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Original Research Article

A Study of Injection Sugammadex as a Reversal Agent in Surgeries Under General Anaesthesia

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Abstract

Background: Residual neuromuscular blockade following general anaesthesia is associated with increased postoperative morbidity and delayed recovery. Sugammadex is a selective reversal agent that offers rapid and predictable reversal of amino steroid neuromuscular blockade.

Objectives: To evaluate the efficacy and safety of injection sugammadex as a reversal agent in surgeries performed under general anaesthesia.

Material and Methods: A prospective observational study was conducted on 100 patients undergoing surgeries under general anaesthesia, assessing perioperative hemodynamic parameters and oxygen saturation following sugammadex administration.

Results: Sugammadex produced rapid neuromuscular recovery with stable pulse rate, blood pressure, mean arterial pressure, and preserved oxygen saturation, without clinically significant adverse effects.

Conclusion: Sugammadex is an effective and hemodynamically safe reversal agent for neuromuscular blockade in general anaesthesia.

Keywords: Sugammadex, Neuromuscular blockade, General anaesthesia, Reversal agent.

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Introduction

Neuromuscular blocking agents form an integral component of modern general anaesthesia, facilitating tracheal intubation, optimizing surgical exposure, and enabling controlled ventilation. However, incomplete or delayed reversal of neuromuscular blockade can result in residual neuromuscular weakness, which is associated with postoperative respiratory complications, delayed recovery, and increased morbidity [1].

Traditionally, acetylcholinesterase inhibitors such as neostigmine have been employed to reverse non-depolarizing neuromuscular blockade, but their indirect mechanism of action, ceiling effect, and muscarinic side effects limit their reliability and safety [2]. Sugammadex represents a major pharmacological advancement in the reversal of neuromuscular blockade. It is a modified γ-cyclodextrin specifically designed to encapsulate aminosteroid neuromuscular blocking agents such as rocuronium and vecuronium, rendering them inactive through a direct binding mechanism [3]. Unlike conventional reversal agents, sugammadex does not rely on increasing acetylcholine concentrations at the neuromuscular junction, thereby eliminating the need for concomitant anticholinergic administration and reducing autonomic adverse effects [4].

The rapid and predictable reversal achieved with sugammadex has been shown to significantly reduce recovery time from neuromuscular blockade, even in cases of deep or profound paralysis [5]. Clinical trials have demonstrated that sugammadex enables faster restoration of train-of-four ratios to safe thresholds compared with neostigmine, leading to earlier extubation and smoother emergence from anaesthesia [6]. This property is particularly advantageous in high-risk

surgical populations, including elderly patients and those with cardiopulmonary comorbidities.

Hemodynamic stability during reversal of neuromuscular blockade is another critical consideration in anaesthetic practice. Neostigmine-associated bradycardia, hypotension, bronchospasm, and excessive secretions may compromise perioperative stability, especially in patients with limited physiological reserve [7]. Sugammadex, owing to its selective mechanism of action, has been associated with minimal cardiovascular and respiratory disturbances, making it a safer alternative in routine and complex surgical procedures [8].

Despite its clinical advantages, concerns regarding cost, hypersensitivity reactions, and renal excretion have necessitated continued evaluation of sugammadex in diverse surgical settings [9]. Understanding its efficacy, safety profile, and perioperative effects under real-world clinical conditions is essential to guide rational use and optimize patient outcomes. Therefore, the present study was undertaken to assess injection sugammadex as a reversal agent in surgeries performed under general anaesthesia, with particular emphasis on neuromuscular recovery, hemodynamic stability, and adverse events [10].

Material and Methods

This prospective observational study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital over a period of twelve months. The study was initiated after obtaining approval from the Institutional Ethics Committee, and written informed consent was obtained from all participants prior to enrolment. The study population consisted of adult patients scheduled for elective surgeries under general anaesthesia requiring neuromuscular blockade.

A total of 100 patients aged between 18 and 65 years, belonging to American Society of Anesthesiologists physical status I, II, or III, were included in the study. Patients with known hypersensitivity to sugammadex, severe renal impairment, neuromuscular disorders, pregnancy, or those unwilling to participate were excluded. All enrolled patients underwent a detailed pre-anaesthetic evaluation, including medical history, physical and systemic examination, airway assessment, and routine laboratory investigations such as complete blood count, renal function tests, random blood glucose, coagulation profile, electrocardiography, and chest radiography where indicated. On the day of surgery, patients were kept nil per oral as per standard fasting guidelines. Standard monitoring including electrocardiography, non-invasive blood pressure, pulse oximetry, and capnography was established in the operating room. After preoxygenation, general anaesthesia was induced using intravenous propofol and fentanyl. Neuromuscular blockade was achieved using an aminosteroid neuromuscular blocking agent, either rocuronium or vecuronium, administered in appropriate weight-based doses to facilitate endotracheal intubation. Anaesthesia was maintained with inhalational agents in an oxygen–air mixture, and additional doses of neuromuscular blockers were administered as required.

