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Indian Journal of Clinical Anaesthesia

Journal homepage: www.ijca.in

Original Research Article

A comparative study on the efficacy of sugammadex (2 mg/kg) in reversing rocuronium- and vecuronium-induced neuromuscular blockade in elective neurosurgery patients

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Abstract

Background: Neurosurgery demands precise anaesthetic management to ensure immobility, smooth extubation, and rapid recovery. Sugammadex, a novel neuromuscular reversal agent, provides rapid and effective recovery from neuromuscular blockade.

Aims and Objectives: This study aimed to compare the efficacy of 2 mg/kg Sugammadex in reversing neuromuscular blockade maintained with Rocuronium or Vecuronium infusion in patients undergoing elective neurosurgery. The primary objective was to compare the mean recovery time from the initiation of Sugammadex administration at the reappearance of TOF count 1 to achieving a train-of-four (TOF) ratio of 0.9. Secondary objectives included assessing side effects, hemodynamic changes, and signs of postoperative residual curarization (PORC).

Materials and Methods: In this prospective, randomized, double-blinded study, 60 patients scheduled for elective neurosurgery were divided into two groups: Group RS (Rocuronium infusion, n = 30) and Group VS (Vecuronium infusion, n = 30). At the end of surgery, all patients received Sugammadex 2 mg/kg for neuromuscular blockade reversal. The mean recovery time, incidence of PORC, postoperative respiratory complications, side effects, and hemodynamic changes following Sugammadex administration were compared between the groups.

Results: The mean recovery time to achieve a TOF ratio of 0.9 after Sugammadex administration was 130.16 ± 26.07 seconds in Group RS and 139.33 ± 33.13 seconds in Group VS. The difference was statistically insignificant (p = 0.238). There were no incidences of PORC or postoperative respiratory complications in either group. Side effects and hemodynamic parameters were comparable and statistically insignificant between the groups.

Conclusion: A dose of 2 mg/kg Sugammadex is equally effective for reversing Rocuronium- and Vecuronium-induced neuromuscular blockade in elective neurosurgery. It demonstrates a favourable safety profile with no significant side effects in either group.

Keywords: Sugammadex, Vecuronium, Rocuronium, Neuromuscular Blockade, TOF Monitoring.

Received: 14-10-2024; **Accepted:** 04-03-2025; **Available Online**: 16-04-2025

1. Introduction

Neuro-anaesthesia requires a fine balance in anaesthetic methods to ensure ideal surgical conditions, evaluation with preservation of neurological function, and emphasizing rapid, high-quality recovery.[1] In neurosurgical patients, Neuromuscular blockade prevents an increase in intracranial pressure by avoiding bucking, straining, and coughing during laryngoscopy, and tracheal intubation and provides optimized surgical conditions in anesthetized patients. Vecuronium and Rocuronium are preferred Neuromuscular blocking agents (NMBAs) as they do not affect intracranial pressure, cerebral perfusion pressure, and mean arterial pressure in ventilated neurosurgical patients.[2] Vecuronium and Rocuronium are intermediate-acting (NMBAs), but studies have shown them to be associated with postoperative residual paralysis.[3,4] The prolonged action can be attributed to various factors including administration in large doses, inhalational agents, or individual patient variability in response to intermediate-duration NMBAs.[5] As a result, patients receiving these agents are susceptible to residual neuromuscular blockade, which may lead to postoperative pulmonary complications like hypoxemia, and pulmonary aspiration and thus associated with increased postoperative morbidity.[6]

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https://doi.org/10.18231/j.ijca.2025.057

Sugammadex, a modified form of γ-cyclodextrin, represents a newer neuromuscular reversal drug with a selective relaxant binding property, which antagonizes the effects of amino steroid muscle relaxants like Rocuronium and Vecuronium.[7] The distinct advantage of Sugammadex compared to Neostigmine an acetylcholinesterase inhibitor, is its ability to reverse neuromuscular blockade of any intensity, whether moderate or profound, caused by Rocuronium or Vecuronium.[8,9]

This study was aimed to evaluate the efficacy of Sugammadex at a dose of 2 mg/kg in reversing neuromuscular blockade induced by continuous infusions of Rocuronium or Vecuronium in patients undergoing elective neurosurgery. The primary objective was to compare the recovery time from the initiation of Sugammadex administration at Train-of-Four (TOF) count T1 to achieve a TOF ratio of ≥0.9 between the two NMBAs. Secondary objectives included evaluating PORC in the post-anaesthesia care unit (PACU) through TOF ratio assessment, a 5-second head-lift test, postoperative respiratory complications, side effects, and hemodynamic changes following Sugammadex administration.

