Original Article

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Anaesthesia Section

Comparison of Cisatracurium and Atracurium on Intubating Conditions and Haemodynamic Responses during Laryngoscopy in Patients Undergoing General Anaesthesia: A Randomised Double-blind Clinical Study

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ABSTRACT

Introduction: General anaesthesia is commonly facilitated by endotracheal intubation, for which Neuromuscular Blocking Agents (NMBA) are used to achieve optimal intubating conditions and haemodynamic stability. Atracurium and cisatracurium are benzylisoquinolinium neuromuscular blockers with distinct pharmacokinetic and pharmacodynamic profiles, which may influence intubation quality and cardiovascular responses.

Aim: To compare Cisatracurium and Atracurium in patients requiring general anaesthesia and undergoing elective surgery with respect to intubating conditions and haemodynamic responses during laryngoscopy.

Materials and Methods: This randomised double-blinded clinical study was conducted at the Department of Anaesthesiology, Sikkim Manipal Institute of Medical Sciences, Gangtok, Sikkim, India, from August 2023 to September 2024. A total of 74 American Society of Anaesthesiologists (ASA) physical status grade I-II patients scheduled for elective surgery under General Anaesthesia (GA) were enrolled and randomly assigned to two equal groups of 37 each. Participants in Group A received Atracurium 0.5 mg/kg intravenously, while those in Group C received Cisatracurium 0.2 mg/kg intravenously. Intubation conditions, cardiovascular stability, duration of action, and cost parameters were evaluated for both groups. Continuous variables were expressed as mean±SD and compared using an Independent t-tests or Mann-Whitney U test, while categorical variables were analysed using Chi-square or Fisher's-exact tests.

Results: The mean age of participants was 37.9 years, with group A averaging 37.9±10.9 years and group C averaging 38.0±12.2 years. Diastolic Blood Pressure (DBP) differed significantly between groups immediately after induction (70.51±14.49) and at 2 (69.68±16.53), 4 (82.00±17.41), and 6 (79.86±10.56) minutes ($p<0.001$). Mean Arterial Pressure (MAP) also showed significant variation at 2 minutes (70.32±8.07) and 4 minutes (83.86±16.61) (p-value <0.001), whereas Heart Rate (HR) and Oxygen Saturation (SpO2) remained comparable. Maintenance dose duration was shorter in Group A (38.3±7.5 min) than in Group C (64.9±20.8 min; $p<0.001$).

Conclusion: Cisatracurium and atracurium are intermediate-acting muscle relaxants; however, cisatracurium releases less histamine, ensuring steadier haemodynamics. The present study inferred that cisatracurium offers favourable haemodynamics, superior intubating conditions, and longer duration of action, although it may be slightly expensive, suggesting that cisatracurium may offer clinical advantages in selected settings.

Keywords: Anesthesiologists, Cost-benefit analysis, Endotracheal, Intubation, Muscle relaxation, Neuromuscular blockade, Neuromuscular blocking agents

INTRODUCTION

The NMBAs are integral to modern anaesthetic practice, particularly for facilitating endotracheal intubation and optimising surgical conditions. Among the non depolarising neuromuscular blockers, atracurium and cisatracurium- both benzylisoquinolinium derivatives- are widely used due to their predictable metabolism, organ-independent elimination pathways, and relatively favourable safety profiles [1]. These characteristics make them especially useful in patients with compromised hepatic or renal function. However, despite their routine clinical use, differences in their pharmacodynamic and pharmacokinetic properties may influence intubating conditions, haemodynamic stability, duration of neuromuscular blockade, and overall cost-effectiveness [2].

Previous studies have compared atracurium and cisatracurium in various clinical settings, focusing on intubating conditions, haemodynamic responses, and recovery profiles [3-5]. Some investigators have reported superior haemodynamic stability [6-10] and better intubating conditions with cisatracurium [1,7], while others have demonstrated comparable efficacy between the two agents [11,12]. Variations in findings across studies may be attributed to differences in dosing regimens, timing of intubation, anaesthetic techniques, patient populations, and scoring systems used to evaluate intubation conditions. Furthermore, many studies have been conducted in heterogeneous surgical populations, limiting the generalisability of their conclusions [13,14].

