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Comparative study of intubating condition between rocuronium and vecuronium for endotracheal intubation in general anesthesia

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ABSTRACT

Background: Muscle relaxation in anesthesia serves two main purposes: Facilitating endotracheal intubation and achieving surgical relaxation. The period from the suppression of protective reflexes during induction to the completion of intubation is critical, with an increased risk of regurgitation. Ensuring a patent airway is fundamental to general anesthesia, commonly achieved through endotracheal intubation. **Aims and Objectives:** This study aims to evaluate the onset time, tracheal intubation conditions, duration of action, and maintenance of anesthesia using vecuronium and rocuronium, monitored by train-of-four (TOF). **Materials and Methods:** This double-blind, prospective, randomized study was conducted over 18 months on patients undergoing elective surgeries under general anesthesia at a tertiary hospital. Ethical committee approval and informed written consent from all participants were obtained. Patients were randomly assigned into two groups of 50 each. **Results:** Demographic parameters between both groups were statistically insignificant ($P>0.05$). The mean onset time, defined as the interval between the end of muscle relaxant administration and completion of intubation, was 99.6 ± 12.03 s in Group A (rocuronium) and 231.0 ± 13.21 s in Group B (vecuronium), a statistically significant difference ($P<0.001$). Intubation conditions were excellent in 36 (72%) and good in 13 (26%) patients in Group A compared to excellent in 28 (56%) and good in 17 (34%) patients in Group B. **Conclusion:** Rocuronium provides earlier excellent and good intubating conditions compared to vecuronium, with similar cardiovascular stability during and after intubation. Rocuronium's rapid onset of action makes it more suitable for quick tracheal intubation in surgical patients under general anesthesia.

Key words: Rocuronium; Vecuronium; Endotracheal intubation; General anesthesia; Train-of-four monitor

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INTRODUCTION

In daily practice, muscle relaxation serves two primary purposes: Aiding in endotracheal intubation and achieving surgical relaxation. The period from the suppression of protective reflexes during induction to the completion of intubation is a critical phase, characterized by a heightened risk of regurgitation. Ensuring a patent airway is a fundamental and critical aspect of general anesthesia, regardless of the technique chosen. One common method for achieving this in clinical practice is endotracheal intubation. The introduction of neuromuscular blocking agents into clinical practice has been a groundbreaking advancement, significantly transforming the field of anesthesiology.[1]

The introduction of muscle relaxants revolutionized anesthetic practice and ushered in the modern era of surgery. This advancement enabled the rapid development of cardiothoracic, neurological, and organ transplant surgeries.[2,3] An optimal neuromuscular blocking agent for intubation should exhibit a rapid onset, short duration of action; provide excellent intubation conditions; and be free from side effects.[4-6]

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Succinylcholine has traditionally been employed in rapid sequence induction techniques due to its quick onset and short duration of action. However, its usage is limited by potential side effects.[7] Non-depolarizing neuromuscular blocking agents, such as pancuronium, vecuronium, atracurium, and cis-atracurium, offer alternatives to succinylcholine but tend to have a delayed onset and a prolonged duration of action at standard doses.[8] In contrast, rocuronium provides a rapid onset of action with a moderate duration, making it suitable for rapid sequence induction.[9,10]

Rocuronium exhibits similarities to vecuronium but possesses greater lipophilicity, reduced potency, and a quicker onset of action. Studies have shown that effective tracheal intubation conditions can be achieved within 60–90 s after administering a dose of 0.6 mg/kg based on a 2_ED95 of rocuronium.[11,12] In addition, rocuronium bromide, also known as ORG-9246, represents a newer non-depolarizing muscle relaxant with rapid onset and intermediate duration of action. It boasts only one-sixth of the potency of vecuronium, which was introduced in the 1990s. While structurally and functionally similar to vecuronium, rocuronium bromide offers the added benefit of rapid onset of action and unchanged excretion in urine, thereby minimizing the risk of metabolite-related side effects. Its introduction is considered advantageous over vecuronium.[4,13] The success of endotracheal intubation relies on the level of muscle relaxation, depth of anesthesia, and the proficiency of the anesthesiologist.