2. Materials and Methods

2.1. Study design

Following approval from the Institutional Ethics Committee (IEC no-SKNMC/Ethics/App/2024/129), this prospective, randomized, double-blinded study was conducted on 60 patients undergoing elective neurosurgery. Participants were aged 18 to 65 years, classified as American Society of Anaesthesiologists (ASA) Grade 1 or 2, and included both male and female patients. Exclusion criteria were patients with neuromuscular disease, Glasgow Coma Scale score below 15, obesity (BMI >30 kg/m²), pregnant or lactating females, renal or hepatic dysfunction, ischemic heart disease, bradycardia, those on beta-blockers, a history of malignant hyperthermia, difficult airways or intubation, prior tracheostomy or intubation, post-operative ventilator support requirements, or allergies to study drugs. Patients on medications interfering with neuromuscular blocking agents, such as magnesium, anticonvulsants, or aminoglycosides, were also excluded. Written informed consent was obtained from all participants.

Participants were randomly assigned to one of two groups—Group VS (Vecuronium) or Group RS (Rocuronium)—using a computer-generated random number sequence concealed in sequentially numbered opaque envelopes. Patients in Group VS received Vecuronium, while Group RS received Rocuronium for muscle relaxation. Sugammadex (2 mg/kg intravenously) was administered to reverse neuromuscular blockade at the end of surgery for both groups. Randomization and drug preparation were performed by an anesthesiologist not involved in the study, while an independent anesthesiologist administered Sugammadex and recorded the study parameters.

Neuromuscular transmission was monitored using a TOF-Watch (Organon Ltd, Ireland) device, employing acceleromyography. After securing intravenous access in the right arm, two electrodes were placed 3–4 cm apart over the ulnar nerve, and a sensor was attached to the thumb to measure adduction of the adductor pollicis brevis muscle. Calibration of the device was performed post-induction and before administering the muscle relaxant. Calibration followed the manufacturer's guidelines, ensuring reliable and standardized measurements.

Preoperative preparations included confirming nil-by-mouth status, obtaining informed consent, and establishing wide-bore intravenous access. Ringer Lactate was initiated at 4 mL/kg. Standard monitoring in the operating room included ECG, SpO_2, capnography, non-invasive arterial pressure, TOF monitoring, BIS (Bispectral Index), and temperature monitoring. Invasive arterial pressure and central venous catheterization were employed based on the surgery's complexity. Premedication consisted of intravenous ondansetron (4 mg), glycopyrrolate (0.2 mg), midazolam (1 mg), fentanyl (2 mcg/kg), and lidocaine hydrochloride (1.5 mg/kg). Induction was achieved with propofol (1.5–2.5 mg/kg), and patients were ventilated using a Bain circuit with 50% oxygen and 50% air.

Anaesthesia was maintained with sevoflurane (1–2%) in oxygen-air mixture. Once the TOF monitor displayed a count of zero, patients were intubated with an appropriately sized cuffed endotracheal tube. A bolus dose of either Rocuronium (0.6 mg/kg) or Vecuronium (0.1 mg/kg) was administered as per the group allocation. Subsequently, continuous infusion of Rocuronium (0.2–0.6 mg/kg/hour) or Vecuronium (0.03–0.07 mg/kg/hour) was initiated, titrated to maintain deep neuromuscular blockade, defined as a TOF count of zero and a post-tetanic count (PTC) below 3. PTC was assessed five minutes after achieving deep blockade and repeated every 10 minutes.

