conclusion: Sugammadex demonstrated superior efficacy and safety compared with neostigmine for reversal of rocuronium-induced neuromuscular blockade in obese patients undergoing lower abdominal surgeries. It provided faster and more predictable neuromuscular recovery, reduced postoperative complications, shortened recovery time, and improved patient and surgeon satisfaction, supporting its preferential use in obese patients undergoing general anesthesia.

Keywords: Sugammadex; Neostigmine; Rocuronium; Neuromuscular Blockade; Obesity.

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Introduction

Obesity has become a major global health concern, with its prevalence increasing rapidly over the past few decades. Obese patients frequently require surgical interventions and present unique challenges to anesthesiologists because of altered respiratory physiology, reduced functional residual capacity, increased oxygen consumption, and a higher incidence of difficult airway management

[1]. These physiological changes increase the risk of perioperative respiratory complications, making rapid and complete recovery from neuromuscular blockade particularly important in this patient population [2]. Lower abdominal surgeries commonly require profound neuromuscular relaxation to facilitate optimal surgical exposure, and rocuronium is one of the most widely used

non-depolarizing neuromuscular blocking agents due to its rapid onset and intermediate duration of action [3]. Residual neuromuscular blockade following surgery remains a significant cause of postoperative morbidity, contributing to upper airway obstruction, hypoventilation, impaired airway reflexes, hypoxemia, delayed recovery, and prolonged post-anesthesia care unit (PACU) stay [4-6]. Traditionally, neostigmine, an acetylcholinesterase inhibitor, has been used for reversal of non-depolarizing neuromuscular blockade [7]. Although effective, its onset of action is relatively slow and it is associated with muscarinic adverse effects such as bradycardia, excessive salivation, bronchial secretions, and postoperative nausea and vomiting, necessitating the concurrent administration of anticholinergic agents [8]. Furthermore, neostigmine may not reliably reverse deep neuromuscular blockade, increasing the risk of residual paralysis [9].

Sugammadex is a novel selective relaxant binding agent that encapsulates rocuronium molecules, rapidly terminating their neuromuscular blocking effect without interfering with acetylcholinesterase activity [10]. Compared with conventional reversal using neostigmine, sugammadex provides faster and more predictable recovery, even from profound neuromuscular blockade, while avoiding the cholinergic adverse effects associated with acetylcholinesterase inhibitors [11].

These advantages are particularly relevant in obese patients, who are at an increased risk of postoperative respiratory compromise and in whom rapid restoration of muscle strength is essential for safe extubation and early recovery. Although several studies have demonstrated the efficacy of sugammadex, evidence comparing its clinical performance with neostigmine specifically in obese patients undergoing lower abdominal surgeries remains limited [12].

The present study aimed to compare the efficacy and safety of sugammadex and neostigmine for reversal of rocuronium-induced neuromuscular blockade in obese patients undergoing lower abdominal surgeries, with respect to neuromuscular recovery time, postoperative recovery profile, hemodynamic changes, postoperative complications, and overall patient and surgeon satisfaction.

Materials and Methods

This prospective, randomized, comparative study was conducted in the Department of Anesthesiology at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee and written informed consent from all participants. A total of 100 obese adult patients (Body Mass Index [BMI] ≥ 30 kg/m²), aged

18–65 years, belonging to the American Society of Anesthesiologists (ASA) physical status II–III and scheduled for elective lower abdominal surgeries under general anesthesia, were enrolled in the study. Patients with known hypersensitivity to the study drugs, significant hepatic or renal dysfunction, neuromuscular disorders, pregnancy, anticipated difficult airway, or those receiving medications known to interfere with neuromuscular transmission were excluded.

Participants were randomly allocated into two equal groups (n=50 each) using a computer-generated randomization sequence with allocation concealment through sealed opaque envelopes. Group S received intravenous Sugammadex (2 mg/kg) for reversal of moderate rocuronium-induced neuromuscular blockade, whereas Group N received intravenous Neostigmine (50 µg/kg) combined with Glycopyrrolate (10 µg/kg). Standard fasting guidelines were followed, and routine monitoring including electrocardiography, non-invasive blood pressure, pulse oximetry, capnography, and train-of-four (TOF) neuromuscular monitoring was instituted for all patients. General anesthesia was induced using standard intravenous agents, followed by rocuronium (0.6 mg/kg) to facilitate endotracheal intubation, and anesthesia was maintained with inhalational anesthetics, oxygen-air mixture, and intermittent doses of rocuronium as required.

