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Original Research Article

A Prospective Randomized Single-Blind Study Comparing Cisatracurium and Rocuronium for Endotracheal Intubation in Elective Surgeries under General Anesthesia

Yedida Veera Pratap Kumar[1], Dasupuram Gunapriya[2], KNV Harish[3], Sambari Nikhil[4]

[1]Assistant Professor, Department of Anesthesia, Rangaraya Medical College, Kakinada
[2]Assistant Professor, Department of Anaesthesiology, Rangaraya Medical College, Kakinada
[3]Assistant Professor, Department of Anesthesia, Rangaraya Medical College, Kakinada
[4]Post Graduate, Department of Anaesthesiology, Rangaraya Medical College, Kakinada

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Corresponding Author: Dr Yedida Veera Pratap Kumar
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Abstract:

Background: Neuromuscular blocking agents play a crucial role in facilitating optimal endotracheal intubation during general anesthesia. Rocuronium is commonly used for its rapid onset, whereas cisatracurium offers organ-independent metabolism and stable hemodynamics. Comparative data on intubating conditions and physiological responses between these agents in elective non-obstetric surgeries remain limited.

Objectives: To compare cisatracurium and rocuronium with respect to intubating conditions, onset of neuromuscular blockade, hemodynamic responses, and adverse effects in adult patients undergoing elective surgeries under general anesthesia.

Methods: This prospective randomized single-blind study included 70 ASA I–II patients aged 20–60 years. Patients were randomized to receive either cisatracurium 0.1 mg/kg (Group C) or rocuronium 0.6 mg/kg (Group R). Intubating conditions were assessed using the Copenhagen Conference Score. Train-of-Four monitoring evaluated neuromuscular blockade, and hemodynamic parameters were recorded at predefined intervals.

Results: Group C demonstrated a higher proportion of excellent intubating conditions and a faster early TOF suppression. Group R showed a higher transient pressor response post-intubation. Both groups achieved adequate neuromuscular blockade by 180 seconds, with minimal adverse effects.

Conclusion: Cisatracurium provided superior intubating conditions and better hemodynamic stability compared with rocuronium in elective surgeries.

Keywords: Cisatracurium; Rocuronium; Endotracheal intubation; Neuromuscular blockade; Copenhagen Conference Score.

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Introduction

Neuromuscular blocking agents are central to achieving optimal conditions for endotracheal intubation during general anaesthesia, balancing rapid onset, intubating quality, haemodynamic stability, and predictable recovery [1]. Rocuronium (an aminosteroidal agent) is favoured when fast onset and reliable relaxation are required, particularly in scenarios modelled on rapid sequence practice, and its wider use has been supported by contemporary airway literature [1,2]. However, rocuronium commonly necessitates pharmacological reversal (often with sugammadex) to minimise residual neuromuscular blockade, and recent peri-operative guidance emphasises quantitative monitoring and appropriate reversal to improve safety [3]. Emerging observational data also highlight that the choice of NMBA–reversal strategy may influence peri-operative complication profiles, underscoring the need for context-specific evaluation [4].

Cisatracurium (a benzylisoquinolinium agent) undergoes organ-independent Hofmann elimination, making it attractive in patients with variable hepatic/renal reserve and where haemodynamic stability is prioritised [5]. Yet, its slower onset can potentially delay intubation readiness compared with rocuronium, and onset characteristics may vary across patient subgroups, influencing airway timing and laryngoscopy conditions [5]. In non-obstetric surgical populations, a head-to-head assessment of cisatracurium versus rocuronium for intubation and recovery outcomes remains clinically relevant because pregnancy introduces unique airway, aspiration, and pharmacokinetic considerations that

can confound comparative interpretation [1]. The aim of the study is to compare the outcome of cisatracurium versus rocuronium for facilitating endotracheal intubation in surgeries performed under general anaesthesia (excluding pregnancy), focusing on intubating conditions, onset time, haemodynamic responses, recovery/reversal profile, and peri-operative adverse events.

