Int. J Med. Pharm. Res.
E-ISSN: 2958-3683 | **P-ISSN**: 2958-3675
Available on: https://ijmpr.in/

International Journal of
Medical and Pharmaceutical Research

ORGINAL ARTICLE OPEN ACCESS

Comparison of Different Doses of Rocuronium Bromide on Intubating Conditions During Endotracheal Intubation in Adults Undergoing Abdominal Surgery

Dr. Jannatul Ferdowsh[1], Dr. Arbind Kumar Ray[2], Dr. Arindam Phukan[3]

[1]Senior Resident, Department of Anaesthesiology, Assam Medical College and Hospital, Assam, India
[2]Associate Professor,Department of Anaesthesiology, Assam Medical College and Hospital, Assam, India
[3]Assistant Professor, Department of Anaesthesiology, Assam Medical College and Hospital, Assam, India

OPEN ACCESS

*Corresponding Author:

Dr. Jannatul Ferdowsh
Senior Resident, Department of Anaesthesiology, Assam Medical College and Hospital, Assam, India

Received: 19-07-2025
Accepted: 02-08-2025
Available Online: 21-08-2025

©Copyright: IJMPR Journal

A B S T R A C T

Background: Rocuronium bromide is a widely used non-depolarizing neuromuscular blocking agent for endotracheal intubation. This study aimed to compare the intubating conditions and hemodynamic changes of three different doses of rocuronium bromide during endotracheal intubation.

Methods: This prospective observational study included 60 ASA I-II adult patients (25-45 years) undergoing elective abdominal surgeries, divided into three groups of 20 patients each: Group A (0.6 mg/kg), Group B (0.9 mg/kg), and Group C (1.2 mg/kg). Intubating conditions were assessed at 60 seconds after administration using Cooper's criteria. Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were recorded before induction, after induction, and at 1, 3, and 5 minutes after intubation. Train-of-four (TOF) monitoring was used to assess neuromuscular blockade.

Results: Clinically acceptable intubating conditions (excellent or good) were observed in 0%, 45%, and 100% of patients in Groups A, B, and C, respectively ($p<0.001$). Mean intubating scores were 3.25±1.07, 5.20±1.67, and 8.35±1.18 in Groups A, B, and C, respectively ($p<0.001$). After intubation, hemodynamic parameters increased in all groups, with Group A showing the most significant changes ($p<0.001$). Mean time to loss of TOF was 123.60±3.27, 93.35±5.02, and 61.50±3.85 seconds in Groups A, B, and C, respectively ($p<0.001$).

Conclusion: Rocuronium bromide at 1.2 mg/kg provides excellent intubating conditions at 60 seconds compared to lower doses. Despite greater hemodynamic fluctuations with increasing doses, all doses demonstrated acceptable hemodynamic stability. Rocuronium can be a suitable alternative when succinylcholine is contraindicated.

Keywords: Rocuronium bromide, Neuromuscular blockade, Intubating conditions, Endotracheal intubation, Train-of-four, Hemodynamic changes.

INTRODUCTION

The introduction of neuromuscular blocking agents into clinical practice has transformed anesthesiology, representing one of the most significant developments in its history [1]. Muscle relaxants are essential for facilitating endotracheal intubation and providing surgical relaxation. The ideal muscle relaxant should exhibit rapid onset, profound muscular relaxation, brief duration of action, minimal hemodynamic fluctuations, and no residual paralysis, allowing patients to regain respiratory function promptly. By reducing the required dose of inhaled anesthetics, neuromuscular blocking drugs have substantially improved safety and created more effective operating conditions during anesthesia [2].

Rapid and safe endotracheal intubation is fundamental to anesthesia administration during surgical procedures, dependent on both the type and degree of muscular relaxation and the depth of anesthesia. D-tubocurarine was first employed as a muscle relaxant during surgery in 1942. Subsequently, numerous non-depolarizing neuromuscular blocking agents were developed for therapeutic settings. However, these drugs presented several adverse effects, including cardiovascular instability, recurrence potential, and residual paralysis [3].

Historically, succinylcholine has been the only muscle relaxant suitable for rapid tracheal intubation [4]. However, its use is associated with numerous side effects, including asystole, hyperkalemia, bradycardia, elevated intraocular pressure, and malignant hyperthermia. Consequently, there remains a need for an ideal muscle relaxant characterized by rapid onset of action, minimal adverse effects, and the ability to create optimal intubating conditions [5].

Rocuronium bromide, a novel amino-steroidal neuromuscular blocking drug with structural similarities to vecuronium, was introduced in 1994 and has emerged as a competitor to succinylcholine. Similar to suxamethonium chloride, rocuronium bromide features an intermediate duration, rapid onset of action, quick recovery, and good to excellent intubating conditions with minimal to no hemodynamic alterations. The introduction of sugammadex has further facilitated rapid recovery from rocuronium bromide-induced neuromuscular blockade [6].

The neuromuscular junction, where the conversion of electrical impulses traveling down nerves into action potentials and muscle contractions occurs via chemical transmitters, plays a critical role in the mechanism of action of neuromuscular blocking agents [7]. When an action potential reaches the presynaptic nerve terminal, it triggers the opening of sodium channels, allowing sodium ions to enter and change the voltage. This voltage change activates calcium channels, permitting calcium ions to enter. The increased calcium levels activate protein kinases, which phosphorylate synapsins, causing vesicles to detach from the cytoskeleton and move to active zones where they release acetylcholine (ACh) molecules—approximately 100-400 quanta per impulse [7].

