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Original Research Article

Efficacy and Safety of Suggamedex Vs Neostigmine in Reversing Neuromuscular Blockade in Adults

Sanjusha Mallipudi[1], Kiran Kumar Suggala[2], T Anusha[3]

[1]Post Graduate Resident, Department of Anaesthesia, Mamata Medical College, Khammam, Telangana, India

[2]Professor and HOD, Department of Anaesthesia, Mamata Medical College, Khammam, Telangana, India

[3]Associate Professor, Department of Anaesthesia, Mamata Medical College, Khammam, Telangana, India

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Corresponding Author: Dr. Kiran Kumar Suggala

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Abstract:

Introduction: Neuromuscular blocking agents (NMBAs) are integral to modern anaesthesia but carry postoperative residual neuromuscular blockade (PRNB) risks, leading to complications like respiratory distress. Neostigmine, traditionally used for NMBA reversal, has limitations, including delayed recovery and muscarinic side effects. Sugammadex, a selective relaxant-binding agent, offers rapid and predictable reversal, potentially enhancing safety and efficiency. This study evaluates the efficacy and safety of Sugammadex compared to neostigmine in adult surgical patients.

Materials and Methods: Sixty adult patients undergoing elective surgery under general anaesthesia were randomised into Sugammadex (Group S, n=30) and neostigmine with glycopyrrolate (Group N, n=30). Neuromuscular function was monitored using acceleromyography. The primary outcome was the time to achieve a Train-of-Four (TOF) ratio ≥ 0.9. Secondary outcomes included PRNB incidence and adverse events. Data were analysed using independent t-tests and chi-square tests, with $p<0.05$ considered significant.

Results: Sugammadex achieved significantly faster recovery to TOF ≥ 0.9 (2.1 ± 0.5 minutes) compared to neostigmine (12.8 ± 3.2 minutes, $p<0.001$). PRNB occurred in 43.3% of Group N patients but was absent in Group S ($p<0.001$). Postoperative nausea and vomiting were more frequent with Sugammadex (23.3% vs. 6.7%, $p=0.071$). Urinary retention and dyspnoea were noted only in Group N. Both agents were well tolerated, with no serious adverse events.

Conclusion: Sugammadex demonstrates superior efficacy in rapidly reversing NMB and reducing PRNB incidence compared to neostigmine. Despite higher costs, its favourable safety profile and operational benefits position it as a transformative agent in perioperative care. Further, multicentre studies are warranted to validate these findings.

Keywords: Sugammadex, Neostigmine, Neuromuscular blocking agents.

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Introduction

Neuromuscular blocking agents (NMBAs) are essential in modern anaesthesia practice [1]. They facilitate procedures such as endotracheal intubation and mechanical ventilation and ensure optimal surgical conditions by suppressing involuntary skeletal muscle movements. [2]

However, using these agents is associated with postoperative residual neuromuscular blockades (PRNB), leading to significant complications, including impaired airway protection, reduced respiratory function, and delayed recovery. [3] Therefore, effective reversal of NMB is critical to prevent such complications and ensure patient safety. Traditionally, acetylcholinesterase inhibitors like neostigmine have been used for NMBA reversal. Neostigmine enhances acetylcholine availability at the neuromuscular junction, competitively antagonising the effects of non-depolarizing NMBAs. [4] [5] However, its indirect mechanism of action can result in limited and unpredictable reversal, necessitating adjunctive use of antimuscarinic agents like atropine or glycopyrrolate to mitigate adverse effects such as bradycardia, hypotension, and increased airway secretions.

Despite these measures, neostigmine remains associated with postoperative complications, including muscarinic side effects, residual paralysis, and delayed recovery.[6] Sugammadex, a novel selective relaxant-binding agent, represents

a paradigm shift in NMBA reversal. Specifically designed to encapsulate and inactivate amino steroidal NMBAs such as rocuronium and vecuronium. [7] Sugammadex acts via a direct and rapid mechanism, allowing for predictable and complete recovery from any depth of blockade without the need for antimuscarinic co-administration. [8] Several studies have demonstrated its superior efficacy compared to neostigmine, with significantly faster recovery times and a reduced incidence of PRNB. Additionally, sugammadex is associated with fewer adverse events, such as bradycardia and postoperative respiratory complications. [6] [9]

The adoption of sugammadex has been linked to operational benefits, including reduced extubation time, shorter operating room (OR) stays, and improved patient turnover in surgical settings. [9] These factors contribute to more efficient use of healthcare resources, although the higher cost of sugammadex compared to neostigmine remains a consideration.