At the conclusion of surgery, sevoflurane and the infusion of muscle relaxants were discontinued. Recovery was monitored until T1 reappeared on the TOF monitor. At this point, a single intravenous bolus of Sugammadex (2 mg/kg) was administered over 10 seconds via a running normal saline infusion. Recovery time was recorded as the interval from Sugammadex administration to achieving a TOF ratio ≥0.9. Patients were extubated after confirming a TOF ratio ≥0.9 and a thorough clinical evaluation.

In the post-anaesthesia care unit (PACU), hemodynamic parameters, including heart rate, mean arterial pressure, and SpO_2, were monitored for one hour. Hypotension, defined as a ≥20% decrease in mean arterial pressure from baseline, was treated with fluid boluses and, if necessary, intravenous ephedrine (6 mg). Bradycardia, defined as a heart rate

<60/min or ≥20% reduction from baseline, was managed with intravenous atropine (0.2 mg).

Postoperative monitoring continued with a focus on evidence of recurarization, indicated by a TOF ratio <0.9, inability to sustain a 5-second head-lift, respiratory complications, or a drop in oxygen saturation. Side effects of Sugammadex, such as metallic taste, nausea, vomiting, tachycardia, bradycardia, hypotension, dizziness, pruritus, or anaphylaxis, were recorded.

2.2. Statistical analysis

Statistical analysis was performed using standard methods to ensure robust and accurate interpretation of data. Quantitative variables were presented as means with standard deviations (SD), while qualitative variables were expressed as percentages. An independent t-test was used to compare quantitative data between the two groups, whereas qualitative data were analysed using the Chi-square test.

Data entry was carried out using Microsoft Excel, and all statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) version 25.0 for Windows (Chicago, IL, USA). A p-value of less than 0.05 was considered statistically significant.

The sample size calculation was based on a prior study by Mesa DS et al., which defined a clinically relevant increase in recovery time as 50%.[10] To achieve statistical significance with a type I error probability ($\alpha = 0.05$), a type II error probability ($\beta = 0.10$), and a statistical power of 90%, a minimum of 22 patients per group was required. To account for potential dropouts, 30 patients were enrolled in each group.

3. Results

All participants (n = 60) completed the study, with 30 patients divided randomly into two groups, Group VS and Group RS. Group VS patients received muscle relaxant Vecuronium and Group RS patients received muscle relaxant Rocuronium intraoperatively. At the end of surgery, both groups received Sugammadex 2mg/kg intravenously for neuromuscular blockade reversal. Demographic data such as age, sex, weight, and surgical duration between the Group VS and Group RS are presented in **Table 1**. Demographic data and duration of surgery were comparable and statistically non-significant between Group VS and Group RS.

The mean recovery time from the initiation of Sugammadex administration to a TOF ratio of 0.9 was 139.33 ± 33.13 seconds in Group VS and 130.16 ± 26.07 seconds in Group RS with a p-value=0.23 which was comparable and statistically non-significant (p-value >0.05) (**Figure 1**).

The minimum and maximum time range required for recovery to TOF>0.9 for Group VS was 60-240 sec and in Group RS was 60-180 sec which showed the fast and comparable recovery of patients from neuromuscular blockade in both groups. All patients in our study recovered within 5 minutes of Sugammadex administration.

Table 1: Demographic data and duration of surgery in Group VS and Group RS

Parameters	Group VS (Mean ± SD)	Group RS (Mean ± SD)	p-value
Age (years)	46.40 ± 12.68	44.90 ± 9.10	0.60 (NS)
Sex (M/F)	17/13	20/10	0.42 (NS)
Weight (Kg)	55.50 ± 5.25	55.36 ± 7.07	0.93 (NS)
Duration of Surgery (Min)	164.66 ± 48.42	165.33 ± 50.90	0.95 (NS)

(NS–Statistically Non-significant, p-value >0.05, using independent t-test, SD- Standard Deviation,)