Non-depolarizing muscle relaxants like rocuronium do not alter the cholinergic receptor's structural conformation; instead, they prevent depolarization by reversibly interacting with one or both α-subunits, blocking acetylcholine's access to the receptor and preventing the ion channel from opening. This interaction reduces the threshold required to initiate an action potential. The competition between acetylcholine and blocking drugs for receptor binding creates a dynamic state, with the relative quantities of each and their respective affinities for the postsynaptic nicotinic receptor determining whether neuromuscular transmission occurs [8].

Rocuronium bromide acts as a non-depolarizing neuromuscular blocking drug with a rapid onset and intermediate duration of action, depending on the dose. It competes with acetylcholine for cholinergic receptors at the motor end plate, causing neuromuscular blockade. Compared to vecuronium, it has 7-8 times less potency, allowing more drug molecules to bind to junctional receptors in a shorter time during circulation, resulting in faster neuromuscular blockade [9].

The pharmacokinetics of rocuronium include 30% binding to plasma proteins and less lipophilicity compared to vecuronium, as evidenced by its smaller volume of distribution [10]. Rocuronium loses its efficacy primarily through liver absorption via an active transport system mediated by a carrier, followed by biliary excretion (>70%), either in a degraded or undegraded state. The two main potential metabolites, 17-desacetyl rocuronium and 16N-desallyl rocuronium, have no pharmacological activity. Liver dysfunction may lead to an extended duration of action, particularly with repeated doses or prolonged intravenous administration, due to an increased volume of distribution. The kidneys eliminate less than 20% of the delivered dose [11].

Several studies have investigated the efficacy and safety of rocuronium at different doses. Cooper et al. [12] found clinically acceptable intubating conditions in 95% of patients at 60 seconds and in 100% at 90 seconds using rocuronium at 0.6 mg/kg. Magorian et al. [13] observed that the onset time for patients receiving rocuronium at 0.9 mg/kg and 1.2 mg/kg was comparable to that of succinylcholine, while the onset time was significantly longer with rocuronium at 0.6 mg/kg and vecuronium. However, intubating conditions did not differ significantly across groups.

The ED95 (effective dose in 95% of patients) for rocuronium is 0.3 mg/kg, with the usual dose for intubation at 60 seconds being 0.6 mg/kg. It has an onset time of 88.9 seconds and a lag time of 25.8 seconds. Intubating conditions can be improved by using higher doses of 0.9 mg/kg or 1.2 mg/kg. The clinical duration of action for 1×ED95, 2×ED95, and 3×ED95 doses is 15, 37, and 53 minutes, respectively [14].

At doses of 2-3×ED95, rocuronium has negligible cardiovascular effects, as it does not alter arterial blood pressure or heart rate. Doses higher than 5×ED95 typically result in increased heart rate. The autonomic safety ratio for vagal block is about 10 times lower compared to vecuronium [15]. Rapid intravenous bolus injection of rocuronium up to 4×ED95 does not lead to increased plasma histamine levels, and the drug is considered safe for use in rapid-sequence induction of anesthesia for perforating eye injuries [15, 16].

Train-of-four (TOF) monitoring is widely employed to assess neuromuscular blockade. Four supramaximal stimuli at 2 Hz frequency are delivered every 0.5 seconds, with each set repeated every 10-12 seconds if used continuously. Under normal neuromuscular transmission, the muscle contracts in response to each stimulus. With a partial non-depolarizing block, the response amplitude gradually decreases from the first to the fourth response, allowing calculation of the TOF

ratio (fourth response amplitude divided by first response amplitude). This ratio inversely correlates with the degree of neuromuscular blockade [17].

The current study aims to evaluate the intubating conditions and hemodynamic changes after administration of three different doses of rocuronium bromide (0.6 mg/kg, 0.9 mg/kg, and 1.2 mg/kg) at 60 seconds in adults undergoing abdominal surgery. The hypothesis is that rocuronium at 1.2 mg/kg provides more favorable intubating conditions compared to lower doses during endotracheal intubation. This comparison is crucial as it may help identify the optimal dose that balances excellent intubating conditions with acceptable hemodynamic stability and appropriate duration of action, particularly in cases where succinylcholine is contraindicated.

AIMS AND OBJECTIVES

The primary aim of this study was to observe and assess the intubating conditions and hemodynamic changes after administration of three different doses (0.6 mg/kg, 0.9 mg/kg, and 1.2 mg/kg) of rocuronium bromide at 60 seconds in adults undergoing abdominal surgery.

The specific objectives were:

1. To determine the intubating conditions of three different doses of rocuronium bromide (0.6 mg/kg, 0.9 mg/kg, and 1.2 mg/kg) at 60 seconds in adults undergoing abdominal surgeries.
2. To determine the hemodynamic changes of three different doses of rocuronium bromide (0.6 mg/kg, 0.9 mg/kg, and 1.2 mg/kg) at 60 seconds in adults undergoing abdominal surgeries.