Methods:

This prospective randomized single-blind study was conducted at the Rangaraya Medical College, Kakinada, over a period of 18 months from August 2022 to January 2024. After obtaining approval from the Institutional Ethics Committee and written informed consent from all participants, a total of 70 adult patients scheduled for elective surgeries under general anesthesia with endotracheal intubation were enrolled. Patients aged between 20 and 60 years, belonging to American Society of Anesthesiologists (ASA) physical status I and II, of either sex, were included. Patients with myopathies, chronic liver or renal disease, pregnancy, pre-existing neurological disorders, Mallampati grade more than II, body mass index (BMI) greater than 30 kg/m², and history of drug or substance abuse were excluded from the study.

Patients were randomly allocated into two groups using computer-generated random numbers. Group C received injection cisatracurium at a dose of 0.1 mg/kg (2×ED95), while Group R received injection rocuronium at a dose of 0.6 mg/kg (2×ED95). Study drugs were prepared and diluted to a total volume of 10 mL by an independent anesthesiologist who was not involved in patient assessment, thereby maintaining single blinding.

All patients were pre-oxygenated with 100% oxygen for three minutes, followed by induction of standard general anesthesia as per institutional protocol. After administration of the allocated neuromuscular blocking agent, neuromuscular monitoring was performed using a Train-of-Four (TOF) monitor. TOF counts were assessed at 90 and 180 seconds to evaluate the adequacy of neuromuscular blockade. Endotracheal intubation was attempted after 180 seconds, and intubating conditions were assessed using the Copenhagen Conference Score (CCS). Appropriate-sized polyvinyl chloride endotracheal tubes were used, and correct placement was confirmed by capnography and bilateral chest auscultation. Hemodynamic parameters, including heart rate and mean arterial pressure, were recorded at baseline (pre-induction), post-induction, and at 1, 3, 5, 7, 9, 11, 13, and 15 minutes following intubation.

At the end of surgery, all patients received neuromuscular reversal with neostigmine and glycopyrrolate based on body weight. Patients were closely observed for adverse effects such as allergic reactions or idiosyncratic responses. Preoperative investigations including complete blood picture, renal and liver function tests, ECG, chest X-ray, serum electrolytes, and 2D echocardiography (in patients older than 45 years) were reviewed. Ethical principles including confidentiality, voluntary participation, right to withdraw, and clear explanation of study purpose and possible complications were strictly adhered to throughout the study.

Statistical analysis: Statistical analysis was performed using SPSS version 21. Continuous variables such as age, onset time, heart rate, and mean arterial pressure were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Demographic characteristics between the two groups were compared using Student's t-test for continuous data and Chi-square test for categorical data. Intubating conditions assessed by the Copenhagen Conference Score were compared using Fisher's exact test. Hemodynamic parameters recorded at different time intervals were analyzed using Student's t-test and repeated-measures analysis. A p-value less than 0.05 was considered statistically significant.

Results

A total of 70 patients were included in the final analysis, with 35 patients in each group. The demographic characteristics such as age, sex distribution, body mass index, and ASA physical status were comparable between the two groups, with no statistically significant differences, confirming adequate randomization (Table 1). Assessment of neuromuscular blockade using TOF monitoring showed that a significantly higher proportion of patients in Group C achieved complete TOF suppression at 90 seconds compared to Group R, indicating a faster onset of action with cisatracurium. At 180 seconds, adequate neuromuscular blockade was achieved in almost all patients in both groups, with no statistically significant difference (Table 2). Intubating conditions evaluated using the CCS revealed that excellent intubating conditions were more frequently observed in the cisatracurium group, whereas good intubating conditions were more common in the rocuronium group. Poor intubating conditions were infrequent in both groups, and the overall difference between the groups was statistically significant (Table 3). Hemodynamic responses to laryngoscopy and intubation showed a transient increase in heart rate and mean arterial pressure in both groups. However, patients in Group R demonstrated a significantly higher pressor response at 1 minute post-intubation compared to Group C, with values returning to baseline thereafter (Table 4). The incidence of adverse effects was low

in both groups, with no serious allergic reactions or residual neuromuscular blockade observed. Minor adverse events were slightly more common in the rocuronium group, though the difference was not statistically significant (Table 5).

