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Research Article

COMPARATIVE EVALUATION OF ROCURONIUM AND CISATRACURIUM PRETREATMENT IN ATTENUATING SUCCINYLCHOLINE-INDUCED FASCICULATIONS AND POSTOPERATIVE MYALGIA: A RANDOMIZED CONTROLLED STUDY

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ABSTRACT

Background: Succinylcholine is widely used for rapid sequence induction due to its rapid onset and short duration of action. However, its use is commonly associated with adverse effects such as muscle fasciculations and postoperative myalgia. Pretreatment with nondepolarizing neuromuscular blocking agents has been proposed as an effective strategy to attenuate these complications.

Objective: To evaluate and compare the effectiveness of rocuronium and cisatracurium pretreatment in reducing succinylcholine-induced fasciculations and postoperative myalgia.

Methods: This prospective, randomized study included 150 patients undergoing elective surgeries under general anesthesia. Patients were equally divided into three groups: saline (control), cisatracurium, and rocuronium (n=50 each). Fasciculations were assessed following succinylcholine administration. Postoperative myalgia was evaluated in the post-anesthesia care unit (PACU) and at 24 hours. Statistical analysis was performed using appropriate tests, with $p<0.05$ considered significant.

Results: Baseline characteristics were comparable across groups. Rocuronium significantly reduced fasciculations, with 82% of patients showing no fasciculations compared to 28% in the saline group ($p<0.001$). Cisatracurium did not show a statistically significant effect. Rocuronium also significantly reduced postoperative myalgia at PACU ($p<0.001$) and at 24 hours ($p=0.012$), whereas cisatracurium showed no significant benefit.

Conclusion: Rocuronium pretreatment is more effective than cisatracurium in reducing succinylcholine-induced fasciculations and postoperative myalgia, making it a preferable option in clinical anesthesia practice.

KEYWORDS: Succinylcholine, Rocuronium, Cisatracurium, Fasciculations, Postoperative Myalgia, Randomized Controlled Study.

Introduction

Succinylcholine remains one of the most widely used neuromuscular blocking agents in anesthetic practice, particularly for rapid sequence induction due to its rapid onset and short duration of action. Despite these advantages, its clinical use is often limited by undesirable adverse effects, most notably muscle fasciculations and postoperative myalgia[1]. These complications, although not life-threatening, can significantly affect patient comfort, delay recovery, and reduce overall satisfaction with anesthesia care.

Muscle fasciculations are brief, involuntary contractions of skeletal muscle fibers that occur immediately after administration of succinylcholine. These contractions are attributed to depolarization at the neuromuscular junction, leading to asynchronous muscle fiber activity[2]. While fasciculations are transient, their clinical significance lies in their association with postoperative myalgia, which may persist for several days following surgery. According to Schreiber et al. (2005), postoperative myalgia occurs in up to 50% of patients receiving succinylcholine, with varying degrees of severity[3].

The exact mechanism underlying postoperative myalgia is not fully understood. However, it is widely believed to be related to muscle fiber damage caused by vigorous, unsynchronized contractions during fasciculations[4]. In addition, increased intracellular calcium levels, membrane phospholipid degradation, and the release of inflammatory mediators may also contribute to muscle soreness[5]. As highlighted by Wong and Chung (2000), these biochemical changes can result in muscle stiffness and discomfort, particularly in ambulatory surgical patients[6].

Various strategies have been proposed to reduce succinylcholine-induced fasciculations and myalgia. Among them, precurarization with non-depolarizing neuromuscular blocking agents has been shown to be one of the most effective approaches[7]. This technique involves the administration of a small, subparalyzing dose of a non-depolarizing agent prior to succinylcholine, thereby attenuating the intensity of depolarization at the neuromuscular junction.

Rocuronium, a steroidal non-depolarizing neuromuscular blocker, is commonly used for this purpose due to its rapid onset of action and favorable pharmacokinetic profile. Studies have demonstrated that rocuronium effectively reduces both the incidence and severity of fasciculations[8]. As reported by Mencke et al. (2001), rocuronium pretreatment significantly decreased the occurrence of moderate to severe fasciculations compared to placebo[9].