Neuromuscular function was monitored intraoperatively using train-of-four stimulation. At the completion of surgery, upon reappearance of the second twitch in the train-of-four response, injection sugammadex was administered intravenously in a dose of 2 mg/kg for reversal of neuromuscular blockade. The time taken to achieve adequate recovery, defined as a train-of-four ratio of 0.9 or more, was recorded. Extubation was performed after confirming complete neuromuscular recovery, adequate spontaneous ventilation, protective airway reflexes, and stable hemodynamic parameters.

Hemodynamic variables including heart rate, systolic and diastolic blood pressure, and oxygen saturation were recorded before administration of sugammadex and at fixed intervals after reversal. Patients were observed for any adverse effects such as bradycardia, hypotension, hypersensitivity reactions, nausea, vomiting, or signs of residual neuromuscular blockade. Postoperative sedation was assessed using a standardized sedation scoring system. All patients were monitored in the postoperative recovery area until they met discharge criteria.

Collected data were compiled and analyzed using appropriate statistical software. Continuous variables were expressed as mean and standard deviation, while categorical variables were expressed as frequencies and percentages. Statistical significance was assessed using suitable tests, and a p-value of less than 0.05 was considered statistically significant.

Results

Table 1 summarizes the perioperative changes in mean pulse rate following administration of sugammadex. The baseline pulse rate was 79.01 ± 5.53 beats/min, which showed a transient increase to 86.46 ± 5.85 beats/min at 1 minute after reversal. This rise was statistically insignificant ($p > 0.05$). By 3 minutes, the pulse rate returned to baseline values and remained stable up to 15 minutes, indicating minimal cardiovascular stimulation associated with sugammadex administration. Table 2 depicts the changes in mean systolic blood pressure at various time intervals. The baseline systolic blood pressure was 119.31 ± 6.13 mmHg,

which increased transiently to 129.27 ± 7.73 mmHg at 1 minute following sugammadex administration. These changes were statistically insignificant ($p > 0.05$), and systolic blood pressure values returned close to baseline within 3–5 minutes, demonstrating good hemodynamic stability.

Table 3 illustrates the perioperative variations in mean diastolic blood pressure. The baseline diastolic blood pressure was 77.22 ± 4.38 mmHg, with a transient rise to 82.73 ± 4.82 mmHg at 1 minute post-reversal. Subsequent readings showed gradual normalization, and none of the changes reached statistical significance ($p > 0.05$), suggesting absence of sustained diastolic instability. Table 4 shows the changes in mean arterial pressure during the perioperative period. Baseline mean arterial pressure was 91.23 ± 3.72 mmHg, which increased to 98.82 ± 4.11 mmHg at 1 minute after sugammadex administration. The values normalized by 3 minutes and remained stable thereafter, with no statistically significant differences observed ($p > 0.05$), confirming cardiovascular safety.

Table 5 presents the perioperative mean oxygen saturation values. Baseline oxygen saturation was 99.71 ± 0.45%, with a minimal reduction to 98.43 ± 0.81% immediately after sugammadex administration. Oxygen saturation remained above 98% at all time points, indicating effective reversal of neuromuscular blockade without respiratory compromise.

Table 1: Mean Pulse Rate (beats/min)

Time	Mean ± SD	p-value
Baseline	79.01 ± 5.53	—
Before Sugammadex	79.24 ± 5.79	0.068
After Sugammadex	85.91 ± 5.81	0.092
At 1 min	86.46 ± 5.85	0.450
At 3 min	79.01 ± 5.53	0.150
At 5 min	78.80 ± 5.40	0.465
At 10 min	78.69 ± 5.14	0.231
At 15 min	78.61 ± 5.13	0.341

Table 2: Mean Systolic Blood Pressure (mmHg)

Time Point	Mean ± SD	p-value
Baseline	119.31 ± 6.13	—
Before Sugammadex	119.09 ± 6.54	0.245
After Sugammadex	128.86 ± 6.72	0.106
At 1 min	129.27 ± 7.73	0.180
At 3 min	121.31 ± 5.13	0.306
At 5 min	120.31 ± 6.83	0.116
At 10 min	119.31 ± 7.03	0.162
At 15 min	119.08 ± 6.01	0.160

Table 3: Mean Diastolic Blood Pressure (mmHg)