Aims

In this study, we aim to evaluate the onset time, tracheal intubation conditions, duration of action, and maintenance of anesthesia using vecuronium and rocuronium, employing a train-of-four (TOF) monitor.

Objectives

1. To compare onset time between vecuronium and rocuronium
2. To compare tracheal intubation conditions between vecuronium and rocuronium
3. To compare duration of action between vecuronium and rocuronium
4. To compare of haemodynamic parameters between two groups.

MATERIALS AND METHODS

The double-blind prospective randomized study was done for 18 months on patients admitted to the tertiary hospital posted for elective surgeries requiring general anesthesia. These patients were operated for gynecological surgery, general surgery, and orthopedic surgery. The study was conducted after obtaining clearance from the Ethical Committee of the Institution. Informed written consent was taken from all the patients, who participated in the study.

Inclusion criteria

ASA physical status Class I and II, male or female patients, scheduled for elective surgery under general anesthesia, age 20–60 years, patients in whom the results for pre-operative laboratory, assays are within the normal range, and patients giving written or witnessed informed consent were included in the study.

Exclusion criteria

Patients not meeting the inclusion criteria; patients with known or suspected renal, hepatic, metabolic, or neuromuscular disorder; patients with a known history of difficult intubation or anticipated difficult intubation (Mallampati class III or IV); patients are known or suspected to have an allergy to narcotics, neuromuscular blocking agents, or other medications used during general anesthesia; patients are receiving or scheduled to receive drugs during the study period known to interfere with the action of neuromuscular blocking agents, with the exception of the anesthetic drug indicated in the underlying protocol; and pregnant or breastfeeding patients and refusal patients were excluded from the study.

Patients were randomly divided into two groups of 50 patients each.

- Group A: (Rocuronium bromide group): Patients received an injection of rocuronium 0.6 mg/kg body weight intravenously
- Group B: (Vecuronium bromide group): Patients received an injection of vecuronium 0.1 mg/kg body weight intravenously.

Data collection procedure

After obtaining the approval of the Scientific Ethics Committee and written consent, a total of 100 patients undergoing elective surgeries under general anesthesia were selected. A detailed pre-anesthetic evaluation including a history of previous medical illness, previous surgeries, general examination, and appropriate baseline investigations was carried out. An informed written consent was obtained. Investigator A prepared the drugs, who loaded an injection of rocuronium at the dose of 0.6 mg/kg and injection of vecuronium at the dose of 0.1 mg/kg body weight according to the study group labeled as drug X and drug Y, respectively.

Group A received an injection of rocuronium 0.6 mg/kg and Group B an injection of vecuronium 0.1 mg/kg.

The investigator, blinded to the study groups, performed direct laryngoscopy on all patients and assessed their intubation conditions. The onset time and clinical durations were recorded in a predefined pro forma. Patients were re-examined on the table, baseline values of pulse and blood pressure were recorded with the help of non-invasive blood pressure monitoring system and pulse oximeter. Examination of the cardiovascular and respiratory systems was done. Intravenous access was obtained with an 18 G venous cannula and infusion of crystalloids such as ringer lactate solution 10 mL/kg was commenced.

TOF of 4 pulses each of 0.2 ms duration at 2 Hz frequency was applied over 2 s to the ulnar nerve and the resultant twitches of adductor pollicis (AP) muscle were observed visually. Patients in Group A received rocuronium 0.6 mg/kg and those in Group B received vecuronium 0.1 mg/kg. Four supramaximal stimuli were given every 15 s until the loss of visual response to nerve stimuli was seen. Onset time was the time from administration of muscle relaxant to the loss of visual response to the nerve stimulus. At this point, direct laryngoscopy was performed, and patients were intubated by a senior anesthesiologist using an appropriately sized Portex endotracheal tube. The anesthesiologist was blinded to the drug used, and the intubating conditions were scored as excellent (8–9), good (6–7), fair (3–5), or poor (0–2) according to the system described by Cooper.