Cisatracurium, a benzylisoquinolinium compound, is another non-depolarizing agent with a distinct advantage of organ-independent metabolism through Hofmann elimination. This makes it particularly suitable for patients with hepatic or renal impairment[10]. However, its relatively slower onset of action compared to rocuronium may influence its effectiveness in precurarization[11]. According to Naguib et al. (2006), the timing and pharmacodynamic properties of the pretreatment agent play a crucial role in determining its efficacy[12].

Although both rocuronium and cisatracurium are widely used in clinical practice, comparative data evaluating their relative effectiveness in preventing succinylcholine-induced fasciculations and postoperative myalgia remain limited. Most available studies focus on individual drug efficacy rather than direct comparisons, leading to a gap in evidence-based decision-making[13].

Given the clinical importance of minimizing patient discomfort and improving perioperative outcomes, it is essential to identify the most effective pretreatment strategy. Therefore, the present study was designed to compare the efficacy of cisatracurium and rocuronium in attenuating succinylcholine-induced fasciculations and postoperative myalgia in patients undergoing elective surgery under general anesthesia[14,15].

Material and Methods

Study Design and Setting

This study was conducted as a prospective, randomized, double-blind, controlled clinical trial in the Department of Anaesthesiology at Jaipur National University Institute of Medical Sciences and Research Centre, Jaipur, Rajasthan. The design was chosen to objectively evaluate the comparative efficacy of cisatracurium and rocuronium pretreatment in attenuating succinylcholine-induced fasciculations and postoperative myalgia, while minimizing bias through appropriate blinding and randomization techniques.

Study Population and Ethical Considerations

A total of 150 patients scheduled for elective surgical procedures under general anesthesia were enrolled over a period of 24 months. Prior to initiation, approval was obtained from the Institutional Ethics Committee. All participants were informed in detail about the nature and purpose of the study, and written informed consent was obtained. The study adhered to ethical principles outlined in the Declaration of Helsinki.

Sample Size and Randomization

The sample size was calculated using a standard prevalence-based formula with a 95% confidence interval and 5% allowable error, based on previously reported incidence rates. Patients were randomly allocated into three equal groups (n=50 each). Group C received cisatracurium 0.01 mg/kg, Group R received rocuronium 0.06 mg/kg, and Group S received 3 mL normal saline as placebo. Randomization was performed using the slip-in-the-box method, and allocation concealment was ensured through sealed opaque envelopes. To maintain blinding, an independent anesthesiology staff member prepared the study drug in identical syringes,

ensuring that both the administering anesthesiologist and the observer remained unaware of group allocation.

Inclusion and Exclusion Criteria

Patients aged 18–60 years, belonging to American Society of Anesthesiologists (ASA) physical status I or II, and willing to provide informed consent were included in the study. Patients were excluded if they had a history of cardiovascular, pulmonary, hepatic, or renal disease, morbid obesity (BMI >40 kg/m²), chronic alcohol or drug abuse, preexisting neuromuscular disorders, anticipated difficult airway, or increased risk of aspiration.

Preoperative Preparation and Monitoring

On arrival in the operating room, all patients were connected to standard monitoring systems, including pulse oximetry, non-invasive blood pressure, electrocardiography, and end-tidal carbon dioxide monitoring. Baseline vital parameters were recorded. Premedication was administered with intravenous glycopyrrolate 0.2 mg. All patients were preoxygenated with 100% oxygen for three minutes prior to induction of anesthesia.

Study Intervention and Induction Protocol

Following preoxygenation, the allocated study drug was administered intravenously in a standardized volume of 3 mL. Patients were ventilated using a bag-mask device for three minutes to allow adequate drug distribution. General anesthesia was then induced using fentanyl 2 µg/kg and propofol 2 mg/kg administered intravenously. Neuromuscular blockade for endotracheal intubation was achieved with succinylcholine 1.5 mg/kg.

The intensity of fasciculations was assessed immediately after administration of succinylcholine using the Harvey grading scale by a blinded anesthesiologist. Fasciculations were graded as absent (no visible muscle activity), mild (localized fine fasciculations without limb movement), moderate (visible contractions involving multiple muscle groups with limb movement), or severe (vigorous, generalized contractions). Laryngoscopy and tracheal intubation were performed one minute after succinylcholine administration.