A critical gap in the existing literature is the lack of consistent evidence regarding the comparative clinical advantages of atracurium and cisatracurium in routine surgical practice. There is no clear consensus on whether cisatracurium offers clinically meaningful superiority over atracurium in terms of intubating conditions and haemodynamic stability, particularly when administered at commonly used clinical doses. Additionally, the duration of action and requirements for maintenance dosing have been variably reported, and few studies

have systematically evaluated these parameters alongside intubation quality [15,16].

Another important gap pertains to economic considerations. Cisatracurium is significantly more expensive than atracurium, which can influence drug selection in resource-limited settings. However, limited studies have evaluated cost-effectiveness in conjunction with clinical efficacy and safety outcomes [9]. As healthcare systems increasingly emphasise value-based care, understanding the balance between clinical benefit and economic cost is essential for rational drug selection.

Moreover, there is a paucity of region-specific randomised controlled studies evaluating these agents in comparable patient populations using standardised protocols. Differences in patient demographics, anaesthetic practices, and institutional protocols may influence outcomes, highlighting the need for locally generated evidence to guide clinical decision-making. Additionally, limited studies [9] have simultaneously assessed multiple clinically relevant outcomes- such as intubating conditions, haemodynamic responses, duration of neuromuscular blockade, and cost- within a single randomised study framework.

Given these gaps, the present study was designed to provide a comprehensive comparison of atracurium and cisatracurium in patients undergoing surgery under GA. By evaluating intubating conditions, haemodynamic parameters, duration of neuromuscular blockade, and cost implications in a randomised and controlled setting, the present study seeks to generate robust evidence to inform clinical practice. The novelty of the current study lies in its integrated assessment of clinical efficacy and economic considerations, as well as its contribution to region-specific data, thereby addressing unresolved questions in the existing literature and aiding anaesthesiologists in making evidence-based choices regarding NMBAs.

The present study aimed to compare the effect of atracurium and cisatracurium on intubating conditions and haemodynamic responses in patients undergoing surgery under GA. The primary outcome was quality of intubating conditions assessed by Cooper R et al., score. Secondary outcomes included haemodynamic parameters (HR, SBP, DBP, MAP), duration to first maintenance dose, and cost comparison.

MATERIALS AND METHODS

This randomised double-blinded clinical study was conducted at the Department of Anaesthesiology, Sikkim Manipal Institute of Medical Sciences, Gangtok, Sikkim, India, from August 2023 to September 2024 after obtaining approval from the Institutional Ethics Committee (SMIMS/IEC/2023-56) and was registered in the Clinical Trials Registry of India (CTRI/2023/08/056012). All the procedures were done according to the Helsinki Declaration of 1975 (revised in 2000). Written informed consent was sought from all the participating patients.

Sample size calculation: Based on a study conducted by Athaluri VV et al., which is as follows [17], proportion of patients with excellent intubation condition in the atracurium group, p1=38 % and proportion of patients with excellent intubation condition in the cisatracurium group, p2=72%.

Sample size is estimated by using the above parameters in the formula given below:

$$N = \frac{\{Z_{1-\frac{\alpha}{2}}\sqrt{2P(1-P)} + Z_{1-\beta}\sqrt{p1(1-p1)+p2(1-p2)}\}^2}{(p1-p2)^2}$$

$$Z_{1-\frac{\alpha}{2}} = 1.96 \text{ at } 95\% \text{ confidence interval}$$

$Z_{1-\beta}$ = 0.84 at 80% Power

$$P = \frac{p1+p2}{2} = 0.38+0.72/2 = 0.55$$

$$N = \frac{\{1.96\sqrt{2\,(0.55)(1-0.55)} + 0.84\sqrt{0.38(1-0.38)+0.72(1-0.72)}\}^2}{(0.38-0.72)^2}$$

N = 3.725/ (0.34*0.34) = 33 rounded off to 35 per group

Minimum samples required N=70 (35 per group)