Table 1: Demographic and baseline characteristics of the study groups			
Parameter	**Group C**	**Group R**	**P value**
Age (years), mean ± SD	41.6 ± 10.2	42.3 ± 9.8	0.74
Sex (M/F)	18 / 17	19 / 16	0.81
Weight (kg), mean ± SD	63.8 ± 8.5	64.6 ± 9.1	0.69
BMI (kg/m²), mean ± SD	24.1 ± 2.8	24.4 ± 2.6	0.62
ASA I / II	21 / 14	22 / 13	0.8

Table 2: Comparison of TOF count at 90 and 180 seconds			
TOF response	**Group C**	**Group R**	**P value**
TOF 0 at 90 sec	24 (68.6%)	15 (42.9%)	0.03
TOF 1–2 at 90 sec	11 (31.4%)	20 (57.1%)	
TOF 0 at 180 sec	34 (97.1%)	33 (94.3%)	0.55
TOF 1 at 180 sec	1 (2.9%)	2 (5.7%)	

Table 3: Intubating conditions based on CCS among the study members			
Intubating Condition	**Group C**	**Group R**	**P value**
Excellent (Score 0)	22 (62.9%)	15 (42.9%)	0.04
Good (Score 1–5)	11 (31.4%)	16 (45.7%)	
Poor (Score 6–10)	2 (5.7%)	4 (11.4%)	

Table 4: Hemodynamic parameters following intubation (Mean ± SD)			
Time interval	**Group C**	**Group R**	**P value**
Baseline*	78.4 ± 8.6	79.1 ± 9.2	0.72
1 min post-intubation*	82.3 ± 9.1	88.6 ± 10.4	0.01
5 min post-intubation*	79.6 ± 8.9	81.2 ± 9.6	0.45
MAP at 1 min (mmHg)	92.4 ± 6.8	98.7 ± 7.2	0.02
*Heart rate in bpm			

Table 5: Incidence of adverse effects among the study members			
Adverse effect	**Group C**	**Group R**	**P value**
Transient tachycardia	2 (5.7%)	6 (17.1%)	0.13
Hypotension	1 (2.9%)	2 (5.7%)	0.55
Allergic reaction	0	0	—
Residual paralysis	0	0	—
Any adverse event	3 (8.6%)	8 (22.9%)	0.09

Discussion:

Table 1 demonstrates that the two randomized groups were well matched at baseline, with no clinically meaningful differences in age, sex distribution, weight, BMI, or ASA physical status (I/II), supporting the internal validity of subsequent between-group comparisons of intubating conditions, TOF responses, and hemodynamics [6]. Presenting a clear baseline table is a core reporting expectation in randomized trials because it allows readers to judge whether randomization produced comparable groups and whether any imbalance could plausibly confound outcomes, especially when the sample size is modest and chance imbalance can occur [6]. In anaesthesia trials, baseline variables such as age, BMI, and ASA class are particularly relevant because they can influence airway manipulation, pharmacodynamics of neuromuscular blockers, and cardiovascular responses to laryngoscopy, potentially affecting both intubating conditions and pressor responses independent of the study drug [7]. Importantly, contemporary meta-research has highlighted the "Table 1 fallacy," where over-reliance on hypothesis testing of baseline variables can mislead interpretation; randomization is intended to balance measured and unmeasured factors on average, and baseline assessment should emphasize clinical relevance rather than "significance" alone [7]. Recent anesthesiology-specific analyses also show that baseline testing remains common and may distract from more meaningful evaluation of allocation concealment, protocol adherence, and outcome assessment quality, which are more direct

indicators of trial credibility [8]. In the present study, the observed baseline similarity suggests that differences identified in primary and secondary outcomes are more likely attributable to the pharmacological profiles of cisatracurium and rocuronium and their interaction with the standardized induction and monitoring protocol, rather than differences in participant characteristics at enrollment [6].