Maintenance of Anesthesia

Anesthesia was maintained with sevoflurane at a concentration of 1% in a mixture of nitrous oxide (67%) and oxygen (33%). Supplemental doses of fentanyl (25–50 µg IV) were administered as required. Mechanical ventilation was adjusted to maintain end-tidal CO_2 between 32 and 36 mmHg. Neuromuscular blockade during surgery was maintained using intermittent doses of rocuronium (0.5 mg/kg every 30 minutes) or cisatracurium (30 µg/kg every 20 minutes), guided by clinical assessment. At the end of surgery, residual neuromuscular blockade was reversed with neostigmine 40 µg/kg and glycopyrrolate 10 µg/kg administered intravenously.

Assessment of Outcomes

Fasciculations

The primary intraoperative outcome was the incidence and severity of fasciculations, assessed immediately following succinylcholine administration using the Harvey scale as described above.

Postoperative Myalgia

Postoperative myalgia was evaluated in the post-anesthesia care unit (PACU) and at 24 hours postoperatively using a standardized four-point scale. Myalgia was graded as absent (no pain), mild (pain only on questioning or deep breathing), moderate (spontaneous pain requiring analgesics), or severe (generalized pain affecting mobility and routine activities).

Statistical Analysis

The primary outcome variables included fasciculation scores and postoperative myalgia at both assessment points. Secondary variables included demographic parameters and intraoperative drug requirements. Data were analyzed using IBM Statistical Package for the Social Sciences (SPSS) Statistics (Version 29.0; IBM Corp., Armonk, NY, USA). Comparisons between groups were performed using the independent samples Student's *t*-test for continuous variables and the Chi-square test for categorical variables. Comparisons between groups for continuous data were performed using independent sample t-tests, whereas categorical variables were analyzed using Chi-square tests and cross-tabulation methods. Odds ratios with 95% confidence intervals were calculated where applicable. A p-value of less than 0.05 was considered statistically significant.

Results

Baseline Characteristics of Study Participants

A total of 150 patients were enrolled and equally distributed into three groups: cisatracurium, rocuronium, and saline (control), with 50 participants in each group. The baseline demographic and clinical characteristics were comparable across all groups, indicating appropriate randomization and homogeneity of the study population.

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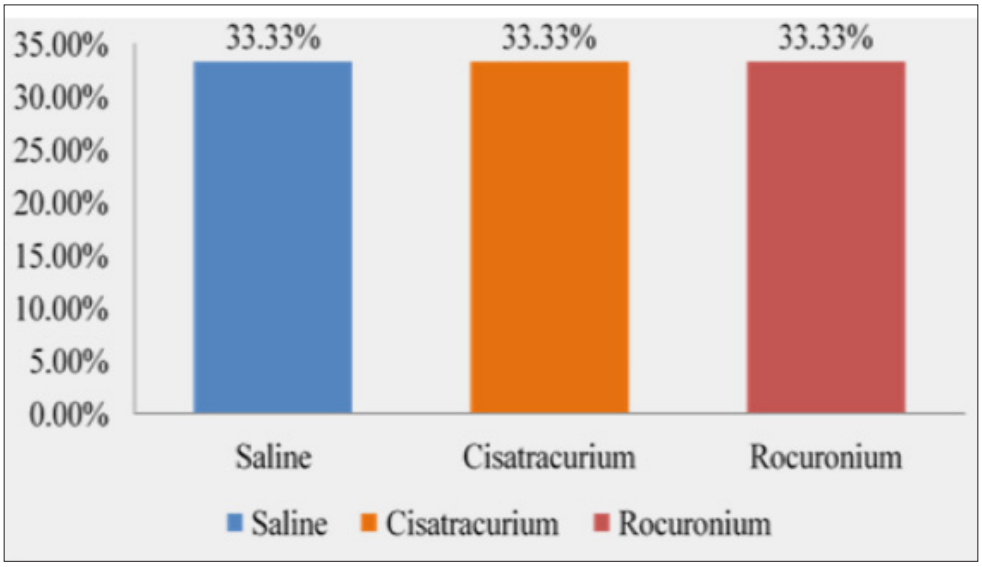

Figure 1: Bar Chart of Group distribution in study population

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (N = 150)