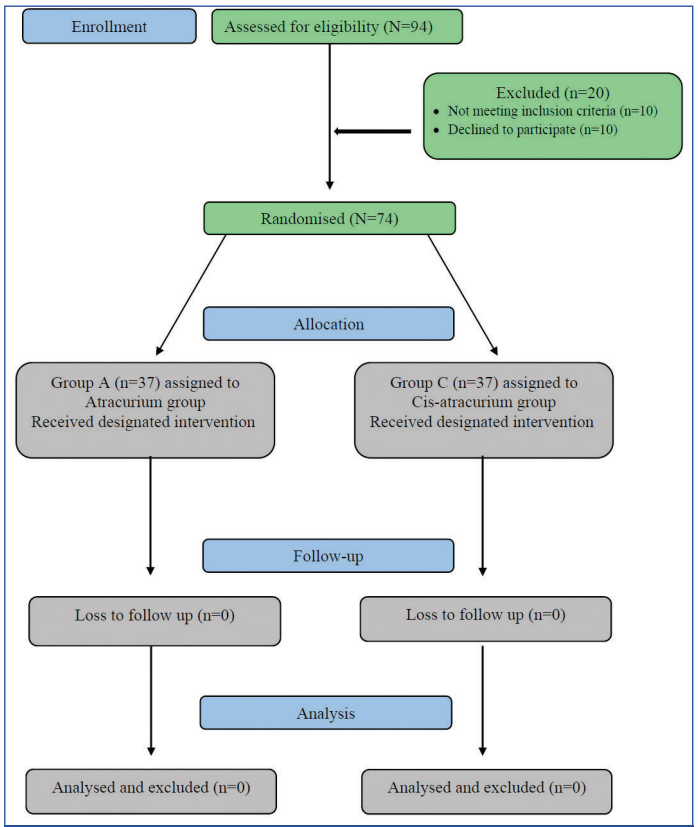
The minimum required sample size was calculated to be 70. To account for potential attrition and for logistical convenience, the final sample size was increased to 74 participants.

Inclusion criteria: Seventy-four patients who underwent elective surgeries under GA, belonging to ASA physical status I or II of both genders, between the ages of 18-60 years, requiring endotracheal intubation were included.

Exclusion criteria: Patients with ASA physical status III and IV patients, patients not consenting, pregnant and lactating mothers, patients with anticipated difficult airway (Mallampati Class III and IV, thyromental height <6 cm, interincisor distance <3 cm and cervical instability), history of bronchial asthma and hypersensitivity to any of the drugs used in the current study were excluded from the study.

Study Procedure

The consenting participants were allocated to one of the two groups- group A, n=37 patients or group C n=37 patients, in the ward using a computer- generated random number table [Table/Fig-1]. The random assignment of groups was concealed in identical opaque sealed envelopes. The drugs were prepared likewise Inj. Atracurium- 0.5 mg/kg actual body weight (induction dose), 0.1 mg/kg (maintenance dose) and Inj. Cisatracurium- 0.2 mg/kg actual body weight (induction dose), 0.02 mg/kg (maintenance dose). The procedure of randomisation and blinding was explained to patients and their relatives by a team of anaesthesiologists and surgeons. Patients were informed that neither they nor the anaesthesiologists knew which drug was administered. They were assured that both agents were approved, recommended, and routinely used. The counselling session was not limited by time or numbers. Patient was given enough time to think, come back and opt for the study.



[Table/Fig-1]: CONSORT (Consolidated Standards Reporting of Trials) the process of recruitment and analysis of the participants under group A and group C.

The investigator, patient and anaesthetist were unaware of the study drug allocation, hence ensuring double blinding. The drugs were prepared by an independent Operation Theatre (OT) technician, not involved in the study. The confidentiality regarding allocation and blinding was guaranteed till the completion of data collection.