Hemodynamic parameters—heart rate, systolic blood pressure (SBP), and diastolic blood pressure (DBP)—were recorded initially in the pre-operative period as baseline values. Subsequent recordings were taken at the time of sedation, induction (including muscle relaxant administration), laryngoscopy, and intubation. After intubation, measurements were taken at 1-minute intervals for the first 5 minutes, then at 5-minute intervals for the next 10 minutes, and at 10-minute intervals thereafter, up to 20 minutes. The total monitoring duration in the post-intubation period was 30 minutes.

Statistical analysis

The data collected for the study was entered into a Microsoft Excel spreadsheet. Continuous variables were reported as mean±SD (standard deviation), whereas categorical variables were presented as frequencies and percentages. To compare continuous variables between the two groups, an unpaired t-test was conducted. For categorical variables, a Chi-square test was performed to compare between the two groups. A $P<0.05$ was considered statistically significant, whereas a $P<0.01$ was regarded as highly significant. Data analysis was carried out using the statistical software SPSS version 20.0.

RESULTS

Demographical data

In Table 1, all demographic parameters are compared in both groups, and they were found to be statistically insignificant ($P>0.05$), so there is an equal distribution of patients according to age, sex, height, weight, and ASA status (Table 1).

In the study group, the ages ranged from 20 to 55 years. The mean age was 42.02 years in Group A and 42.26 years in Group B. However, the difference in mean age between the two groups was not statistically significant ($P=0.911$) (Table 1).

The study comprised a total of 58 male patients and 42 female patients. Group A comprised 26 (52%) male patients and 24 (48%) female patients whereas Group B comprised 32 (64%) male patients and 18 (36%) female patients. The result of sex distribution was not statistically significant ($P=0.224$) (Table 1).

The mean weight of the patients in Group A was 59.48±9.89 and Group B was 61.60±10.69, whereas the mean height of the patients in Group A was 158.70±8.08 and Group B was 157.48±6.41, which was not statistically significant ($P=0.306$ and $P=0.405$), respectively (Table 1) while 66% of patients in Group A and 70% of patients in Group B belong to ASA physical status I and 34% of patients in Group A and 30% of patients in Group B belong to ASA physical status II (Table 1).

Comparison of mean time of onset between two groups

The mean onset time was considered the time interval (in minutes) between the end of the administration of muscle relaxant and completion of intubation

Table 1: Demographical data between two groups

Parameters	Group-A (n=50)	Group-B (n=50)	P-value
@Age (years)			Not significant
Mean	42.02	42.26	0.911
SD	10.63	10.79	
@Weight (kg)			Not significant
Mean	59.48	61.60	0.306
SD	9.89	10.69	
@Height (cm)			Not significant
Mean	158.70	157.48	0.405
SD	8.08	6.41	
#Sex (%)			Not significant
Male	26 (52.0)	32 (64.0)	0.224
Female	24 (48.0)	18 (36.0)	
#ASA Grade (%)			Not significant
I	33 (66.0)	35 (70.0)	0.668
II	17 (34.0)	15 (30.0)	

#By Chi-square test, @By student "t" test

was 99.6±12.03 s in Group A and 231.0±13.21 s in Group B which was statistically significant P<0.001 (Table 2).

Profile of intubating conditions between two groups

In the present study after administration of the muscle relaxant, intubating conditions with Group A were excellent in 36 (72%) and good in 13 (26%) patients, whereas in Group B, intubating conditions were excellent in 28 (56%) and good in 17 (34%) patients which were comparable. None of the patients in either group had impossible intubation (Table 3).

Comparison of mean hemodynamic parameters between two groups

The mean pulse rate in Group A and Group B was 80.28±8.97 and 80.56±8.65 min, respectively, with no statistically significant difference between the two groups (P=0.874).

In both Group A and Group B, the mean systolic pressure was 118.28±9.94 and 120.80±6.46 mmHg, respectively (P=0.14), whereas the diastolic pressure was 81.16±6.89 and 81.24±5.54 mmHg, respectively (P=0.95), indicating comparability between the two groups. There were no significant differences noted between the two groups regarding changes in heart rate, SBP, and DBP at specified time intervals during the surgery. The pulse rate increased slightly after the administration of the muscle relaxant. However, a significant rise in pulse rate was observed during laryngoscopy and intubation compared to baseline, followed by a gradual return to baseline pulse rate after intubation in both groups (Table 4).