Variable	Cisatracurium (n=50)	Rocuronium (n=50)	Saline (n=50)	p-value
Age (years, Mean ± SD)	34.26 ± 6.4	34.04 ± 6.5	34.00 ± 6.58	0.977
Weight (kg, Mean ± SD)	66.16 ± 5.83	66.66 ± 6.50	65.96 ± 6.05	0.841
Height (cm, Mean ± SD)	161.7 ± 7.3	162.2 ± 6.85	162.0 ± 6.9	0.938
Female, n (%)	32 (64)	36 (72)	27 (54)	0.948
Male, n (%)	18 (36)	14 (28)	23 (46)	

The mean age of participants was 34.26 ± 6.4 years in the cisatracurium group, 34.04 ± 6.5 years in the rocuronium group, and 34.00 ± 6.58 years in the saline group, with no statistically significant difference (p = 0.977). Similarly, no significant differences were observed in mean weight (p = 0.841) and mean height (p = 0.938) among the groups. Gender distribution was also comparable, with females constituting the majority of the study population (63.3%), and no statistically significant difference across the groups (p = 1.000). These findings confirm that the study groups were well matched, minimizing potential confounding factors (Table 1).

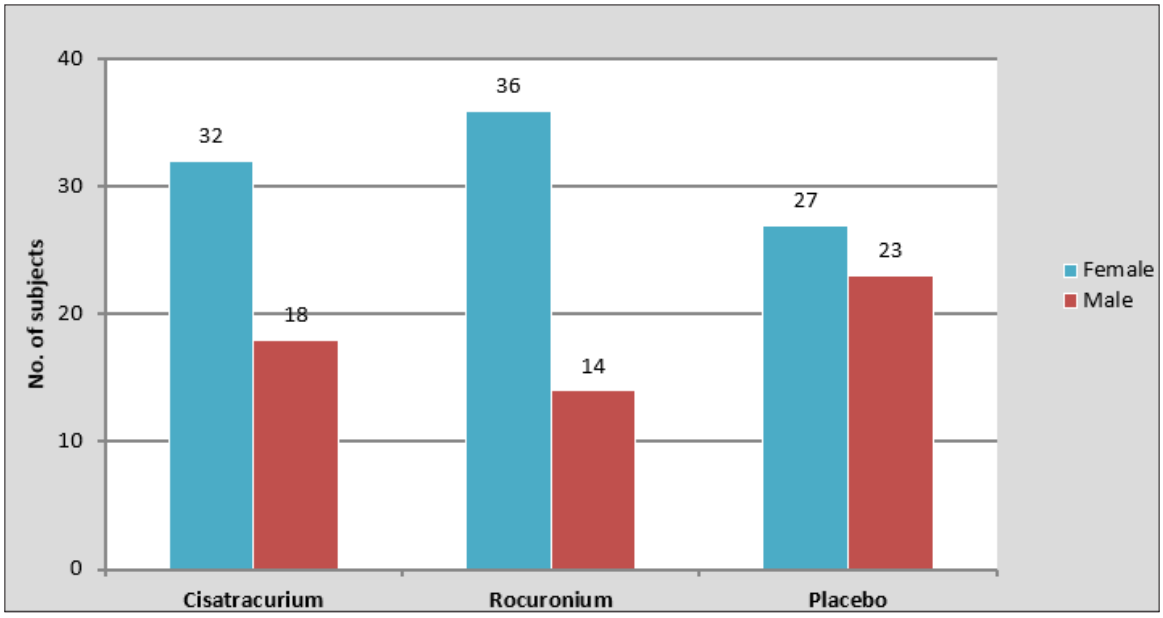

Figure 2: Bar chart of gender in study population

Incidence and Severity of Fasciculations

The incidence and severity of succinylcholine-induced fasciculations differed across the study groups (Table 2). The rocuronium group demonstrated the lowest incidence, with 82% of patients exhibiting no fasciculations, compared to 40% in the cisatracurium group and 28% in the saline group.