This study aims to comprehensively evaluate the efficacy and safety of sugammadex versus neostigmine in reversing neuromuscular blockade in adult patients. By synthesising existing evidence, we seek to elucidate the comparative advantages and limitations of these agents, with the ultimate goal of optimising patient outcomes and enhancing perioperative care. This exploration will also address the implications for healthcare resource utilisation, particularly in balancing clinical benefits with cost considerations.

Materials and Methods

This randomized, prospective, double-blind study was conducted at Mamata Medical College, Khammam, between July 2023 and July 2024, following approval from the Institutional Ethics Committee. A total of 60 adult patients scheduled for elective surgeries under general anesthesia requiring neuromuscular blockade were included in the study. All participants provided written informed consent before enrollment. Patients were randomly divided into two groups: Group S (Sugammadex, n=30) and Group N (Neostigmine, n=30). Randomization was performed using a computer-generated sequence, and allocation was concealed through the use of opaque, sealed envelopes. The study included individuals aged 18 to 65 with an American Society of Anesthesiologists (ASA) physical status classification of I or II. Patients were excluded if they had a history of neuromuscular disorders, significant liver or kidney dysfunction, or known hypersensitivity to the study medications. All patients were managed with a standardized anesthesia protocol. Anesthesia induction was achieved using intravenous propofol at a dose of 2 mg/kg and fentanyl at 2 µg/kg, while maintenance was provided with sevoflurane in a 50% oxygen-air mixture. Neuromuscular blockade was induced using vecuronium at a loading dose of 0.08-0.12mg/kg and maintained with 0.02-0.04 mg/kg. Neuromuscular function was monitored throughout the procedure using acceleromyography at the adductor pollicis muscle to assess the train-of-four (TOF) ratio. After surgery, when TOF monitoring indicated the presence of two twitches, patients in Group S were administered intravenous sugammadex at 2 mg/kg, while those in Group N received intravenous neostigmine at 0.05 mg/kg along with glycopyrrolate at 0.01 mg/kg.

The primary outcome measured was the time, in seconds, required to reach a TOF ratio of ≥ 0.9 following the administration of the reversal agent. Secondary outcomes included the occurrence of residual neuromuscular blockade (TOF ratio < 0.9) in the recovery room, postoperative issues such as nausea, vomiting, or bradycardia, and any adverse reactions related to the study drugs. The clinical personnel responsible for collecting data and assessing outcomes were blinded to the group assignments to ensure unbiased evaluations.

Data analysis was conducted using SPSS software version 25. Continuous data were expressed as mean ± standard deviation and compared using an independent t-test, while categorical data were presented as percentages and evaluated with the chi-square test. Statistical significance was defined as a p-value less than 0.05.

Results

The study enrolled 60 patients evenly distributed between the Sugammadex and neostigmine groups, with no statistically significant differences in baseline characteristics. The mean age of participants was comparable between the groups (45.3 ± 12.1 years for the Sugammadex group and 47.8 ± 11.6 years for the neostigmine group, p=0.56). Both groups had a similar gender distribution, with a slightly higher proportion of male participants (60% in the Sugammadex group and 56.7% in the neostigmine group, p=0.793). The average BMI and ASA physical status classifications were also evenly matched, ensuring comparable baseline profiles between the two groups. (Table 1)

Table 1: Patient Demographics and Baseline Characteristics

Characteristic	Sugammadex Group (n=30)	Neostigmine Group (n=30)	p-value
Age (years)	45.3 ± 12.1	47.8 ± 11.6	0.56
Gender			0.793
Male	18	17	
Female	12	13	
BMI (kg/m²)	26.5 ± 3.2	27.1 ± 3.5	0.45
ASA Physical Status			0.573
I	20	22	
II	10	8	

Efficacy outcomes demonstrated significant advantages for Sugammadex over neostigmine.

The mean time to achieve a TOF ratio ≥ 0.9 was markedly shorter in the Sugammadex group (2.1 ± 0.5 minutes) compared to the neostigmine group (12.8 ± 3.2 minutes, p<0.001). Additionally, residual neuromuscular blockade was observed in 43.3% of patients in the neostigmine group, whereas no cases were reported in the Sugammadex group (p<0.001). These results highlight the superior effectiveness of Sugammadex in rapidly and completely reversing neuromuscular blockade. (Table 2)

Table 2: Efficacy Outcomes

Outcome Measure	Sugammadex Group (n=30)	Neostigmine Group (n=30)	p-value
Time to TOF Ratio ≥ 0.9 (minutes)	2.1 ± 0.5	12.8 ± 3.2	<0.001
Incidence of Residual Neuromuscular Blockade	0 (0%)	13 (43.3%)	<0.001