Preoperatively, preanesthetic evaluation was done for all patients enrolled in the study, including detailed history taking, clinical examination and necessary investigations were done, following which, patients were randomly allocated into two groups. In the operating room, an 18 G i.v., cannula was secured for i.v. fluids and drugs, and another 20 G i.v. cannula was secured for administration of the study drug. All routine ASA monitors, including pulse oximeter, BP-cuff and ECG leads, were attached, and baseline parameters were noted. A standardised anaesthesia technique was used for all patients and was performed by a skilled anaesthesiologist with a minimum of five years' experience, and drugs were administered by an equally experienced OT technician. Patients were premedicated with Inj. Glycopyrrolate (4 µg/kg) and Inj. Ondansetron (0.15 mg/kg) i.v.. Preoxygenation via face mask was done with 100% oxygen for three minutes, maintaining a tight seal. Induction was done with Inj. Propofol (2 mg/kg) and Inj. Fentanyl (2 µg/kg) intravenously, followed by administration of the study drug over five seconds and flushed with normal saline over 15 seconds. After three minutes of head tilt and chin lift bag mask ventilation, direct laryngoscopy using a Macintosh blade size 3 (for females) and size 4 (for males) was done and intubating conditions were noted according to Cooper R et al., scoring [18]. Bilateral air entry was checked, and ET tube position was confirmed with 5-point auscultation and End Tidal CO_2, after which the tube was fixed and secured. Post-induction and post-intubation haemodynamic responses were noted at a fixed time interval of two minutes by an experienced OT technician. The parameters were recorded immediately after the study drug was administered, followed by noting down the time for 1st maintenance dose. Anaesthesia was maintained with inhalational agent Isoflurane and intermittent positive pressure ventilation with fresh gases; nitrous oxide and oxygen in the ratio of 40:60, and neuromuscular blockade was maintained with bolus doses of either Inj. Atracurium (0.1 mg/kg) or Inj. Cis atracurium (0.02 mg/kg) i.v. according to the study drug that was administered during induction, using a circle absorber system connected to the anaesthesia workstation. At the end of the surgery, neuromuscular blockade was reversed with Inj, Neostigmine (0.05 mg/kg) i.v. and Inj. Glycopyrrolate (0.008 mg/kg) i.v. After the end of the surgery and reversal of neuromuscular blockade, the patient was extubated and subsequently shifted out to the Post-Anaesthesia Care Unit (PACU).

The haemodynamic parameters (HR, BP, Mean Blood Pressure and SpO_2) were recorded in all groups as per the mentioned time frames i.e., before induction, immediately after induction, two minutes after induction, four minutes after induction, six minutes after induction, eight minutes after induction and 10 minutes after induction.

The intubating condition parameters were recorded according to the following scoring/grading systems i.e., Cooper R et al., scoring [18], (Excellent=8-9, Good=6-7, Poor=5-6, Bad=0-4) Modified Cormack-Lehane grading [19] - Easy=Grade 1-2a; Restricted= Grade 2b-3a; and Difficult= Grade 3b-4. Body Mass Index (BMI) and the time at which the 1st maintenance dose was administered were also noted as a single reading [20].

STATISTICAL ANALYSIS

The data were tabulated and analysed using Microsoft Excel and Jamovi statistical software (version 2.7.12; The Jamovi Project, Sydney, Australia). Continuous variables were summarised as mean±SD and categorical variables as frequencies and percentages. Baseline characteristics were compared between groups using independent t-tests or Mann-Whitney U tests for continuous variables and Chi-square or Fisher's-exact tests for categorical variables. Repeatedly measured hemodynamic outcomes (HR, SBP, DBP, MAP at six time points) were used in repeated measures Analysis of Variance (ANOVA) with time as the within-subject factor and group (Cisatracurium vs Atracurium) as the between-subject factor; Mauchly's test of sphericity was assessed, and Greenhouse-Geisser corrected p-values were reported if sphericity was violated. The study considered p-value <0.05 as significant.

RESULTS

The study included a total of 74 participants with 37 participants in each group. The mean age of the participants in the study was found to be 37.9 years, which was 37.9±10.92 years and 38.0±12.2 years in group A and group C, respectively. The participants in the study were uniformly distributed across all age groups and genders as depicted in the [Table/Fig-2]. The mean height of the participants in group A and group C was 159.49±8.15 cm and 157.49±8.83 cm, respectively, whereas the mean height of all the participants was noted to be 158.39 cm. The mean BMI of the participants in group A and group C was found to be 24.15±3.69 kg/m^2 and 23.76±4.65 kg/m^2, respectively.