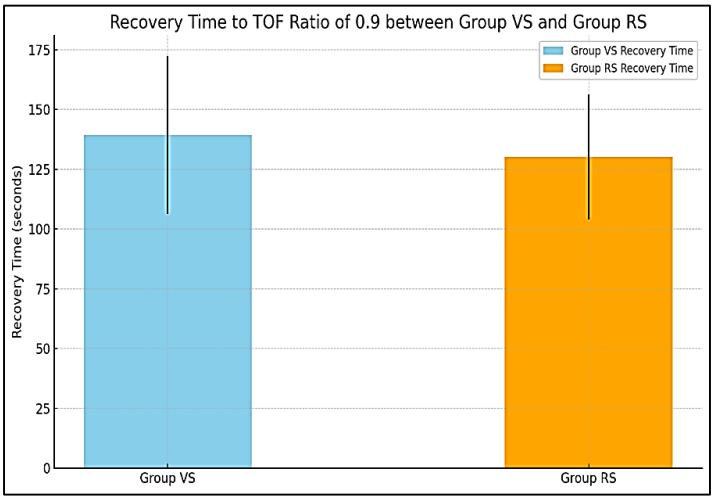

Figure 1: Comparison of mean recovery time to TOF>0.9 between Group VS and Group RS

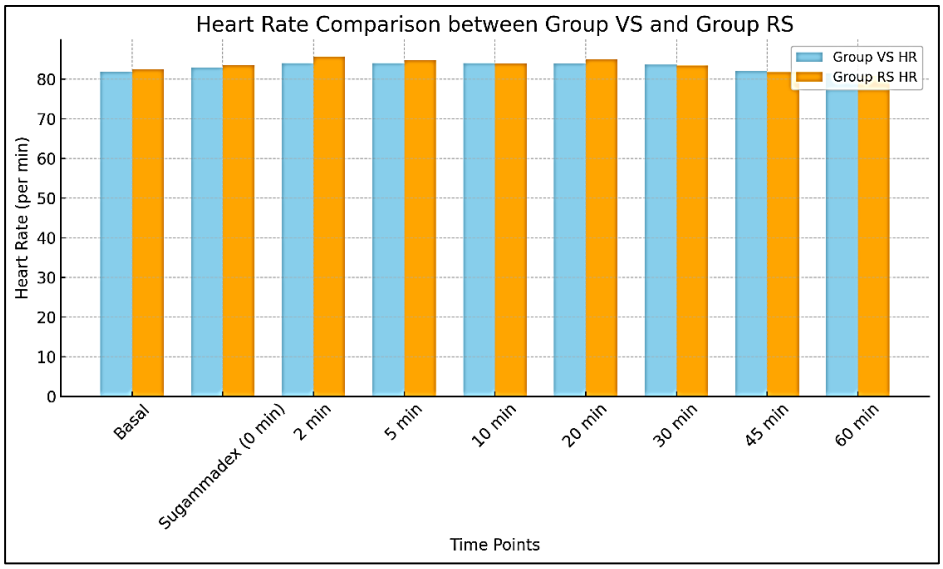

Figure 2: Comparison of Mean Heart Rate (HR) between Group VS and Group RS

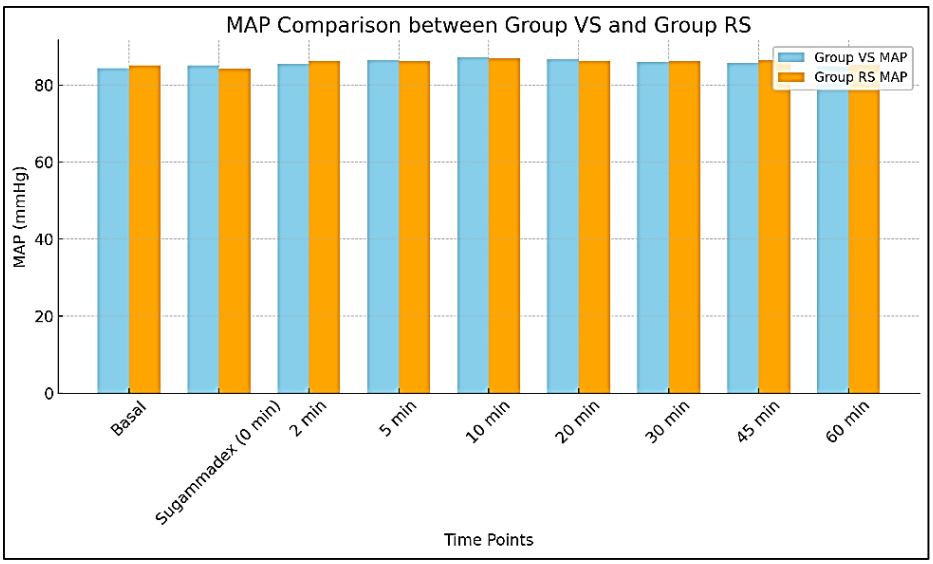

Figure 3: Comparison of Mean MAP (mean arterial Pressure) between Group VS and Group RS