MATERIALS AND METHODS

Study Design and Setting

This was a hospital-based observational study conducted in the Department of Anesthesiology, Assam Medical College and Hospital, Dibrugarh, India, over a period of one year (March 2023 to February 2024). Ethical clearance was obtained from the Institutional Ethics Committee (Human) of Assam Medical College and Hospital before commencing the research.

Study Population

The study population comprised adult patients undergoing elective abdominal surgeries under general anesthesia at Assam Medical College and Hospital. A total of 60 patients were enrolled in the study based on the inclusion and exclusion criteria.

Sample Size Calculation

Considering the proportion of excellent intubating conditions in patients receiving 0.6 mg/kg, 0.9 mg/kg, and 1.2 mg/kg to be 50%, 75%, and 90% respectively, as reported in previous studies, the sample size was calculated to be 20 in each group with 95% confidence and 80% power.

Inclusion Criteria

- Individuals aged 25 to 45 years (regardless of sex)
- Patients classified as Mallampati Grade (MPG) I or II
- Patients with American Society of Anesthesiologists (ASA) physical status I or II
- Patients scheduled for elective abdominal surgery under general anesthesia
- Patients who provided written informed consent for participation in the study

Exclusion Criteria

- Known or anticipated difficult airway
- Patients with neuromuscular diseases
- History of malignant hyperthermia
- Renal or hepatic diseases
- Known allergy to drugs

Grouping

Patients were randomly divided into three groups with 20 patients in each group:

- Group A: Received rocuronium bromide 0.6 mg/kg
- Group B: Received rocuronium bromide 0.9 mg/kg
- Group C: Received rocuronium bromide 1.2 mg/kg

Pre-Anesthetic Assessment

Each patient was visited a day before their planned surgery. A thorough clinical assessment was performed, which included evaluating the patient's general health, nutritional status, and body weight. Additionally, a detailed examination

of the respiratory, cardiovascular, and central nervous systems was conducted, along with ASA grading, an assessment of the airway, and a review of any associated diseases and allergy history.

All patients were explained about the anesthesia technique, and written informed consent was obtained. Patients were kept nil per oral for 8 hours prior to surgery.

The following laboratory investigations were performed for all patients:

- Complete blood count
- Random blood sugar
- Renal function test
- Liver function test
- Chest X-ray
- Standard 12-lead ECG
- Serum electrolytes (as required)

Anesthesia Protocol

The anesthesia machine and circuits were checked for proper functioning, and all emergency and resuscitation drugs and equipment were kept ready. On the day of surgery, after confirmation of NPO status, patients were shifted to the operating room, and an intravenous line was secured using an 18G cannula in a vein on the dorsum of the hand. Maintenance intravenous fluids were started.

The following monitors were connected to the patients:

1. Electrocardiogram monitor
2. Noninvasive blood pressure monitor
3. Pulse oximeter
4. Neuromuscular monitor

Baseline vital signs such as heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure were recorded.

Premedication

All patients received intravenous premedication comprising:

- Injection glycopyrrolate (4 μg/kg)
- Injection ondansetron (0.1 mg/kg)
- Injection fentanyl (2 μg/kg)

Neuromuscular Monitoring Setup

For ulnar nerve stimulation, electrodes were applied at the volar side of the wrist. The ulnar nerve motor point was located 1.5-2.5 cm proximal to the pisiform bone on the thumb side of the flexor carpi ulnaris tendon. The distal electrode was placed about 1 cm proximal to the point at which the proximal flexion crease of the wrist crosses the radial side of the tendon to the flexor carpi ulnaris muscle. The proximal electrode was placed 2-5 cm proximal to the distal electrode.

Induction and Intubation

Patients were preoxygenated for 3 minutes and then induced with injection propofol (1.5 mg/kg). Following loss of consciousness, the ulnar nerve was stimulated at the wrist using a MIPM TOF monitor. The current strength was progressively increased, and single twitch elicited. When maximal thumb adduction was obtained, the current strength was noted, and one and a half times this strength was used for elicitation of Train of Four stimulus.

A bolus intravenous dose of rocuronium bromide (0.6, 0.9, or 1.2 mg/kg) was administered over a duration of 5 seconds, depending on the assigned group. Patients were ventilated with 100% oxygen. TOF was elicited at 2 Hz (one stimulus every 0.5 seconds), and the trachea was intubated 60 seconds after rocuronium administration with an appropriately sized endotracheal tube after laryngoscopy.

Intubation was performed by a single experienced anesthesiologist in all cases. The endotracheal tube was secured after confirming bilateral air entry. The conditions of intubation were evaluated and scored according to the scoring system described by Cooper et al. as follows:

Intubating Conditions Scoring System (Cooper et al.):

- Jaw Relaxation: Poor/impossible (0), Minimal/difficult (1), Moderate/fair (2), Good/easy (3)
- Vocal Cord Position: Closed (0), Closing (1), Moving (2), Open (3)

- Response to Intubation: Severe coughing/bucking (0), Mild coughing (1), Slight diaphragmatic movement (2), None (3)

Overall Intubating Conditions:

- Poor: 0-2 points
- Fair: 3-5 points
- Good: 6-7 points
- Excellent: 8-9 points

Clinically acceptable intubating conditions were defined as those scored as "good" or "excellent" (score ≥ 6).
The time from the end of injection of the relaxant to the time when all four responses of TOF were abolished was noted for all three groups.