Table 2: Incidence of Fasciculations Across Study Groups

Fasciculation Grade	Cisatracurium (n=50)	Rocuronium (n=50)	Saline (n=50)
Nil	20 (40)	41 (82)	14 (28)
Mild	17 (34)	4 (8)	25 (50)
Moderate	10 (20)	4 (8)	9 (18)
Severe	3 (6)	1 (2)	2 (4)

Table 3: Comparative Analysis of Fasciculations (Saline vs Intervention Groups)

Comparison	p-value
Saline vs Cisatracurium	>0.05
Saline vs Rocuronium	<0.001*

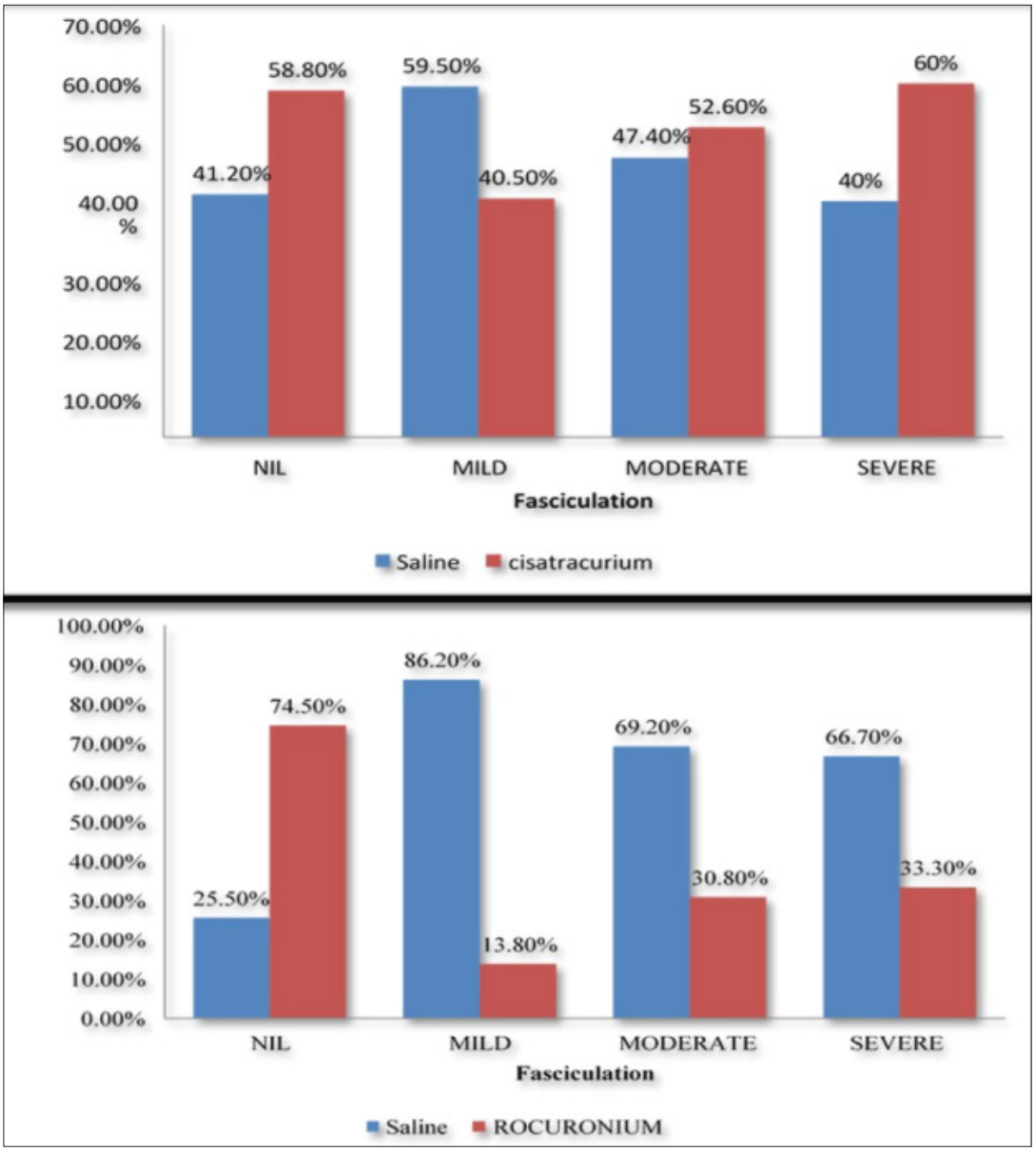

Figure 3: Comparative Analysis of Fasciculations (Saline vs Intervention Groups)

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Mild fasciculations were most frequently observed in the saline group (50%), followed by the cisatracurium group (34%), whereas only 8% of patients in the rocuronium group experienced mild fasciculations. Moderate and severe fasciculations were less common overall but were still lower in the rocuronium group compared to the other groups. No statistically significant difference between the saline and cisatracurium groups ($p > 0.05$). In contrast, the rocuronium group showed a statistically significant reduction in fasciculations when compared to saline ($p < 0.001$), indicating superior efficacy of rocuronium in preventing succinylcholine-induced fasciculations (Table 3).