Parameters	Group A (n=37) n (%)	Group C (n=37) n (%)	Total (N=74) n (%)	p-value#
Gender				
Male	9 (24.3)	10 (27.0)	19 (25.7)	0.790
Female	28 (75.7)	27 (73.0)	55 (74.3)	
Age (in years)				
20-29	13 (35.1)	10 (27.0)	23 (31.1)	0.261
30-39	8 (21.6)	11 (29.7)	19 (25.7)	
40-49	6 (16.2)	11 (29.7)	17 (23.0)	
≥50	10 (27.0)	5 (13.5)	15 (20.3)	
ASA classification				
1	23 (62.2)	25 (67.6)	48 (64.9)	0.626
2	14 (37.8)	12 (32.4)	26 (35.1)	
BMI classification (South-Asian Classification)				
Underweight	3 (8.1)	4 (10.8)	7 (9.5)	0.704
Normal	11 (29.7)	15 (40.5)	26 (35.1)	
Overweight	7 (18.9)	6 (16.2)	13 (17.6)	
Obese	16 (43.2)	12 (32.4)	28 (37.8)	

[Table/Fig-2]: Distribution of the study participants based on demographics (N=74).
Chi-square test or independent t-test has been used to calculate p-value

The comparison of DBP and MABP between the two study groups was recorded at various follow-up intervals are depicted in [Table/Fig-3]. There was statistical significance noted between the two groups at follow-up intervals; immediately after induction, two minutes, four minutes, and six minutes (p-value <0.05) for DBP and at follow-up intervals of two minutes and four minutes (p-value <0.05) for MAP. A Repeated Measures Analysis of Variance (RM-ANOVA) was performed to evaluate changes in haemodynamic parameters such as HR, Systolic Blood Pressure (SBP), DBP, and MAP over time intervals following induction, and to compare these trends between the Cisatracurium and Atracurium groups.

Cooper R et al., scoring were used for intubating conditions. The three parameters measured have been mentioned in [Table/Fig-4]. An overall statistical significance was noted among the participants in the two groups based on the Cooper R et al., Grading. (p-value <0.05), which can be seen in [Table/Fig-4] that the majority of participants from group C were graded as excellent when compared to group A.

The scoring of the participants based on the Modified Cromack-Lehane Grading system are depicted in [Table/Fig-5]. There was no statistically significant difference noted as the p-value was >0.05.

Parameters	Groups	Pre-induction	Immediately after induction	At 2 minutes	At 4 minutes	At 6 minutes	At 8 minutes	At 10 minutes	Time x Group (p-value)#
HR (Mean±SD)	A	79.59±(14.94)	87.78±(12.38)	91.16±(17.63)	94.32±(12.09)	94.11±(11.90)	93.68±(11.08)	93.16±(11.99)	0.230
	C	81.86±(11.44)	87.95±(14.23)	89.00±(14.61)	100.05±(13.52)	97.03±(12.32)	97.54±(13.80)	96.14±(14.32)	
	p-value	**0.523**	**0.958**	**0.766**	**0.059**	**0.298**	**0.117**	**0.336**	
SBP (Mean±SD)	A	127.95±(13.94)	105.51±(14.53)	103.30±(20.30)	124.78±(19.94)	116.22±(14.32)	107.35±(13.18)	107.92±(15.20)	0.006
	C	126.14±(12.95)	101.46±(14.49)	92.84 (10.57)	109.08±(19.86)	112.97±(10.79)	107.73±(8.36)	105.62±(10.15)	
	p-value	**0.770**	**0.141**	**0.027**	**0.001**	**0.468**	**0.581**	**0.646**	
DBP (Mean±SD)	A	80.84±(10.68)	70.51±(14.49)	69.68±(16.53)	82.00±(17.41)	79.86±(10.56)	73.81±(9.59)	74.22±(11.49)	0.059
	C	79.46±(9.09)	64.14±(12.19)	58.73±(7.76)	70.65±(14.67)	73.89±(8.47)	71.49±(8.84)	69.46±(9.22)	
	p-value	**0.577**	**0.043**	**0.002**	**0.001**	**0.013**	**0.267**	**0.055**	
MAP (Mean±SD)	A	94.78±(10.06)	81.19±(13.68)	80.41±(16.59)	97.38±(16.38)	91.35±(10.52)	84.62±(9.35)	85.19±(11.87)	0.004
	C	94.35±(9.61)	75.84±(12.65)	70.32±(8.07)	83.86±(16.61)	87.14±(8.29)	83.78±(7.88)	81.62±(9.27)	
	p-value	**0.850**	**0.068**	**0.004**	**0.001**	**0.082**	**0.778**	**0.209**	