Maintenance and Monitoring

After intubation and observation of the intubating conditions and hemodynamic profiles, anesthesia was maintained with 33.3% oxygen and 66.7% nitrous oxide, along with titrated doses of sevoflurane.

Heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial blood pressure were recorded at 1 minute, 3 minutes, and 5 minutes after intubation. Neuromuscular function was monitored using TOF stimuli every 5 minutes.

Reversal and Extubation

At the end of surgery, patients were reversed with injection glycopyrrolate (0.01 mg/kg) and injection neostigmine (0.05 mg/kg) after recovery of spontaneous respiration. Thorough oropharyngeal suctioning was done, and patients were extubated when fully awake and after recovery of adequate muscle tone, cough reflex, and sustained head lift for 5 seconds. Patients were then shifted to the post-anesthesia care unit (PACU).

Statistical Analysis

The statistical analysis was performed using the Statistical Package for Social Sciences (SPSS for Windows, version 20.0, Chicago, SPSS Inc.) and Microsoft Excel 2010. Results on continuous measurements are presented as mean ± standard deviation and were compared using Student's t-test or ANOVA test as appropriate. Discrete data are expressed as number (%) and were analyzed using Chi-square test or Fisher's exact test (where the cell counts were <5). For all analyses, a statistical significance level was set at 5% (p-value < 0.05). Post-hoc analysis was performed for significant ANOVA results to identify specific between-group differences.

RESULTS

Demographic Characteristics

A total of 60 patients were included in the study, with 20 patients in each of the three groups. The demographic characteristics of patients in all three groups are presented in Table 1. There were no statistically significant differences among the groups regarding age, weight, ASA status, and Mallampati grading (p > 0.05).

Table 1: Demographic Characteristics

Variable	Group A (0.6 mg/kg)	Group B (0.9 mg/kg)	Group C (1.2 mg/kg)	p-value
Age (years, mean ± SD)	36.15 ± 6.78	37.00 ± 6.31	35.40 ± 6.40	0.740
Weight (kg, mean ± SD)	55.30 ± 8.21	54.55 ± 7.86	55.00 ± 7.49	0.955
ASA Status I (n, %)	9 (45.00)	10 (50.00)	11 (55.00)	0.819
ASA Status II (n, %)	11 (55.00)	10 (50.00)	9 (45.00)	0.819
Mallampati Grade I (n, %)	10 (50.00)	12 (60.00)	9 (45.00)	0.627
Mallampati Grade II (n, %)	10 (50.00)	8 (40.00)	11 (55.00)	0.627

Intubating Conditions

Table 2: Assessment of Jaw Relaxation, Vocal Cord Position, and Response to Intubation

Parameter	Score	Group A (n=20)	Group B (n=20)	Group C (n=20)	p-value
Jaw Relaxation					
Poor (Impossible)	0	2 (10.00)	0 (0.00)	0 (0.00)	0.126
Minimal (Difficult)	1	17 (85.00)	6 (30.00)	0 (0.00)	<0.001
Moderate (Fair)	2	1 (5.00)	12 (60.00)	5 (25.00)	<0.001

Parameter	Score	Group A (n=20)	Group B (n=20)	Group C (n=20)	p-value
Good (Easy)	3	0 (0.00)	2 (10.00)	15 (75.00)	<0.001
Mean score ± SD		0.95 ± 0.39	1.80 ± 0.62	2.75 ± 0.44	<0.001
Vocal Cord Position					
Closed	0	0 (0.00)	0 (0.00)	0 (0.00)	--
Closing	1	16 (80.00)	4 (20.00)	0 (0.00)	<0.001
Moving	2	4 (20.00)	14 (70.00)	4 (20.00)	<0.001
Open	3	0 (0.00)	2 (10.00)	16 (80.00)	<0.001
Mean score ± SD		1.20 ± 0.41	1.90 ± 0.55	2.80 ± 0.41	<0.001
Response to Intubation					
Severe bucking/coughing	0	2 (10.00)	1 (5.00)	0 (0.00)	0.212
Mild coughing	1	14 (70.00)	9 (45.00)	0 (0.00)	<0.001
Slight diaphragmatic movement	2	4 (20.00)	9 (45.00)	4 (20.00)	0.128
None	3	0 (0.00)	1 (5.00)	16 (80.00)	<0.001
Mean score ± SD		1.10 ± 0.55	1.50 ± 0.69	2.80 ± 0.41	<0.001

Values are presented as n (%) or mean ± SD.

Table 3: Overall Intubating Conditions According to Cooper's Criteria

Intubating Condition	Score	Group A (n=20)	Group B (n=20)	Group C (n=20)	p-value
Excellent	8-9	0 (0.00)	2 (10.00)	15 (75.00)	<0.001
Good	6-7	0 (0.00)	7 (35.00)	5 (25.00)	0.017
Poor	3-5	18 (90.00)	10 (50.00)	0 (0.00)	<0.001
Bad	0-2	2 (10.00)	1 (5.00)	0 (0.00)	0.349
Mean score ± SD		3.25 ± 1.07	5.20 ± 1.67	8.35 ± 1.18	<0.001
Clinical Acceptability					
Clinically Acceptable	6-9	0 (0.00)	9 (45.00)	20 (100.00)	<0.001
Clinically Unacceptable	0-5	20 (100.00)	11 (55.00)	0 (0.00)	<0.001

Values are presented as n (%) or mean ± SD.