Postoperative Myalgia at PACU

The assessment of postoperative myalgia in the post-anesthesia care unit (PACU) revealed notable differences among the groups (Table 4). The rocuronium group had the highest proportion of patients without myalgia (94%), followed by the cisatracurium group (76%) and the saline group (64%).

Mild and moderate myalgia were more commonly observed in the saline group compared to the intervention groups. Importantly, severe myalgia was reported only in the saline group (6%) and was absent in both the cisatracurium and rocuronium groups. No statistically significant difference between the saline and cisatracurium groups ($p > 0.05$). However, a statistically significant reduction in postoperative myalgia was observed in the rocuronium group compared to saline ($p < 0.001$) (Table 5).

Table 4: Postoperative Myalgia at PACU Among Study Groups

Myalgia Grade	Cisatracurium (n=50)	Rocuronium (n=50)	Saline (n=50)
Nil	38 (76)	47 (94)	32 (64)
Mild	7 (14)	2 (4)	9 (18)
Moderate	5 (10)	1 (2)	6 (12)
Severe	0 (0)	0 (0)	3 (6)

Table 5: Comparative Analysis of Myalgia at PACU

Comparison	p-value
Saline vs Cisatracurium	>0.05
Saline vs Rocuronium	<0.001*

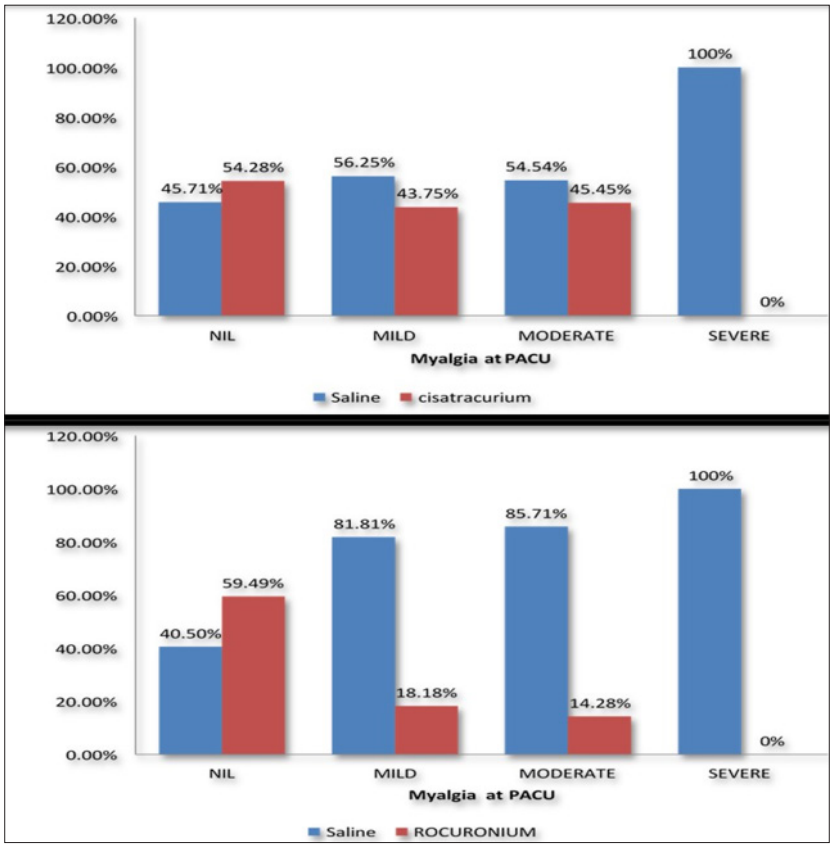

Figure 4: Comparative Analysis of Myalgia at PACU

Table 6: Postoperative Myalgia at 24 Hours and Comparative Analysis

Myalgia Grade	Cisatracurium (n=50)	Rocuronium (n=50)	Saline (n=50)
Nil	40 (80)	45 (90)	34 (68)
Mild	5 (10)	3 (6)	10 (20)
Moderate	5 (10)	2 (4)	4 (8)
Severe	0 (0)	0 (0)	2 (4)