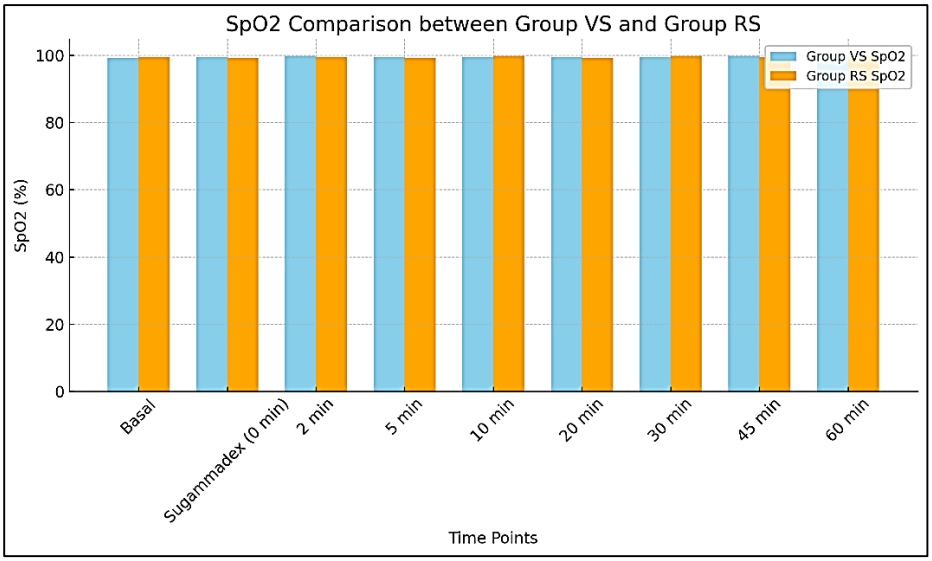

Figure 4: Comparison of Mean oxygen saturation (SPO_2) between Group VS and Group RS.

Hemodynamic parameters after Sugammadex administration including Heart rate, Mean Arterial Blood pressure, and Oxygen saturation (Spo2) were noted at basal value, at the time of Sugammadex administration (0min), at 2min, 5min, 10min, 20min, 30min, 45min, and 60min. Mean Heart rates (**Figure 2**) and Mean MAP (**Figure 3**) were comparable and statistically insignificant using an independent t-test (p value> 0.05) between Group VS and Group RS. There were no instances of bradycardia or hypotension observed in either group, and all hemodynamic values remained stable and comparable in both groups after Sugammadex administration.

The mean SpO_2 did not differ significantly between the two groups (p-value>0.05). All patients in both groups maintained SpO2 (SpO2 >94%) and did not require any supplemental oxygen in PACU. There was no episode of desaturation noted in either group (**Figure 4**).

In terms of recovery, all patients demonstrated a TOF ratio greater than 0.9 in the PACU, indicating complete neuromuscular recovery, and all patients performed the 5-second head lift test without difficulty (**Table 2**).

Table 2: Comparison of TOFR >0.9 and head lift test at PACU between Group VS and Group RS

Parameters	Group VS	Group RS
Patients with TOFR >0.9 in PACU.	30 (100%)	30 (100%)
Performed 5-second Head Lift in PACU.	30 (100%)	30 (100%)

Table 3: Comparison of side effects between Group VS and Group RS

Side Effects	Group VS (Mean ±SD)	Group RS (Mean ±SD)	p-value
Nausea	5 (16.6%)	3 (10%)	0.44 (NS)
Vomiting	0 (0%)	0 (0%)	
Cough	2 (6.6%)	1 (3.3%)	0.53 (NS)
Respiratory Desaturation	0 (0%)	0 (0%)	
Metallic Taste	0 (0%)	0 (0%)	
Hypotension	0 (0%)	0 (0%)	
Bradycardia	0 (0%)	0 (0%)	
Rash	0 (0%)	0 (0%)	
Pruritis	0 (0%)	0 (0%)	