Table 2 presents the assessment of jaw relaxation, vocal cord position, and response to intubation across the three groups. For jaw relaxation, Group C demonstrated significantly better scores with 75% of patients showing good relaxation compared to 10% in Group B and 0% in Group A ($p < 0.001$). The mean jaw relaxation score was highest in Group C (2.75 ± 0.44), followed by Group B (1.80 ± 0.62) and Group A (0.95 ± 0.39), with the differences being statistically significant ($p < 0.001$).

Similarly, for vocal cord position, Group C showed the best outcomes with 80% of patients having open vocal cords, compared to 10% in Group B and 0% in Group A ($p < 0.001$). The mean vocal cord position score was highest in Group C (2.80 ± 0.41), followed by Group B (1.90 ± 0.55) and Group A (1.20 ± 0.41), with the differences being statistically significant ($p < 0.001$).

Regarding response to intubation, Group C again demonstrated superior results with 80% of patients showing no response, compared to 5% in Group B and 0% in Group A ($p < 0.001$). The mean response to intubation score was highest in Group C (2.80 ± 0.41), followed by Group B (1.50 ± 0.69) and Group A (1.10 ± 0.55), with the differences being statistically significant ($p < 0.001$).

Table 3 summarizes the overall intubating conditions according to Cooper's criteria. Excellent intubating conditions were observed in 75% of patients in Group C, 10% in Group B, and 0% in Group A ($p < 0.001$). Good intubating conditions were found in 25% of patients in Group C, 35% in Group B, and 0% in Group A ($p = 0.017$). The mean intubating condition score was highest in Group C (8.35 ± 1.18), followed by Group B (5.20 ± 1.67) and Group A (3.25 ± 1.07), with the differences being statistically significant ($p < 0.001$).

When categorized as clinically acceptable (scores 6-9) or unacceptable (scores 0-5), 100% of patients in Group C had clinically acceptable intubating conditions, compared to 45% in Group B and 0% in Group A ($p < 0.001$).

Hemodynamic Parameters

Table 4: Changes in Heart Rate and Blood Pressure

Parameter	Group A (0.6 mg/kg)	Group B (0.9 mg/kg)	Group C (1.2 mg/kg)	p-value
Heart Rate (beats/min)				
Before induction	84.70 ± 6.84	82.40 ± 5.57	82.40 ± 8.38	0.494
After induction	94.00 ± 6.87	91.60 ± 10.35	90.60 ± 8.16	0.442
1 minute after intubation	129.80 ± 3.94	122.80 ± 4.92	118.80 ± 3.27	<0.001
3 minutes after intubation	124.80 ± 3.33	118.40 ± 4.92	116.00 ± 2.51	<0.001
5 minutes after intubation	120.40 ± 3.22	111.90 ± 6.07	111.40 ± 3.68	<0.001
Systolic BP (mmHg)				
Before induction	120.50 ± 9.24	118.20 ± 6.32	121.20 ± 8.86	0.489
After induction	116.90 ± 8.86	115.10 ± 5.71	117.70 ± 8.24	0.555
1 minute after intubation	159.80 ± 6.22	149.10 ± 9.30	143.40 ± 4.73	<0.001
3 minutes after intubation	150.40 ± 7.75	144.60 ± 8.41	140.10 ± 5.49	<0.001
5 minutes after intubation	138.20 ± 8.92	137.80 ± 7.67	134.50 ± 4.98	0.228
Diastolic BP (mmHg)				
Before induction	77.50 ± 4.54	78.70 ± 4.51	78.00 ± 4.54	0.703
After induction	75.60 ± 4.38	76.80 ± 4.32	75.90 ± 4.56	0.673
1 minute after intubation	111.80 ± 5.23	107.80 ± 6.05	103.70 ± 4.78	<0.001
3 minutes after intubation	108.20 ± 5.98	104.20 ± 5.58	101.30 ± 4.60	<0.001
5 minutes after intubation	104.00 ± 7.40	99.50 ± 4.30	97.40 ± 3.73	<0.001
Mean Arterial Pressure (mmHg)				
Before induction	91.83 ± 5.23	91.73 ± 4.05	92.12 ± 5.27	0.966
After induction	91.40 ± 6.88	89.57 ± 4.00	89.52 ± 5.34	0.447
1 minute after intubation	124.00 ± 3.49	120.03 ± 5.51	116.93 ± 3.34	<0.001
3 minutes after intubation	119.40 ± 3.19	116.47 ± 5.14	114.23 ± 3.02	<0.001
5 minutes after intubation	114.70 ± 2.77	111.77 ± 4.01	109.77 ± 2.43	<0.001

Values are presented as mean ± SD.

Table 5: Train-of-Four (TOF) Monitoring

Parameter	Group A (0.6 mg/kg)	Group B (0.9 mg/kg)	Group C (1.2 mg/kg)	p-value
TOF Count at Intubation				
4	0 (0.00)	0 (0.00)	0 (0.00)	--
3	7 (35.00)	0 (0.00)	0 (0.00)	<0.001
2	13 (65.00)	4 (20.00)	0 (0.00)	<0.001
1	0 (0.00)	16 (80.00)	3 (15.00)	<0.001
0	0 (0.00)	0 (0.00)	17 (85.00)	<0.001
Mean TOF count ± SD	2.35 ± 0.49	1.20 ± 0.41	0.15 ± 0.37	<0.001
Mean time to loss of TOF (seconds)	123.60 ± 3.27	93.35 ± 5.02	61.50 ± 3.85	<0.001

Values are presented as n (%) or mean ± SD.