Concerning safety, the occurrence of postoperative nausea and vomiting was greater in the Sugammadex group (23.3%) compared to the neostigmine group (6.7%), although this disparity did not achieve statistical significance (p=0.071). Urinary retention and dyspnea were exclusively noted in the neostigmine cohort, affecting 10% and 6.7% of patients, respectively; nevertheless, these results lacked statistical significance (p=0.076 and p=0.150). No significant adverse events were identified in either group, suggesting that both medications were well tolerated. (Table 3)

Table 3: Safety and Cost Outcomes

Outcome Measure	Sugammadex Group (n=30)	Neostigmine Group (n=30)	p-value
Postoperative Nausea and Vomiting	7 (23.3%)	2 (6.7%)	0.071
Urinary Retention	0 (0%)	3 (10%)	0.076
Shortness of Breath	0 (0%)	2 (6.7%)	0.150

Discussion

The comparison of sugammadex and neostigmine in reversing neuromuscular blockade (NMB) reveals significant advantages for sugammadex in terms of efficacy and safety. In this study, sugammadex demonstrated a markedly shorter mean time to achieve a Train-of-Four (TOF) ratio ≥ 0.9 compared to neostigmine. Patients in the sugammadex group required an average of 2.1 ± 0.5 minutes to recover, whereas those in the neostigmine group required 12.8 ± 3.2 minutes. This result aligns with findings from prior studies, including Hristovska A et al.'s [6] meta-analysis, which documented mean recovery times of 2.0 minutes for sugammadex and 12.9 minutes for neostigmine. Similarly, Fiorda Diaz J et al. [10] observed a reduction in recovery time to TOF ratio ≥ 0.9 by nearly 67% with sugammadex compared to neostigmine, emphasizing its clinical efficacy in both moderate and deep NMB scenarios.

Residual neuromuscular blockade (PRNB) was entirely absent in the sugammadex group, whereas it was observed in 43.3% of patients in the neostigmine group. These findings echo results from Carron M et al. [9] who reported a significantly lower risk of PRNB with sugammadex. This ability to reliably and completely reverse NMB positions sugammadex as a key agent in minimizing postoperative complications such as hypoxia, aspiration, and respiratory distress.

In terms of safety, both agents were well tolerated, with no serious adverse events reported in either group. Postoperative nausea and vomiting (PONV) occurred more frequently in the sugammadex group (23.3%) than in the neostigmine group (6.7%), but this difference was not statistically significant. Previous studies, including Subramani Y et al. [11] have reported similar trends, noting a slightly higher incidence of PONV with sugammadex that

does not compromise its overall safety profile. Notably, urinary retention and shortness of breath were observed only in the neostigmine group, consistent with the muscarinic side effects associated with acetylcholinesterase inhibitors. Sugammadex, by avoiding interaction with muscarinic receptors, eliminates the need for anticholinergic co-administration, reducing associated risks such as bradycardia and bronchospasm.

Comparing these findings with other studies underscores sugammadex's consistent efficacy and safety across various surgical contexts. Fiorda Diaz J et al. [10] emphasized sugammadex's versatility in outpatient procedures, where it reduced recovery times and improved operational efficiency. Subramani Y et al. [11] highlighted its effectiveness in morbidly obese patients, demonstrating significantly faster recovery and fewer adverse events compared to neostigmine. Hristovska A et al. [6] further reported a 60% reduction in adverse events with sugammadex, including a lower incidence of bradycardia and residual paralysis. These findings collectively reinforce sugammadex's superior profile in both general and high-risk patient populations.

The clinical implications of these findings are profound. Sugammadex's ability to provide rapid and complete NMB reversal enhances patient safety by reducing the risk of PRNB and associated complications. This advantage is particularly critical in high-risk populations, such as patients with comorbidities or those undergoing extensive surgical procedures. Furthermore, the faster recovery times associated with sugammadex translate to shorter operating room turnover and reduced anesthesia duration, offering significant benefits in terms of resource utilization and operational efficiency. While the higher upfront cost of sugammadex remains a consideration, these operational advantages may offset the expense, particularly in high-throughput surgical settings. While the evidence supporting sugammadex is robust, this study has certain limitations. The single-center design and relatively small sample size limit the generalizability of the findings. To validate these results, future studies should include multicenter trials with larger and more diverse populations. Moreover, comprehensive cost-benefit analyses are essential to evaluate the economic feasibility of sugammadex across varying healthcare settings. Further investigation into long-term outcomes, such as the effects of quicker recovery on patient satisfaction and overall healthcare quality, would provide a more comprehensive understanding of its role in contemporary anesthetic practice.

Conclusion

Sugammadex demonstrates clear advantages over neostigmine in reversing neuromuscular blockade. Its rapid recovery times, reduced PRNB incidence, and favorable safety profile position sugammadex as a transformative agent in anesthetic practice. As evidence continues to accumulate, sugammadex is likely to become the standard of care for NMB management, delivering superior patient outcomes and improving perioperative efficiency.

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