(NS–Statistically Non-significant, using Chi-Square test p-value >0.05, SD- Standard Deviation)

In our study, we found Sugammadex to be safe with minimal side effects in both groups (**Table 3**). In Group VS 5 patients (16.6%) and in Group RS 3 patients (10%) complained of nausea which was comparable and statistically non-significant. Coughing was observed in 2 patients (6.6%) in the VS group and in 1 patient (3.3%) in the RS group immediately following extubation. The coughs resolved within 5 minutes without the need for treatment. No significant respiratory or cardiovascular complications were observed in either group.

4. Discussion

Neuroanaesthesia has evolved over the years, due to the advent of newer surgical techniques and specific surgical requirements, which have resulted in changes in neuroanaesthesia practices.[11] When administering anaesthesia to neurosurgical patients most significant considerations regarding a neurosurgical anaesthetic are the effects on hemodynamic, intracranial pressure, smooth induction, extubation, and good postoperative recovery.[12] The use of muscle relaxants for providing optimal conditions remained one of the important aspects of conventionally followed neuroanaesthesia practices.

Vecuronium and Rocuronium are non-depolarizing muscle relaxants with an intermediate duration of action commonly used in neurosurgical anaesthesia. Some important considerations and limitations while giving neuromuscular agents are their pharmacological effects, patient factors, drug interactions and risk of delayed recovery in neurosurgical patients.[13]

Sugammadex, a relatively new reversal agent, has been shown to accelerate neuromuscular recovery from Rocuronium, with a decreased incidence of postoperative residual curarization compared to the conventionally used Neostigmine.[14] This characteristic of Sugammadex is particularly beneficial in neurosurgical patients, where smooth extubation and complete recovery from neuromuscular blockade are essential. Sugammadex acts as a selective relaxant binder for steroidal neuromuscular blocking drugs, with a greater affinity for Rocuronium than for Vecuronium.[15]

Sugammadex is a modified form of gamma-cyclodextrin, a compound consisting of glucose molecules arranged in a ring structure. It forms tight, water-soluble complexes with muscle relaxants in a 1:1 ratio by encapsulating them within its ring structure. The neuromuscular blockade ends when the muscle relaxant dissociates from the neuromuscular junction. Moreover, Sugammadex does not affect acetylcholinesterase receptors, eliminating the need for co-administration of an anticholinergic agent like glycopyrrolate, which helps to avoid associated side effects like tachycardia.[16]

This unique property of Sugammadex offers a distinct advantage over Neostigmine, particularly in neurosurgical patients, where maintaining hemodynamic stability is crucial. In our study, we observed stable and comparable

hemodynamic parameters after the administration of Sugammadex in both groups.

According to good clinical practice guidelines, neuromuscular monitoring using quantitative methods such as acceleromyography (Train-of-Four, TOF) is essential for all patients receiving neuromuscular blocking agents. The recovery from neuromuscular blockade is typically assessed through the TOF ratio (TOFR), which is the T4/T1 ratio, where T4 represents the fourth muscle response and T1 is the first. A satisfactory recovery is achieved when the TOFR is greater than 0.9, at which point the patient can be considered safe for extubation.[17,18] In our study, all patients in both groups achieved a TOF ratio of 0.9 after receiving Sugammadex for reversal, with no clinical signs indicating postoperative residual neuromuscular blockade. To ensure the accuracy of detecting residual blockade, the TOF device was calibrated at baseline for all study participants. Many previous studies have administered various doses of Sugammadex upon the reappearance of T2 on the TOF monitor to reverse neuromuscular blockade induced by bolus doses of Rocuronium or Vecuronium.