Table 4 presents the hemodynamic changes observed in the three groups before induction, after induction, and at various time points after intubation. The baseline heart rate was comparable across the three groups ($p = 0.494$). One minute after intubation, heart rate increased significantly in all groups, with Group A showing the highest increase (129.80 ± 3.94 beats/min), followed by Group B (122.80 ± 4.92 beats/min) and Group C (118.80 ± 3.27 beats/min). The differences

were statistically significant ($p < 0.001$). The heart rate gradually decreased at 3 and 5 minutes after intubation in all groups, but the differences between groups remained statistically significant ($p < 0.001$).

The baseline systolic blood pressure was also comparable across the three groups ($p = 0.489$). After induction, there was a slight decrease in systolic blood pressure in all groups. One minute after intubation, systolic blood pressure increased significantly, with Group A showing the highest increase (159.80 ± 6.22 mmHg), followed by Group B (149.10 ± 9.30 mmHg) and Group C (143.40 ± 4.73 mmHg). The differences were statistically significant ($p < 0.001$). At 3 minutes after intubation, systolic blood pressure remained elevated but started to decrease, with significant differences between groups ($p < 0.001$). By 5 minutes after intubation, the differences between groups were no longer statistically significant ($p = 0.228$).

Diastolic blood pressure followed a similar pattern, with baseline values being comparable across groups ($p = 0.703$). One minute after intubation, diastolic blood pressure increased significantly, with Group A showing the highest increase (111.80 ± 5.23 mmHg), followed by Group B (107.80 ± 6.05 mmHg) and Group C (103.70 ± 4.78 mmHg). The differences were statistically significant ($p < 0.001$). Diastolic blood pressure remained significantly different between groups at 3 and 5 minutes after intubation ($p < 0.001$).

Mean arterial pressure (MAP) also showed a similar trend, with baseline values being comparable across groups ($p = 0.966$). One minute after intubation, MAP increased significantly, with Group A showing the highest increase (124.00 ± 3.49 mmHg), followed by Group B (120.03 ± 5.51 mmHg) and Group C (116.93 ± 3.34 mmHg). The differences were statistically significant ($p < 0.001$). MAP remained significantly different between groups at 3 and 5 minutes after intubation ($p < 0.001$).

Table 5 presents the results of Train-of-Four (TOF) monitoring. At the time of intubation (60 seconds after rocuronium administration), the TOF count varied significantly between groups. In Group A, 35% of patients had a TOF count of 3, and 65% had a count of 2. In Group B, 20% of patients had a TOF count of 2, and 80% had a count of 1. In Group C, 15% of patients had a TOF count of 1, and 85% had a count of 0. The mean TOF count was highest in Group A (2.35 ± 0.49), followed by Group B (1.20 ± 0.41) and Group C (0.15 ± 0.37), with the differences being statistically significant ($p < 0.001$).

The mean time to loss of TOF (complete neuromuscular blockade) was significantly different between groups, with Group C showing the shortest time (61.50 ± 3.85 seconds), followed by Group B (93.35 ± 5.02 seconds) and Group A (123.60 ± 3.27 seconds) ($p < 0.001$).

DISCUSSION

This study evaluated the intubating conditions and hemodynamic changes following administration of three different doses of rocuronium bromide (0.6 mg/kg, 0.9 mg/kg, and 1.2 mg/kg) at 60 seconds in adults undergoing abdominal surgery under general anesthesia. The findings clearly demonstrate a dose-dependent improvement in intubating conditions with increasing doses of rocuronium.

Demographic Data

In our study, the demographic characteristics, including age, weight, ASA physical status, and Mallampati grading, were comparable across all three groups, which minimizes the potential confounding factors that might influence the study outcomes. This finding is consistent with the study by Jamshid Ali et al. [18], who also reported comparable demographic data in their investigation of intubating conditions with rocuronium.

Intubating Conditions

The assessment of intubating conditions using Cooper's criteria revealed significant differences among the three doses of rocuronium. None of the patients in Group A (0.6 mg/kg) achieved clinically acceptable intubating conditions at 60 seconds, whereas 45% of patients in Group B (0.9 mg/kg) and 100% of patients in Group C (1.2 mg/kg) had clinically acceptable conditions. These findings suggest that higher doses of rocuronium are required for optimal intubating conditions at 60 seconds.

Our results for Group A (0.6 mg/kg) differ from those reported by Cooper et al. [12], who found clinically acceptable intubating conditions in 95% of patients at 60 seconds with rocuronium at 0.6 mg/kg. This discrepancy might be attributed to differences in the timing of intubation, as Cooper et al. may have waited for optimal conditions before attempting intubation, whereas in our study, intubation was strictly performed at 60 seconds regardless of the conditions. For Group B (0.9 mg/kg), our finding that 45% of patients achieved clinically acceptable intubating conditions is lower than the rates reported by some previous studies. Somboonviboon et al. [19] reported acceptable conditions in 77.8% of patients with rocuronium at 0.9 mg/kg. Similarly, Sudha et al. [20] observed excellent intubating conditions in 88.1% of

patients and good conditions in 11.9% with rocuronium at 0.9 mg/kg. The variation in results could be due to differences in the anesthetic technique, premedication, and the subjective nature of assessing intubating conditions.