[Table/Fig-3]: Comparison of the study participants based on haemodynamic parameters in group A and group C (N=74).
(HR: Heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; SD: Standard deviation); # Chi-square test or independent t-test has been used to calculate p-value

Parameters	Group A n (%)	Group C n (%)	p-value#
Jaw relaxation			
Minimal (1)	6 (16.2)	6 (16.2)	0.313
Moderate (2)	18 (48.6)	12 (32.4)	
Good (3)	13 (35.1)	19 (51.4)	
Vocal cord position			
Closed (0)	2 (5.4)	1 (2.7)	0.003
Closing (1)	3 (8.1)	2 (5.4)	
Moving (2)	17 (45.9)	5 (13.5)	
Open (3)	15 (40.5)	29 (78.4)	
Response to intubation*			
Slight diaphragmatic movement (2)	12 (32.4)	6 (16.2)	0.175
None (3)	25 (67.6)	31 (83.8)	
Cooper R et al., grading			
Excellent	14 (37.8)	28 (75.7)	0.004
Good	16 (43.2)	5 (13.5)	
Fair	7 (18.9)	4 (10.8)	

[Table/Fig-4]: Comparison of study participants based on scoring of intubation conditions - jaw relaxation, vocal cord position and response to intubation for Cooper R et al., grading. (n=74).
*None of the participants scored 0 (Coughing and bucking) and 1 (Mild coughing) under response to intubation parameter; # Chi-square test or independent t-test has been used to calculate p-value

Modified Cromack-Lehane Grading	Group A n (%)	Group C n (%)	Total n (%)	p-value#
1	11 (29.72)	9 (24.32)	20 (27.02)	0.828
2a	13 (35.13)	15 (40.54)	28 (37.83)	
2b	10 (27.02)	9 (24.32)	19 (25.67)	
3	2 (5.4)	4 (10.81)	6 (8.1)	
4	1 (2.7)	0 (0)	1 (1.35)	

[Table/Fig-5]: Comparison of study participants between Group A and Group C based on intubation condition under Modified Cromack-Lehane grading (N=74).
Chi-square test or Independent t-test has been used to calculate the p-value

The number of participants who required a maintenance dose of the drug during the surgery is depicted in [Table/Fig-6]. There was no statistical significance noted between the two groups (p-value>0.05).

The distribution of study participants based on the procedure is represented in [Table/Fig-7]. Laparoscopic cholecystectomy was the most common procedure. The other procedures included one of each fixation of fracture left clavicle, bilateral humerus fracture fixation, laminectomy, laparoscopic tubal ligation, open

Parameters	Group A n (%)	Group C n (%)	p-value#
Requirement of maintenance dose			
Yes	17 (45.9)	11 (29.7)	0.150
No	20 (54.1)	26 (70.3)	
Mean time duration to maintenance dose			
Mean time duration	38.29 (7.49)	64.91 (20.81)	**<0.001**

[Table/Fig-6]: Comparison of study participants based on the requirement of maintenance dose and mean time-duration to maintenance dose (N=74).
Chi-square test or independent t-test has been used to calculate p-value

Procedure	Group A n (%)	Group C n (%)	Total n (%)
Lap cholecystectomy	29 (78.37)	32 (86.48)	61 (82.43)
Fracture left clavicle	1 (2.7)	0	1 (1.35)
Bilateral humerus fracture	2 (5.4)	0	2 (2.7)
Laminectomy	1 (2.7)	0	1 (1.35)
Lap tubal ligation	1 (2.7)	0	1 (1.35)
Excision of Right tubo-ovarian mass	1 (2.7)	0	1 (1.35)
Lap appendicectomy	2 (5.4)	1 (2.7)	3 (4.05)
Lap cholecystectomy + appendicectomy	0	1 (2.7)	1 (1.35)
Lap salphingo-opherectomy + cholecystectomy	0	1 (2.7)	1 (1.35)
Breast lump excision	0	1 (2.7)	1 (1.35)
Septoplasty	0	1 (2.7)	1 (1.35)

[Table/Fig-7]: Distribution of study participants based on procedure N=74.

reduction internal fixation plating and radial nerve, right ovarian tumour with tubo-ovarian mass excision and two laparoscopic appendicectomies for group A (Atracurium). Under group C, the other procedures included Cholecystectomy + Appendicectomy, Laparoscopic Appendicectomy, laparoscopic salpingo-opherectomy + cholecystectomy and right breast lump excision and septoplasty.