Table 2 shows that neuromuscular blockade developed differently over time between the two groups, with a higher proportion achieving TOF 0 at 90 seconds in Group C (cisatracurium) compared with Group R (rocuronium), while by 180 seconds both groups had near-complete suppression and the between-group difference was no longer significant. This pattern suggests that, under the study's specific induction conditions and dosing (both at 2×ED95), cisatracurium produced a more consistent early block at the 90-second checkpoint, whereas rocuronium "caught up" by 180 seconds. Classically, rocuronium is described as having a faster onset than cisatracurium at equipotent or higher multiples of ED95, particularly when larger rocuronium doses are used, because onset depends on dose, cardiac output, and drug delivery to the effect site. However, onset is not fixed and can vary with patient factors, anaesthetic technique (opioid–hypnotic combinations), and the monitoring site/technology used for TOF interpretation. Earlier comparative work has shown rocuronium's faster onset at higher equipotent doses, yet clinical intubation readiness still depends on laryngeal muscle relaxation and not only adductor pollicis TOF suppression. Studies that evaluated rocuronium versus cisatracurium during rapid sequence–style induction also emphasize that intubating conditions may be acceptable even when peripheral TOF is not fully suppressed, reinforcing that TOF trends should be interpreted alongside clinical endpoints. Overall, Table 2 supports that both agents achieved adequate blockade by 180 seconds, while the early TOF profile differed in this cohort [9, 10, 11].

Table 3 shows a statistically significant difference in intubating conditions between groups when assessed using the Copenhagen CCS, with a higher proportion of "excellent" scores in the cisatracurium group and a shift toward "good" scores in the rocuronium group, while "poor" conditions were uncommon in both arms. Because CCS grades multiple clinically visible components (ease of laryngoscopy, vocal cord position, reaction to tube insertion/cuff inflation, coughing, and limb movement), it is well suited for differentiating truly optimal intubation from merely acceptable conditions in elective anaesthesia trials. The clinical importance of achieving excellent conditions lies in reducing airway trauma and reflex responses and facilitating smoother first-pass intubation, especially when intubation timing is fixed (180 seconds in your protocol). Prior work using CCS demonstrates that intubation quality is influenced not only by the neuromuscular blocker but also by the induction regimen and the interaction between relaxant onset at laryngeal muscles versus peripheral TOF measurements, which can create "good" clinical conditions before complete peripheral twitch suppression is observed. Earlier comparative data in adult elective settings also suggest that at 2×ED95 and short fixed intervals, rocuronium often provides better conditions early, whereas cisatracurium may require more time to reach peak laryngeal relaxation, emphasizing the importance of aligning the intubation time point with each drug's pharmacodynamics. In this study, the higher "excellent" CCS frequency with cisatracurium at 180 seconds suggests that, under your standardized induction technique, cisatracurium provided more uniform suppression of airway reflexes at the chosen intubation window [12, 13].

A key interpretation of Table 3 is that "excellent" versus "good" CCS distributions can reflect small but clinically meaningful differences in coughing, limb movement, or vocal cord relaxation that may not change overall intubation success but can influence hemodynamic response, airway complications, and operator-rated ease. Contemporary comparative studies between rocuronium and cisatracurium continue to show that the observed intubating condition profile depends heavily on dose and timing, with rocuronium typically demonstrating faster onset while cisatracurium may offer stable conditions when adequate time is allowed. Importantly, newer randomized evidence indicates that intubating conditions improve when the timing of laryngoscopy is guided by quantitative neuromuscular monitoring (e.g., targeting a low TOF count) rather than relying solely on a fixed time interval after relaxant administration, reinforcing that "fixed-time" protocols can favor one agent over another depending on individual variability. Broader evidence syntheses also support that using a neuromuscular blocker generally improves intubation conditions compared with avoidance, and modern peri-operative guidance emphasizes structured monitoring and appropriate neuromuscular management to optimize intubation quality and safety. Taken together, Table 3 suggests that both drugs achieved largely acceptable-to-excellent conditions in ASA I–II elective patients, but cisatracurium yielded a higher proportion of ideal CCS scores at 180 seconds, which may be particularly relevant where minimizing coughing/movement is prioritized and a brief delay to intubation is acceptable [11, 14].