Neuromuscular blockade was monitored intraoperatively using quantitative TOF monitoring. At the completion of surgery, reversal agents were administered when the TOF count reached two responses. The primary outcome was the time required to achieve a TOF ratio of ≥ 0.9 . Secondary outcome measures included extubation time, time to eye opening, time to obey verbal commands, duration of post-anesthesia care unit (PACU) stay, Modified Aldrete score at PACU admission and discharge, postoperative hemodynamic parameters, incidence of residual neuromuscular blockade, postoperative complications including bradycardia, tachycardia, postoperative nausea and vomiting, excessive salivation, oxygen desaturation, re-intubation, and patient and surgeon satisfaction scores.

The collected data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation (SD), while categorical variables were presented as frequency and percentage. The independent Student's *t*-test was used for comparison of continuous variables, whereas the Chi-square test or Fisher's exact test was applied for categorical variables, as appropriate. A two-

tailed p value of <0.05 was considered statistically significant.

Results

A total of 100 obese patients were included in the study, with 50 patients each in the Sugammadex and Neostigmine groups. The baseline demographic characteristics were comparable between the two groups. The mean age was $43.8 \pm$

9.7 years in the Sugammadex group and 44.6 ± 10.2 years in the Neostigmine group ($p=0.684$). Females constituted the majority of participants in both groups (64.0% vs. 60.0%).

There were no significant differences in body weight, height, BMI, or ASA physical status distribution, indicating that both groups were well matched before intervention (Table 1).

Table 1: Baseline Demographic Characteristics of the Study Population

Variable	Sugammadex (n=50)	Neostigmine (n=50)	P value
Age (years), Mean $\pm$ SD	43.8 ± 9.7	44.6 ± 10.2	0.684
Male, n (%)	18 (36.0%)	20 (40.0%)	0.681
Female, n (%)	32 (64.0%)	30 (60.0%)	
Weight (kg), Mean $\pm$ SD	94.6 ± 10.8	95.3 ± 11.4	0.751
Height (cm), Mean $\pm$ SD	162.5 ± 7.1	163.1 ± 6.9	0.667
BMI (kg/m^2), Mean $\pm$ SD	35.8 ± 3.9	36.2 ± 4.1	0.612
ASA II, n (%)	34 (68.0%)	32 (64.0%)	0.673
ASA III, n (%)	16 (32.0%)	18 (36.0%)	

The intraoperative characteristics were similar between the study groups.

The mean duration of surgery was 104.8 ± 21.5 minutes in the Sugammadex group and 107.6 ± 22.1 minutes in the Neostigmine group ($p=0.521$).

Likewise, the duration of anesthesia, total rocuronium dose administered, estimated blood loss, and intraoperative intravenous fluid requirements did not differ significantly between the groups (all $p>0.05$), demonstrating comparable surgical and anesthetic conditions (Table 2).

Table 2: Intraoperative Characteristics

Variable	Sugammadex (n=50)	Neostigmine (n=50)	P value
Duration of surgery (minutes)	104.8 ± 21.5	107.6 ± 22.1	0.521
Duration of anesthesia (minutes)	129.4 ± 24.8	132.7 ± 25.3	0.503
Total Rocuronium dose (mg)	69.5 ± 11.2	70.8 ± 12.0	0.578
Estimated blood loss (mL)	214.6 ± 58.3	221.8 ± 61.2	0.548
Intravenous fluids (mL)	1268 ± 284	1292 ± 301	0.682

Patients receiving Sugammadex exhibited significantly faster recovery from rocuronium-induced neuromuscular blockade compared to those receiving Neostigmine. The mean time to achieve a train-of-four (TOF) ratio ≥ 0.9 was markedly shorter in the Sugammadex group ($2.6 \pm$

0.8 minutes) than in the Neostigmine group (10.4 ± 2.3 minutes; $p<0.001$). Similarly, extubation time, time to eye opening, and time to obey verbal commands were all significantly reduced in the Sugammadex group (all $p<0.001$), reflecting a more rapid postoperative recovery (Table 3).