Mesa DS et al. conducted a study where deep neuromuscular blockade was maintained by a continuous infusion of Rocuronium (0.3 to 0.6 mg/kg/hour). They administered Sugammadex at doses of 2 mg/kg or 4 mg/kg when the first response (T1) appeared on the TOF monitor. Their study found that the median recovery time for Rocuronium-induced neuromuscular blockade with 2 mg/kg of Sugammadex to achieve a TOFR of 0.9 was 129 seconds. They concluded that a 2 mg/kg dose of Sugammadex, when administered after continuous Rocuronium infusion, is effective for reversing neuromuscular blockade at the reappearance of T1.[10] In our study, we observed similar results, with the mean recovery time to a TOF ratio of 0.9 being 130.16 ± 26.07 seconds in Group RS and 139.33 ± 33.13 seconds in Group VS. These results confirm that Sugammadex at a dose of 2 mg/kg is equally effective in reversing neuromuscular blockade induced by both Vecuronium and Rocuronium.

Deana C. et al. conducted a study comparing Sugammadex and Neostigmine for reversing Rocuronium-induced neuromuscular blockade in patients undergoing liver transplantation. In their study, neuromuscular block was maintained with a continuous infusion of Rocuronium, and at the end of surgery, moderate neuromuscular blockade was reversed using either 2 mg/kg of Sugammadex or 50 mcg/kg of Neostigmine. They concluded that Sugammadex effectively reversed neuromuscular blockade induced by Rocuronium infusion in liver transplantation patients.[19] Building upon these findings and the established effectiveness of Sugammadex, we chose to administer 2 mg/kg of Sugammadex for reversing moderate neuromuscular blockade induced by either Rocuronium or Vecuronium during continuous infusion in our study.

Sugammadex was initially introduced for the clinical reversal of Rocuronium-induced neuromuscular blockade and later extended to reverse Vecuronium-induced blockade, which shares a similar pharmacological profile. In a dose-finding study, Puhringer F. K. et al. assessed various doses of Sugammadex (0.5 mg/kg to 4 mg/kg) for reversing moderate neuromuscular blockade induced by Rocuronium or Vecuronium. Their findings indicated that Sugammadex doses of 2.0 mg/kg and 4.0 mg/kg achieved mean recovery times of 1.4 ± 0.5 minutes and 1.5 ± 0.4 minutes, respectively, in Rocuronium-induced blockade. In Vecuronium-induced blockade, the mean recovery times were slightly longer at 3.4 ± 1.9 minutes and 3.0 ± 2.2 minutes for the same doses. The study highlighted a dose-dependent decrease in recovery time required to achieve a TOF ratio > 0.9. Among patients receiving 2 mg/kg of Sugammadex, only one in the Rocuronium group exhibited signs of recurrence of neuromuscular blockade, while no such recurrence was observed in the Vecuronium group. Additionally, no serious adverse events were associated with Sugammadex administration. The authors concluded that Sugammadex is a well-tolerated drug with a dose-dependent efficacy in reversing moderate neuromuscular blockade induced by both Rocuronium and Vecuronium.[20]

Suy K et al. investigated the dose-response relationship of various doses of Sugammadex when used for reversing moderate neuromuscular blockade induced by Vecuronium and Rocuronium. Their study demonstrated that the mean time to recovery to a TOF ratio greater than 0.9 with a Sugammadex dose of 2 mg/kg was 1.7 ± 0.6 minutes for Rocuronium and 2.3 ± 0.8 minutes for Vecuronium, with no statistically significant difference between the two. They concluded that Sugammadex enabled rapid recovery without any clinical signs of residual blockade in any patient.[21] Our findings were consistent with these results. In our study, the mean recovery time to a TOF ratio of 0.9 was 139.33 ± 33.13 seconds in Group VS, which was comparable to the 130.16 ± 26.07 seconds observed in Group RS. Although Sugammadex has a higher affinity for Rocuronium due to its faster complex formation rate, leading to shorter recovery times, we found no statistically or clinically significant difference in recovery times between the two groups. This lack of difference could be attributed to various factors, including the continuous infusion of NMBAs, which may influence recovery time. Further studies incorporating plasma drug concentration measurements are required to better understand the pharmacokinetics of Sugammadex.

Additionally, no patients in our study exhibited signs of postoperative residual curarization. Our results confirm that Sugammadex at a dose of 2 mg/kg is equally effective as a reversal agent for Rocuronium and Vecuronium-induced neuromuscular blockade.