Table 2: Comparison of mean time of onset between groups A and B

Groups	Meantime (Mean±SD)	P-value
Group-A	99.60±12.03	<0.001*
Group-B	231.0±13.21	

By student "t" test significant*

Table 3: Profile of intubating conditions between groups A and B

Condition	Group-A (n=50) No. %	Group-B (n=50) No. %
Excellent	36 (72.0)	28 (56.0)
Good	13 (26.0)	17 (34.0)
Fair	01 (02.0)	05 (10.0)

By Chi-square test P=0.1447, Not significant

Comparison of changes in mean pulse rate between groups

The mean pulse rate values for Group A and Group B are nearly identical at baseline (Group A: 80.28±8.97 and Group B: 80.86±8.65), during sedation, induction, intubation, and at 1, 2, 3, 4, 5, 10, 20, and 30 min post-intervention. Group A has a slightly higher mean pulse rate compared to Group B during laryngoscopy (Group A: 95.04±7.60 and Group B: 92.04±8.15). However, across all these time points, there are no statistically significant differences in mean pulse rate between the two groups (P>0.05) (Figure 1).

Comparisons of changes in mean SBP between groups

The mean SBP values for Group A and Group B are nearly similar at baseline (Group A: 118.28±9.94 mmHg and Group B: 120.62±6.48 mmHg), during sedation, intubation, and at 2, 3, 4, 5, 10, and 20 min post-intervention. Group A has a slightly higher mean SBP compared to Group B during induction (Group A: 126.84±7.00 mmHg and Group B: 124.40±5.17 mmHg), during laryngoscopy, and at 1 and 30 min post-intervention. However, across all these time points, there are no statistically significant differences in mean SBP between the two groups (P>0.05) (Figure 2).

Comparison of changes in mean DBP between groups

The mean DBP values for Group A and Group B are nearly identical at baseline (Group A: 81.16±6.89 mmHg and Group B: 81.24±5.54 mmHg), induction, during laryngoscopy, and at 1, 4, 5, and 10 min post-intervention. Group A has a slightly higher mean DBP compared to Group B during sedation (Group A: 83.20±6.55 mmHg and Group B: 81.68±5.57 mmHg), intubation, and at 2, 3, 20, and 30 min post-intervention. However, across all these time points, there are no statistically significant differences in mean DBP between the two groups (P>0.05) (Figure 3).

Table 4: Comparison of mean hemodynamic parameters between groups A and B

Parameters	Mean hemodynamic parameters (Mean±SD)		P-value	Remarks
	Group A	Group B		
Pulse rate	80.28±8.97	80.56±8.65	0.874	Not significant
Systolic blood pressure	118.28±9.94	120.80±6.46	0.14	Not significant
Diastolic blood pressure	81.16±6.89	81.24±5.54	0.95	Not significant
MAP	93.53±6.58	95.49±4.39	0.08	Not significant