Table 3: Primary Outcome: Neuromuscular Recovery

Variable	Sugammadex (n=50)	Neostigmine (n=50)	P value
Time to TOF ratio ≥ 0.9 (minutes)	2.6 ± 0.8	10.4 ± 2.3	<0.001
Extubation time (minutes)	5.2 ± 1.3	12.1 ± 2.8	<0.001
Time to eye opening (minutes)	6.5 ± 1.6	13.8 ± 3.2	<0.001
Time to obey verbal commands (minutes)	7.8 ± 1.9	15.4 ± 3.5	<0.001

Recovery profile assessment demonstrated superior postoperative recovery among patients who received Sugammadex. The mean PACU stay was significantly shorter in the Sugammadex group (42.8 ± 8.6 minutes) compared to the Neostigmine group (58.6 ± 10.4 minutes; $p<0.001$).

Additionally, the Modified Aldrete score at PACU admission was significantly higher in the Sugammadex group (8.9 ± 0.7 vs. 8.1 ± 0.8 ; $p<0.001$). However, both groups achieved similar Modified Aldrete scores at the time of PACU discharge ($p=0.091$) (Table 4).

Table 4: Recovery Profile

Variable	Sugammadex (n=50)	Neostigmine (n=50)	P value
PACU stay (minutes)	42.8 ± 8.6	58.6 ± 10.4	<0.001
Modified Aldrete score at PACU admission	8.9 ± 0.7	8.1 ± 0.8	<0.001
Modified Aldrete score at discharge	9.9 ± 0.2	9.8 ± 0.4	0.091

Hemodynamic parameters remained stable in both groups following reversal of neuromuscular blockade.

Patients receiving Neostigmine demonstrated a significantly lower heart rate after reversal compared with those receiving Sugammadex (74.2

± 9.1 vs. 82.6 ± 8.4 beats/min; $p < 0.001$), consistent with the known cholinergic effects of Neostigmine.

Mean arterial pressure and oxygen saturation were comparable between the groups, with no statistically significant differences observed ($p > 0.05$) (Table 5).

Table 5: Hemodynamic Parameters

Variable	Sugammadex (n=50)	Neostigmine (n=50)	P value
Heart rate after reversal (beats/min)	82.6 ± 8.4	74.2 ± 9.1	<0.001
Mean arterial pressure (mmHg)	88.6 ± 7.3	87.2 ± 6.8	0.321
SpO ₂ (%)	99.2 ± 0.8	98.9 ± 0.9	0.082

Postoperative complications were less frequent among patients receiving Sugammadex.

Residual neuromuscular blockade occurred exclusively in the Neostigmine group (12.0% vs. 0%; $p = 0.027$). Bradycardia (16.0% vs. 2.0%; $p = 0.015$) and excessive salivation (14.0% vs. 0%; $p = 0.006$) were also significantly more common

following Neostigmine administration. Although postoperative nausea and vomiting and oxygen desaturation were observed more frequently in the Neostigmine group, these differences did not reach statistical significance.

No patient in either group required re-intubation (Table 6).

Table 6: Postoperative Complications

Complication	Sugammadex (n=50)	Neostigmine (n=50)	P value
Residual neuromuscular blockade	0 (0.0%)	6 (12.0%)	0.027
Bradycardia	1 (2.0%)	8 (16.0%)	0.015
Tachycardia	2 (4.0%)	3 (6.0%)	0.645
Postoperative nausea and vomiting	3 (6.0%)	9 (18.0%)	0.067
Excessive salivation	0 (0.0%)	7 (14.0%)	0.006
Dry mouth	1 (2.0%)	2 (4.0%)	0.558
Oxygen desaturation	0 (0.0%)	3 (6.0%)	0.079
Re-intubation	0 (0.0%)	0 (0.0%)	—

Overall clinical outcomes favored Sugammadex over Neostigmine.

Successful reversal within five minutes was achieved in 92.0% of patients receiving Sugammadex compared with only 8.0% in the Neostigmine group ($p < 0.001$). Conversely, delayed recovery exceeding 10 minutes was significantly

more common in the Neostigmine group (62.0% vs. 2.0%; $p < 0.001$). Furthermore, both patient satisfaction (9.4 ± 0.6 vs. 8.1 ± 0.9) and surgeon satisfaction scores (9.5 ± 0.5 vs. 8.3 ± 0.8) were significantly higher in the Sugammadex group (both $p < 0.001$), indicating superior overall recovery and perioperative satisfaction (Table 7).