Our findings for Group C (1.2 mg/kg) are consistent with those of Raizada et al. [21], who reported excellent intubating conditions in 90% of patients with rocuronium at 1.2 mg/kg at 60 seconds. Similarly, Raghavan et al. [22] found that all patients receiving rocuronium at 1.2 mg/kg achieved ideal intubating conditions, comparable to our finding of 100% clinically acceptable conditions.

When analyzing the individual components of intubating conditions, we observed a dose-dependent improvement in jaw relaxation, vocal cord position, and response to intubation. The mean scores for all three parameters were significantly higher in Group C compared to Groups A and B ($p < 0.001$), indicating superior conditions with the highest dose. This observation is in line with the findings of Sardhara et al. [23], who also reported better intubating conditions with higher doses of rocuronium.

Hemodynamic Changes

In our study, all three doses of rocuronium were associated with increases in heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure following intubation. However, the magnitude of these changes was greatest in Group A and least in Group C. This observation differs from what might be expected, as higher doses of rocuronium typically lead to greater hemodynamic changes due to more profound neuromuscular blockade and potentially deeper anesthesia requirements.

Levy et al. [15] reported that there were no significant differences in hemodynamic parameters with rocuronium doses of 0.6, 0.9, and 1.2 mg/kg, which partially contradicts our findings. Similarly, Raghavan et al. [22] found no statistically significant differences in mean heart rate and mean arterial pressure during intubation with increasing doses of rocuronium bromide.

The hemodynamic changes observed in our study, especially the more pronounced changes in Group A, might be due to the less optimal intubating conditions in this group, which could have led to more intense laryngoscopic stimulation and consequent sympathetic response. This hypothesis is supported by the fact that the patients in Group C, who had the best intubating conditions, showed the least hemodynamic changes.

Neuromuscular Monitoring

The TOF monitoring in our study provided valuable insights into the neuromuscular effects of different doses of rocuronium. The mean TOF count at intubation (60 seconds) decreased with increasing doses of rocuronium, from 2.35 ± 0.49 in Group A to 0.15 ± 0.37 in Group C ($p < 0.001$). This finding is expected, as higher doses of rocuronium lead to more profound neuromuscular blockade.

The mean time to loss of TOF (complete neuromuscular blockade) also decreased with increasing doses, from 123.60 ± 3.27 seconds in Group A to 61.50 ± 3.85 seconds in Group C ($p < 0.001$). This observation is consistent with the findings of Chavan et al. [24], who also reported a dose-dependent decrease in the time to complete neuromuscular blockade with rocuronium.

The correlation between TOF counts and intubating conditions provides further support for the dose-dependent effect of rocuronium. Group C, which had the lowest TOF counts at intubation, demonstrated the best intubating conditions, while Group A, with the highest TOF counts, had the poorest conditions. This relationship was also observed by Raizada et al. [21], who reported a significant correlation between TOF counts and intubating conditions.

Clinical Implications

Our findings have several clinical implications. First, they suggest that rocuronium at 1.2 mg/kg provides optimal intubating conditions at 60 seconds, making it a viable alternative to succinylcholine for rapid sequence induction in cases where succinylcholine is contraindicated. Second, the minimal hemodynamic changes observed with rocuronium at 1.2 mg/kg, despite the rapid and profound neuromuscular blockade, support its use in patients with cardiovascular concerns.

However, it is important to note that the use of high-dose rocuronium (1.2 mg/kg) is associated with a prolonged duration of action, as evidenced by the faster time to loss of TOF in Group C. This prolonged duration may not be desirable in short surgical procedures or in patients who are at risk of difficult mask ventilation or intubation. In such cases, the availability of sugammadex for rapid reversal of rocuronium-induced neuromuscular blockade provides an important safety measure.

Limitations

Our study has several limitations. First, the sample size was relatively small, with only 20 patients in each group. A larger sample size would provide more robust results. Second, the study was conducted in a single center, which limits the generalizability of the findings. Third, the assessment of intubating conditions, although based on established criteria, has an inherent element of subjectivity. Fourth, the hemodynamic monitoring was limited to the first 5 minutes after intubation, and longer-term effects were not evaluated. Finally, we did not assess the duration of neuromuscular blockade or the ease of reversal, which are important considerations in the clinical use of rocuronium.

CONCLUSION

Based on the findings of our study, we conclude that rocuronium bromide at a dose of 1.2 mg/kg provides excellent intubating conditions at 60 seconds in adults undergoing abdominal surgery under general anesthesia. This dose is superior to lower doses (0.6 mg/kg and 0.9 mg/kg) in terms of jaw relaxation, vocal cord position, and response to intubation. The intubating conditions improve with increasing doses of rocuronium, but the duration of neuromuscular blockade also prolongs, as evidenced by the faster time to loss of TOF with higher doses.

The hemodynamic changes following intubation were less pronounced with higher doses of rocuronium, possibly due to the better intubating conditions and consequent reduced laryngoscopic stimulation. All three doses of rocuronium demonstrated acceptable hemodynamic stability, making it a suitable agent for a wide range of patients.