The cost of atracurium vs cisatracurium among the study participants was noted to be as follows. The mean cost of the drug among group A i.e., Artacil® (atracurium) and group C i.e., CisArtacil® (cisatracurium), was Rs 213.95 (±35.27) and Rs 585.40 (±113.08), respectively. The difference in mean cost of the two drugs was found to be statistically significant (p-value <0.01)

DISCUSSION

Appropriate selection of NMBAs is one of the mainstays in the anaesthetic practice and is used extensively in patients undergoing general anaesthesia for any surgery (Bohra P et al.,) [21]. The

current study focused on evaluating the effects of muscle relaxation by using ease of intubation as the parameter, between atracurium and cis-atracurium. After the randomised recruitment of the study participants, it was noted that the participants in both the study groups, i.e., group A and group C, were comparable concerning their demographic profile, such as age and gender, as well as ASA I and II grading (p-value >0.05). The above findings were also observed in studies conducted by Oza PV et al., Ranjan P et al., Khobragde M et al., [22-24]. The current study had a female predominant study population at 74.3%, which was similar in both groups. Based on age group, participants were similarly divided across all age groups. The mean age of the participants in the study was found to be 37.9 years, which was 37.9±10.92 years and 38.0±12.2 years in group A and group C, respectively.

The most common type of surgery observed in the current study was laparoscopic cholecystectomy across both study groups, group A and group C, at 21.46% and 23.68% respectively, with a total of 45.14% cases being laparoscopic cholecystectomy. As the most frequent surgical procedure, laparoscopic cholecystectomy likely reflects the cases most common at the centre of the study.

The haemodynamic parameters assessed by the investigator were HR, SBP, DBP, MAP and SpO_2 at preinduction, immediately after induction, at 2 minutes, at 4 minutes, at 6 minutes, at 8 minutes and at 10 minutes. It was noted that the HR in the atracurium group and cisatracurium group were comparable at all points of follow-up (p-value> 0.05). The difference in mean SBP, however, was statistically significant at 2 minutes and 4 minutes after induction. These findings were similar to the findings reported by Chambyal T et al., where SBP, DBP and MAP were statistically significant at one minute and three minutes post-induction (p-value <0.05) [6]. The mean DBP was found to be statistically significant immediately after induction, at 2 minutes, 4 minutes, and 6 minutes (p-value <0.05) between the two groups. A difference in the average of MAP was noted to be statistically significant at 2 minutes and 4 minutes following induction (p-value <0.05). The SpO_2 was comparable at points of follow-up between the two groups. Contrary to the statistical significance noted in the present study, studies by Prajapati K et al., Gurjar VS et al., Arun Kumar TV et al., and Ranjan R et al., reported the comparability of haemodynamic parameters at all points of follow-up [7-10].