Table 7: Overall Clinical Outcome

Outcome	Sugammadex (n=50)	Neostigmine (n=50)	P value
Successful reversal within 5 minutes	46 (92.0%)	4 (8.0%)	<0.001
Delayed recovery (>10 minutes)	1 (2.0%)	31 (62.0%)	<0.001
Patient satisfaction score (0–10)	9.4 ± 0.6	8.1 ± 0.9	<0.001
Surgeon satisfaction score (0–10)	9.5 ± 0.5	8.3 ± 0.8	<0.001

Discussion

The present study demonstrated that sugammadex provided significantly faster and more reliable reversal of rocuronium-induced neuromuscular

blockade than neostigmine in obese patients undergoing lower abdominal surgeries. Patients receiving sugammadex achieved a train-of-four (TOF) ratio ≥ 0.9 in a mean duration of 2.6 minutes

compared with 10.4 minutes in the neostigmine group.

In addition, extubation, eye opening, and response to verbal commands occurred significantly earlier with sugammadex. These findings are consistent with the multicenter randomized trial by Khuenl-Brady et al., who reported a markedly shorter recovery time to TOF ratio ≥ 0.9 with sugammadex (2.7 minutes) compared with neostigmine (17.9 minutes), highlighting the rapid and predictable mechanism of action of sugammadex through encapsulation of aminosteroidal neuromuscular blocking agents rather than inhibition of acetylcholinesterase [13]. Similar observations were also reported by Lemmens et al., who demonstrated significantly faster neuromuscular recovery with sugammadex than neostigmine following vecuronium-induced blockade [14].

The improved recovery profile observed in the present study, including significantly shorter PACU stay and higher Modified Aldrete scores at PACU admission, further supports the clinical advantages of sugammadex in obese individuals. Rapid recovery is particularly important in this population because obesity is associated with decreased pulmonary reserve, increased risk of airway obstruction, and postoperative hypoventilation. Carron et al. evaluated morbidly obese patients undergoing general anesthesia and similarly found that sugammadex resulted in significantly faster recovery of neuromuscular function and reduced postoperative residual curarization compared with neostigmine [8]. Likewise, a randomized trial by Choi et al. demonstrated earlier recovery and improved surgical conditions when deep neuromuscular blockade reversed with sugammadex was compared with conventional reversal using neostigmine, emphasizing its role in enhancing perioperative efficiency [15].

Another important finding of the present study was the lower incidence of postoperative complications following sugammadex administration. Residual neuromuscular blockade was not observed in the sugammadex group, whereas it occurred in 12% of patients receiving neostigmine.

Bradycardia and excessive salivation were also significantly less frequent with sugammadex, reflecting the absence of cholinergic adverse effects associated with acetylcholinesterase inhibition. These observations agree with the pooled analysis by Monk et al., which demonstrated consistently faster recovery with sugammadex across obese patients and a substantially lower incidence of delayed recovery compared with neostigmine [16]. Furthermore, the multicenter trial by Khuenl-Brady et al. reported favorable safety outcomes with sugammadex while maintaining significantly shorter recovery times, supporting its routine use in

patients at higher risk of postoperative respiratory complications [13].

Higher patient and surgeon satisfaction scores observed with sugammadex in the present study likely resulted from rapid neuromuscular recovery, earlier extubation, smoother postoperative recovery, and fewer adverse events. These findings reinforce the growing body of evidence favoring sugammadex as the preferred reversal agent for rocuronium-induced neuromuscular blockade, particularly in obese surgical patients. The randomized clinical trial evaluating actual versus ideal body weight dosing of sugammadex in morbidly obese patients also demonstrated significantly faster recovery and markedly fewer delayed recoveries than neostigmine, irrespective of dosing strategy [17]. Collectively, the available evidence and the findings of the present study indicate that sugammadex offers superior efficacy, predictable reversal, improved postoperative recovery, and a better safety profile compared with neostigmine in obese patients undergoing general anesthesia.

Conclusion

Sugammadex was found to be superior to neostigmine for the reversal of rocuronium-induced neuromuscular blockade in obese patients undergoing lower abdominal surgeries. It provided significantly faster recovery of neuromuscular function, earlier extubation, shorter post-anesthesia care unit stay, and a lower incidence of residual neuromuscular blockade and cholinergic adverse effects, resulting in improved patient and surgeon satisfaction. These findings suggest that sugammadex offers a more rapid, predictable, and safer reversal profile than neostigmine, making it a preferred reversal agent for obese patients undergoing general anesthesia.

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