Postoperative Myalgia at 24 Hours

At 24 hours postoperatively, the incidence of myalgia decreased across all groups, although differences persisted (Table 6). The highest proportion of patients without myalgia was observed in the rocuronium group (90%), followed by the cisatracurium group (80%) and the saline group (68%).

Mild and moderate myalgia remained more frequent in the saline group, while severe myalgia was observed only in the saline group (4%) and was absent in both intervention groups.

Comparative analysis further revealed that the difference between the saline and cisatracurium groups was not statistically significant ($p > 0.05$). In contrast, the reduction in myalgia in the rocuronium group compared to saline was statistically significant ($p = 0.012$), indicating sustained benefit (Table 6).

Discussion

Succinylcholine continues to be widely used in clinical anesthesia because of its rapid onset, reliable intubating conditions, and short duration of action. However, its use is frequently associated with undesirable effects such as muscle fasciculations and postoperative myalgia, which may affect patient comfort and recovery. Various pharmacological strategies have been explored to mitigate these adverse effects, among which pretreatment with nondepolarizing neuromuscular blocking agents remains one of the most practical and widely studied approaches.

The present study aimed to evaluate and compare the effectiveness of rocuronium and cisatracurium pretreatment in reducing succinylcholine-induced fasciculations and postoperative myalgia. The findings of this study provide important insights into the relative efficacy of these agents.

Baseline Characteristics

The baseline demographic and clinical variables, including age, gender, weight, and height, were comparable across all three groups (Table 1), indicating successful randomization and minimizing the likelihood of confounding bias. The absence of statistically significant differences ($p > 0.05$) ensures that the observed outcomes can be attributed primarily to the pharmacological interventions rather than patient-related factors.

This finding is consistent with Gupta A et al. (2024), who reported similar homogeneity in baseline characteristics in studies evaluating neuromuscular blocking agents[16]. In contrast, a study by Kumar J et al. (2024) highlighted that imbalance in demographic variables, particularly age and sex, can significantly influence the incidence of postoperative myalgia [17]. The balanced baseline profile in the present study therefore strengthens the internal validity of the results.

Incidence and Severity of Fasciculations

The incidence and severity of fasciculations were markedly reduced in the rocuronium group compared to both cisatracurium and saline (Table 2). A substantial proportion of patients in the rocuronium group (82%) exhibited no fasciculations, whereas this proportion was considerably lower in the cisatracurium (40%) and saline (28%) groups. Mild fasciculations were predominantly observed in the saline group, indicating a clear benefit of rocuronium pretreatment.

The comparative analysis (Table 3) further demonstrated that rocuronium significantly reduced fasciculations compared to saline ($p < 0.001$), while cisatracurium did not show a statistically significant effect ($p > 0.05$). These findings suggest that rocuronium is more effective in preventing the prejunctional receptor activation responsible for fasciculations.

These results agree with Schreiber JU et al. (2005), who reported that rocuronium significantly reduced the incidence of fasciculations compared to placebo and other nondepolarizing agents[18]. Similarly, Thilen SR et al. (2023) observed a marked reduction in fasciculations with rocuronium pretreatment[19].

However, contrasting findings have been reported by McNeil BD et al. (2021), who suggested that low-dose cisatracurium may have a modest effect on reducing fasciculations, although the reduction was not consistently statistically significant[20]. This discrepancy may be attributed to differences in dosing regimens and timing of administration. Overall, the present study supports the superior efficacy of rocuronium in preventing succinylcholine-induced fasciculations.

Postoperative Myalgia at PACU

The incidence of postoperative myalgia in the immediate postoperative period (PACU) was significantly lower in the rocuronium group compared to saline (Table 4). A higher proportion of patients in the rocuronium group (94%)

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reported no myalgia, compared to 76% in the cisatracurium group and 64% in the saline group. Severe myalgia was observed only in the saline group.