Under Cooper R et al., scoring system, it was found that jaw relaxation was minimal, moderate and complete in 16.2%, 48.6% and 35.1% participants in group A, and 16.2%, 32.4% and 51.4% in group C, respectively [18]. None of the participants reported impossible to intubate, which was comparable to findings of Harle P et al., and Prajapati K et al., [1,7]. There was no statistically significant difference between the two groups. This finding was similar to the results reported by Harle P et al., where no statistical significance was noted for the mean difference of the two groups (p-value >0.05) [1]. A study by Subha PD et al. reported the mean score of parameters under the Cooper R et al., scoring and reported a statistically significant difference of scores with higher scores in the Cisatracurium group [11]. (p-value <0.05). The association between the vocal cord position and the drug used, i.e., atracurium and cisatracurium in our current study, was found to be statistically significant (p-value <0.05) with comparable results in a study done by Pranathi et al., at a cisatracurium loading dose of 0.1 mg/kg and atracurium dose of 0.5 mg/kg [12]. However, the same study reported no statistical significance between atracurium at 0.5 mg/kg and cisatracurium at 0.15 mg/kg. This can be suggestive of variability in scoring at different doses of cisatracurium. Similar statistical significance was noted between atracurium and cisatracurium in a study by Harle P et al., [1]. This can be suggestive of variability in scoring at different doses of cisatracurium. The response to intubation parameters showed no statistical significance between the two study groups (p-value>0.05). The findings were contrary to those reported by Prajapati K et al., where response to intubation was found to be significant between group A and group CA receiving 0.5 mg/kg and 0.15 mg/kg initial dose, respectively [7]. The overall Cooper R et al., scoring in our current study was found to be statistically significant, with a higher score reported amongst the Cisatracurium receiving participants (group C) compared to atracurium receiving participants (group A). These findings are concurrent with the findings of Chambyal T et al., Prajapati K et al., Subha PD et al., (p-value <0.05) [6,7,11]. Chambyal T et al., reported that overall Cooper R et al., scoring was 53.3%, 30.0% and 16.7% patients in group 1 (receiving atracurium 0.5 mg/kg initial dose) scoring excellent, good and fair, respectively and among group 2 (receiving 0.2 mg/kg initial dose similar to the current study) 76.7% and 23.3% scored excellent and good, respectively, whereas none of them scored fair [1].

The current study also used modified Cormack-Lehane grading, which was not found to be statistically significant between the two study groups: group A and group C.

The present study reported no significant association between the drug used and requirement of maintenance dose (p-value >0.05), a statistically significant difference in mean was noted among the participants of the cisatracurium and atracurium groups who required a maintenance dose (p-value <0.05). The above findings were similar to the statistically significant difference of mean for mean time duration to maintenance dose in studies by Ranjan R et al., mean time duration of 70.14±1.87 minutes among the cisatracurium group following the 1st dose in relation to 44.9±2.45 minutes among the atracurium group [10].

Kumar NPB et al., also reported a statistically significant difference in the mean, with the average duration of action of cisatracurium being 46.45±9.61 minutes, which was higher than that of group A (atracurium) (39.74±8.35 min) [25]. Both studies reported a higher mean time duration among the cis-atracurium group as compared to the atracurium group. However, on the contrary, a study by Narang D et al., reported a lower mean duration of action for the cisatracurium group (at 0.1 mg/kg initial dose) when compared with the atracurium group (at 0.3 mg/kg atracurium as initial dose), which was statistically significant [2].

In a study by Arun Kumar TV et al., a higher mean cost for cisatracurium as compared to atracurium at 439.54 INR and 245.98 INR, respectively, with p-value <0.01 was found [9]. This finding is similar to the current study, where Artacil® and Cis-Artacil® were used, which had a mean cost of 213.95 INR and 585.40 INR, respectively, where a statistically significant difference of mean cost was noted (p-value <0.01). The cost of drugs can often impact the choice in planning anaesthesia. Multiple studies have shown a haemodynamic superiority of cis-atracurium over atracurium; hence, despite a higher cost, it is often opted for, especially in cases where haemodynamic instability is suspected. The cases which are relatively more haemodynamically stable can utilise atracurium as an effective NMBA.

Limitation(s)

The study reports limitations, which included the inability to objectively assess neuromuscular blockade due to the absence of TOF monitoring and the use of the modified Cormack–Lehane grading system for evaluating intubating conditions, which was subjective and may have introduced inter-observer variability, as intubations were performed by different trained anaesthesiologists.

CONCLUSION(S)

The present study demonstrated that both atracurium and cisatracurium provided comparable overall intubating conditions during general anaesthesia. However, cisatracurium was associated with significantly greater haemodynamic stability. While parameters such as response to intubation, jaw relaxation, and modified

Cormack-Lehane grading were similar between groups, vocal cord position and Cooper R et al., grading were superior with cisatracurium. Additionally, the duration of action of equipotent intubating doses was significantly longer with cisatracurium compared to atracurium. Despite its higher cost, cisatracurium offers the advantages of more stable haemodynamics, improved intubating conditions, and prolonged duration of neuromuscular blockade, making it a favourable alternative to atracurium in clinical practice.

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