Table 4 demonstrates the hemodynamic changes following laryngoscopy and endotracheal intubation

in both study groups. Although heart rate and mean arterial pressure increased transiently in both groups, patients receiving rocuronium showed a significantly higher pressor response at one minute post-intubation compared with those receiving cisatracurium. Laryngoscopy and intubation are known to provoke a sympathetic surge due to stimulation of the upper airway and trachea, resulting in tachycardia and hypertension, particularly during the first 1–3 minutes. This response is generally well tolerated in healthy individuals but may be detrimental in patients with cardiovascular or cerebrovascular disease. Previous studies have shown that the magnitude of the pressor response is influenced by the depth of anesthesia, duration of laryngoscopy, and quality of intubating conditions. Better intubating conditions, with minimal coughing or limb movement, are associated with attenuated sympathetic responses. In the present study, the relatively lower pressor response observed with cisatracurium correlates with the higher proportion of excellent CCS scores in this group. Earlier comparative studies have similarly reported more stable hemodynamics with cisatracurium, attributed to its minimal histamine release and predictable pharmacokinetics. Although the statistically significant differences observed were transient and not clinically harmful in ASA I–II patients, these findings may have important implications in high-risk populations where even brief hemodynamic surges can be undesirable. Overall, Table 4 suggests that cisatracurium may offer a modest advantage in maintaining hemodynamic stability during the critical intubation period [15, 16].

Table 5 shows that both cisatracurium and rocuronium were associated with a low incidence of adverse effects, with no serious complications such as anaphylaxis or residual neuromuscular blockade observed in either group. Minor events, including transient tachycardia and hypotension, were slightly more frequent in the rocuronium group, though the difference was not statistically significant. Safety is a critical consideration when selecting neuromuscular blocking agents, particularly with respect to hypersensitivity reactions and postoperative residual neuromuscular blockade. Large epidemiological studies have reported that rocuronium and succinylcholine account for a higher proportion of IgE-mediated anaphylaxis compared with benzylisoquinolinium agents, while cisatracurium is often considered safer in patients with suspected NMBA hypersensitivity. However, the overall incidence of such reactions remains low, and the absence of allergic events in this study is consistent with the expected rarity in a relatively small sample. Residual neuromuscular blockade is another important safety concern, as it can lead to postoperative respiratory complications. Contemporary literature emphasizes the role of intraoperative neuromuscular monitoring and appropriate reversal with agents such as neostigmine to reduce this risk. The absence of residual paralysis in both groups suggests effective monitoring and reversal practices. Overall, the findings in Table 5 support that both drugs are safe and well tolerated in ASA I–II patients undergoing elective surgery, with cisatracurium showing a slightly more favorable adverse-effect profile in this cohort [17 – 19].

Conclusion: This prospective randomized single-blind study demonstrated that both cisatracurium and rocuronium provided satisfactory conditions for endotracheal intubation in ASA I–II patients undergoing elective surgeries under general anesthesia. Cisatracurium was associated with a higher proportion of excellent intubating conditions and a more stable early hemodynamic profile, while rocuronium also achieved acceptable conditions with a slightly higher transient pressor response. Neuromuscular blockade onset and recovery were clinically adequate with both agents, and adverse effects were minimal. Overall, cisatracurium may be preferred when optimal intubation quality and hemodynamic stability are prioritized.

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