Comparative analysis (Table 5) revealed that the reduction in myalgia with rocuronium was statistically significant ($p < 0.001$), whereas cisatracurium did not demonstrate a significant difference compared to saline. This suggests that rocuronium not only reduces fasciculations but also translates this benefit into improved postoperative comfort.

These findings are consistent with Naguib M et al. (2011), who reported a significant reduction in postoperative myalgia with rocuronium pretreatment[21]. Similarly, Almismary KS (1991) et al. (2023) observed a lower incidence of myalgia in patients receiving nondepolarizing agents prior to succinylcholine[22].

In contrast, a study by Pace NL et al. (1990) suggested that the relationship between fasciculations and myalgia is not always direct, indicating that other mechanisms may also contribute to postoperative pain[23]. This highlights that while reducing fasciculations is beneficial, it may not entirely eliminate myalgia in all cases.

Postoperative Myalgia at 24 Hours

At 24 hours postoperatively, the incidence of myalgia decreased across all groups; however, the rocuronium group continued to demonstrate superior outcomes (Table 6). A significantly higher proportion of patients in the rocuronium group (90%) reported no myalgia compared to the saline group (68%), with statistical significance ($p = 0.012$).

The sustained reduction in myalgia suggests that the protective effect of rocuronium extends beyond the immediate postoperative period. In contrast, cisatracurium did not show a statistically significant difference compared to saline.

These findings are supported by the study, who observed reduced myalgia at 24 hours with rocuronium pretreatment[21]. Additionally, a meta-analysis by Glaubitz S et al. (2019) demonstrated that nondepolarizing muscle relaxants reduce postoperative myalgia by approximately 30%[18, 24].

However, contrasting evidence from Messeri A et al. (2023) suggested that while nondepolarizing agents reduce early myalgia, their long-term benefits may be limited[25]. The sustained benefit observed in the present study may be attributed to the specific pharmacodynamic profile of rocuronium.

The findings of our study to clearly demonstrate that rocuronium is significantly more effective than cisatracurium in reducing both succinylcholine-induced fasciculations and postoperative myalgia. While cisatracurium showed a trend toward reduction, the effect was not statistically significant.

The mechanism underlying this difference may be related to the faster onset and greater receptor occupancy achieved by rocuronium, allowing it to more effectively block prejunctional acetylcholine receptors and prevent asynchronous muscle fiber activation. These findings are consistent with the pharmacological properties described by Schreiber JU et al. (2005)[18].

Clinical Implications

From a clinical perspective, the use of low-dose rocuronium as a pretreatment agent offers a simple, safe, and effective strategy to reduce succinylcholine-related adverse effects. This can enhance patient comfort, improve perioperative experience, and potentially reduce postoperative analgesic requirements.

Conclusion

This study found that pretreatment with rocuronium is significantly more effective than cisatracurium in reducing both succinylcholine-induced fasciculations and postoperative myalgia in patients undergoing elective surgeries. Rocuronium markedly decreased the incidence and severity of fasciculations and provided a sustained reduction in postoperative myalgia, both in the immediate postoperative period (PACU) and at 24 hours.

In contrast, although cisatracurium showed a trend toward reduction in fasciculations and myalgia, the differences were not statistically significant when compared to the control group. These findings suggest that cisatracurium, at the studied dose and timing, may have limited clinical utility as a defasciculating agent.

The results of this study highlight the clinical advantage of using low-dose rocuronium as a pretreatment strategy to improve patient comfort and minimize succinylcholine-related adverse effects without compromising safety. Given its effectiveness, ease of administration, and favorable pharmacological profile, rocuronium can be considered a preferable option for defasciculation in routine anesthetic practice.

Further studies with larger sample sizes and varied dosing regimens may help to refine optimal pretreatment protocols and explore long-term outcomes.

Author Contributions

Conceptualization, SC; methodology, SC & DKH; software, SC; validation, DKH; formal analysis, SC & DKH; investigation, SC; resources, DKH; data curation, SC; writing—original draft, SC; writing—review & editing, DKH; visualization, SC; supervision, DKH; project administration, DKH; funding acquisition, DKH. All authors contributed to the article and approved the submitted version.

Generative AI statement

No use of artificial intelligence was involved in the study.

Conflict of Interest

The authors declare that the research was conducted in the

absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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