The correlation between TOF counts and intubating conditions supports the use of neuromuscular monitoring to guide the timing of intubation, especially when using lower doses of rocuronium.

In conclusion, rocuronium bromide at 1.2 mg/kg is recommended for situations requiring excellent intubating conditions at 60 seconds, particularly when succinylcholine is contraindicated. However, the choice of dose should be individualized based on the clinical context, including the urgency of intubation, the expected duration of surgery, and the patient's comorbidities.

REFERENCES

1. LeVasseur R, Desai SP. Ebenezer Hopkins Frost (1824-1866): William T.G. Morton's first identified patient and why he was invited to the Ether demonstration of October 16, 1846. Anesthesiology. 2012;117:238-42.
2. Heier T. Muscle relaxants. Tidsskr Nor Laegeforen. 2010;130:398-401.
3. Blobner M, Mirakhur RK, Wierda JM, Wright PM, Olkkola KT, Debaene B, et al. Rapacuronium 2.0 or 2.5 mg kg-1 for rapid-sequence induction: comparison with succinylcholine 1.0 mg kg-1. Br J Anaesth. 2000;85:724-31.
4. Perry J, Lee J, Wells G. Rocuronium versus succinylcholine for rapid sequence induction intubation. Cochrane Database Syst Rev. 2003;(1)
5. McCourt KC, Salmela L, Mirakhur RK, Carroll M, Makinen MT, Kansanaho M, et al. Comparison of rocuronium and suxamethonium for use during rapid sequence induction of anaesthesia. Anaesthesia. 1998;53:867-71.
6. Sparr HJ, Beaufort TM, Fuchs-Buder T. Newer neuromuscular blocking agents: how do they compare with established agents? Drugs. 2001;61:919-42.
7. Omar A, Marwaha K, Bollu PC. Physiology, neuromuscular junction. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021.
8. Wood SJ, Slater CR. Safety factor at the neuromuscular junction. Prog Neurobiol. 2001;64:393-429.
9. Naguib M, Brull SJ. Update on neuromuscular pharmacology. Curr Opin Anaesthesiol. 2009;22:483-90.
10. Atherton DP, Hunter JM. Clinical pharmacokinetics of the newer neuromuscular blocking drugs. Clin Pharmacokinet. 1999;36:169-89.
11. Proost JH, Eriksson LI, Mirakhur RK, Roest G, Wierda JM. Urinary, biliary and faecal excretion of rocuronium in humans. Br J Anaesth. 2000;85:717-23.
12. Cooper R, Mirakhur RK, Clarke RSJ, Bombs Z. Comparison of intubating conditions after administration of ORG 9426 (rocuronium) and suxamethonium. Br J Anaesth. 1992;69:269-73.
13. Magorian T, Flannery KB, Miller RD. Comparison of rocuronium, succinylcholine, and vecuronium for rapid-sequence induction of anesthesia in adult patients. Anesthesiology. 1993;79:913-8.
14. Heggeri VM, Harbishettar AS, Deka A, Rajkhowa T. Intubating conditions of two different doses of rocuronium at 60 seconds; by clinical assessment; and with T.O.F response of adductor pollicis muscle. J Clin Diagn Res. 2015;9
15. Levy JH, Davis GK, Duggan J, Szlam F. Determination of the hemodynamics and histamine release of rocuronium (Org 9426) when administered in increased doses under N2O/O2-sufentanil anesthesia. Anesth Analg. 1994;78:318-21.
16. Miller RD, Eriksson LI, Fleisher LA, Wiener-Kronish JP, Cohen NH, Young WL. Miller's Anesthesia. 8th ed. Philadelphia: Elsevier Saunders; 2015.

17. Boon M, Martini C, Dahan A. Recent advances in neuromuscular block during anesthesia. F1000Res. 2018;7:167.
18. Ali J, Gurcoo SA, Shora A, Qazi S. Intubating conditions of rocuronium bromide and succinylcholine during rapid sequence induction of anaesthesia in unpremedicated adult patients. J Anaesth Clin Pharmacol. 2008;24:337-42.
19. Somboonviboon W, Bunburaphong P. Randomized controlled study of evaluation intubating conditions of rocuronium in 108 Thai patients. J Med Assoc Thai. 2000;83:850-5.
20. Sudha P, Manju B. Comparison of the effect of two different doses of rocuronium on intubating condition. Int Surg J. 2016;3:582-5.
21. Raizada N, Gaurav, Yadav MK, Singh RB, Prabhakar T. Comparison of different doses of rocuronium for endotracheal intubation. Int J Contemp Med Res. 2018;5
22. Raghavan L, Venkatesan G, Padmanabhan KR. A prospective randomised clinical trial of three different doses of rocuronium for intubation in adults. J Evolution Med Dent Sci. 2016;5:6560-4.
23. Sardhara NV, Shah SA, Pipaliya DP, Gupta S. Comparative study of different doses of rocuronium bromide for endotracheal intubation. Ann Anesth Pain Med. 2020;3:1011.
24. Chavan SG, Gangadharan S, Gopakumar AK. Comparison of rocuronium at two different doses and succinylcholine for endotracheal intubation in adult patients for elective surgeries. Saudi J Anaesth. 2016;10:379-83.