Sorgenfrei et al. investigated the dose-response relationship and safety profile of Sugammadex as a reversal

agent for Rocuronium-induced neuromuscular blockade. Their study observed side effects such as cough, sudden movement, nausea, and vomiting post-Sugammadex administration. Hypotension occurred in two patients but was likely associated with Sugammadex in only one case, which resolved promptly without adverse clinical outcomes. Importantly, no recurarization was reported, and Sugammadex demonstrated safety and tolerability at doses of 2.0 mg/kg or more, with a dose-dependent effect.[22] Our findings align with these results in terms of safety. All patients in our study remained vitally stable, with no incidences of bradycardia or hypotension following Sugammadex administration. Mild side effects included nausea in 5 patients (16.6%) in Group VS and 3 patients (10%) in Group RS, which were statistically non-significant between the groups. These side effects were likely multifactorial, stemming from factors such as neurosurgery and opioid use, rather than being directly related to Sugammadex. No episodes of vomiting were observed. Two patients (6.6%) in Group VS and one patient (3.3%) in Group RS experienced transient cough during extubation, which was resolved without clinical implications. No serious adverse events or cases of postoperative recurarization were noted.

Our study further supports the findings of Ghoneim AA et al., who demonstrated that Sugammadex at 4 mg/kg provided rapid and effective reversal of Rocuronium-induced neuromuscular block in paediatric neurosurgical patients, outperforming traditional cholinesterase inhibitors like neostigmine. They also observed hemodynamic stability with Sugammadex, whereas neostigmine administration was associated with significant increases in MAP and HR.[23] Similarly, we observed stable hemodynamics during reversal in neurosurgical patients treated with Sugammadex.

Our findings demonstrate that administering Sugammadex at a dose of 2 mg/kg is both safe and effective in reversing neuromuscular blockade induced by continuous infusion of either Rocuronium or Vecuronium in neurosurgical patients. Sugammadex facilitates rapid and complete recovery, ensuring successful extubation with fewer postoperative respiratory complications. This contributes to decreased morbidity and reduces the associated economic burden for neurosurgical patients.

An important consideration in clinical practice is the cost of drugs. Rocuronium (10 ml costs approximately 1345.00 INR) is significantly more expensive than Vecuronium (10 ml costs approximately 122.00 INR). Considering this economic disparity, the combination of Sugammadex with Vecuronium offers a cost-effective and safe option for neurosurgical patients without compromising efficacy. This combination not only ensures optimal clinical outcomes but also provides a financially sustainable approach for healthcare systems.

This study had certain limitations that should be considered. The relatively small sample size may limit the generalizability of our findings, and larger, multicentric studies are needed to validate our results. Additionally, we did not measure plasma concentrations of Sugammadex, Rocuronium, or Vecuronium, which could have provided deeper insights into the pharmacokinetic and pharmacodynamic profiles of these agents. Furthermore, the study did not evaluate long-term outcomes or potential rare adverse events, which could contribute to a more comprehensive safety profile. Future research focusing on these aspects, along with cost-effectiveness analyses across varied clinical settings, is recommended to establish the optimal use of Sugammadex with Vecuronium.

5. Conclusion

Sugammadex at a dose of 2 mg/kg is both safe and effective in reversing neuromuscular blockade caused by Vecuronium or Rocuronium. It enables rapid recovery with stable hemodynamics and no serious side effects facilitating smooth extubation and reducing postoperative respiratory complications. Its safety profile and efficacy make it a valuable choice in neurosurgical practice supporting quicker recovery and lowering patient morbidity.

6. Source of Funding

None

7. Conflict of Interest

None.

8. Ethical Committee Approval

This study was done after Institutional Ethics Committee approval -SKNMC/Ethics/App/2024/129.

9. Acknowledgment

None.

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Cite this article: Mehta S, Singh ND, Pawar KS, Magar AN. A comparative study on the efficacy of sugammadex (2 mg/kg) in reversing rocuronium- and vecuronium-induced neuromuscular blockade in elective neurosurgery patients. *Indian J Clin Anaesth*. 2025;12(2):365–372.