Time Point	Mean ± SD	p-value
Baseline	77.22 ± 4.38	—
Before Sugammadex	76.81 ± 5.40	0.217
After Sugammadex	82.23 ± 4.55	0.090
At 1 min	82.73 ± 4.82	0.080
At 3 min	79.22 ± 5.37	0.221
At 5 min	78.22 ± 4.87	0.101
At 10 min	77.41 ± 7.32	0.089
At 15 min	77.22 ± 3.85	0.321

Table 4: Mean Arterial Pressure (mmHg)

Time	Mean ± SD	p-value
Baseline	91.23 ± 3.72	—
Before Sugammadex	91.21 ± 4.58	0.950
After Sugammadex	98.73 ± 4.07	0.060
At 1 min	98.82 ± 4.11	0.070
At 3 min	92.23 ± 3.22	0.121
At 5 min	91.23 ± 3.78	0.650
At 10 min	91.04 ± 3.75	0.342
At 15 min	90.94 ± 3.80	0.223

Table 5: Perioperative Mean Oxygen Saturation (%)

Time	Mean ± SD (%)
Baseline	99.71 ± 0.45
Before Sugammadex	98.92 ± 1.06
After Sugammadex	98.43 ± 0.81
At 1 min	98.66 ± 0.96
At 3 min	98.75 ± 1.19
At 5 min	98.88 ± 0.24
At 10 min	99.05 ± 0.94
At 15 min	99.12 ± 0.97

Discussion

The present study evaluated the efficacy and cardiovascular safety of sugammadex as a reversal agent for aminosteroid neuromuscular blockade in patients undergoing surgeries under general anaesthesia. The results demonstrate that sugammadex provided effective reversal without producing clinically significant hemodynamic instability or respiratory compromise. As shown in Table 1, a transient increase in pulse rate was observed immediately following sugammadex administration, with a peak mean value of 86.46 ± 5.85 beats/min at 1 minute, which normalized by 3 minutes and remained stable thereafter. This transient change was statistically insignificant and clinically benign, reflecting the absence of cholinergic stimulation commonly seen with anticholinesterase-based reversal agents. Similar findings have been reported by Brull and Kopman, who emphasized the predictable and stable cardiovascular profile of sugammadex during neuromuscular recovery [11].

Table 2 and Table 3 illustrate the perioperative systolic and diastolic blood pressure trends following reversal. Although a modest rise in systolic and diastolic pressures was noted immediately after administration, values returned toward baseline within minutes, and none of the changes were statistically significant.

This hemodynamic stability supports the pharmacological advantage of sugammadex, which acts through direct encapsulation of neuromuscular blocking agents rather than altering autonomic balance. Large clinical series and controlled trials have similarly demonstrated minimal blood pressure fluctuations with sugammadex when compared with neostigmine, particularly in patients with limited cardiovascular reserve [12].

Mean arterial pressure trends presented in Table 4 further confirm the cardiovascular safety of sugammadex. The brief elevation in MAP observed at 1 minute post-administration resolved rapidly, with values remaining within physiological limits throughout the observation period. Maintenance of stable MAP is critical in preventing myocardial and cerebral hypoperfusion, especially in elderly and ASA grade II–III patients. Previous investigations have shown that sugammadex does not provoke significant sympathetic or parasympathetic responses, thereby preserving perioperative hemodynamic equilibrium [13].

Respiratory safety is a key determinant of successful neuromuscular reversal. As demonstrated in Table 5, oxygen saturation remained consistently above 98% at all measured time points, indicating effective restoration of respiratory muscle function and absence of residual neuromuscular blockade. Residual paralysis is a well-recognized contributor to postoperative hypoxemia and airway obstruction, and the findings of the present study reinforce evidence that sugammadex significantly reduces this risk by facilitating rapid and complete neuromuscular recovery [14].

Overall, the study findings align with existing literature supporting sugammadex as a reliable and safe reversal agent with superior efficacy and fewer adverse effects compared to conventional anticholinesterase agents. The absence of significant hemodynamic disturbances and maintenance of optimal oxygenation underscore its suitability for routine use in general anaesthesia, including in patients with comorbid conditions. Continued evaluation in varied surgical populations will further clarify its role in enhancing postoperative recovery and patient safety [15].

Conclusion

Sugammadex proved to be an effective and safe reversal agent for aminosteroid neuromuscular blockade in surgeries under general anaesthesia. The study demonstrated stable perioperative hemodynamic parameters, preserved oxygen saturation, and absence of clinically significant adverse effects following its administration. These findings support the use of sugammadex as a reliable alternative to conventional reversal agents, contributing to improved recovery profiles and enhanced perioperative safety.

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