MAP: Mean arterial pressure

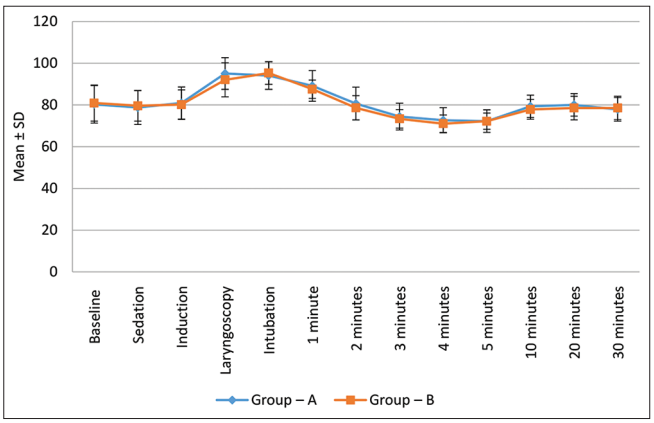

Figure 1: Comparison of changes in mean pulse rate between two groups

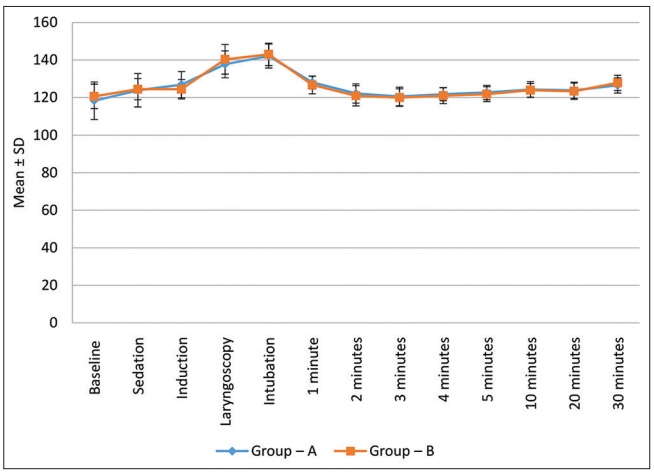

Figure 2: Comparison of changes in mean systolic blood pressure between two groups

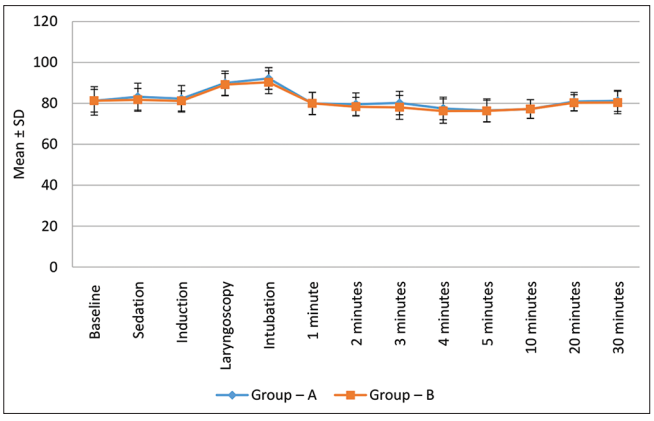

Figure 3: Comparison of changes in mean diastolic blood pressure between two groups

DISCUSSION

Demographical data

In our study, the mean age of the patients was 42.02 years in Group A and 42.26 years in Group B, with no statistically significant difference (P=0.911). The mean weight of the patients was 59.48 kg in Group A and 61.60 kg in Group B. Males comprised 52% of Group A and 64% of Group B. Regarding ASA physical status, 66% of patients in Group A were ASA I and 34% were ASA II, whereas in Group B, 70% were ASA I and 30% were ASA II.

Misra et al. included 90 patients aged 16–60 years with ASA physical status I and II of either sex in their comparative study of rocuronium, vecuronium, and succinylcholine for rapid sequence induction of anesthesia, which was comparable to our study population.[4]

Similarly, Shukla et al. studied patients aged 20–60 years with ASA physical status I and II for a comparative evaluation of the hemodynamic effects and intubating conditions after the administration of rocuronium (ORG 9426) and succinylcholine, which was also comparable to our study.[14]

Onset time comparison between vecuronium and rocuronium

In our study, the onset time after the administration of a muscle relaxant was defined as the time interval (in seconds) from the administration of the relaxant to the loss of visual response to the nerve stimulus (TOF). This onset time was 99.6±12.03 s in Group A and 231±13.21 s in Group B (P<0.001), indicating a significant difference.

Wierda et al. found that intubating conditions at 60 s using a standard intubating dose of 0.6 mg/kg body weight (2 × ED95) of rocuronium under intravenous anesthesia was excellent.[15] Similarly, Cooper et al. reported that the onset time decreased from about 60 s with a dose of 0.6 mg/kg of rocuronium to approximately 45 s with a dose of 0.9 mg/kg.[16]

Magorian et al. conducted that studies showing the onset times for patients receiving 0.9 mg/kg, 1.2 mg/kg of rocuronium, and 1.0 mg/kg of succinylcholine were 75±28 s, 55±49 s, and 50±17 s, respectively.[8] Scheiber et al. found that excellent to good intubating conditions developed significantly faster in the rocuronium group compared to the vecuronium and atracurium groups in a study of 20 patients.[17]

Virmani et al. and Lin et al. compared the neuromuscular action of vecuronium 0.1 mg/kg and rocuronium 0.6 mg/kg. Virmani et al. found that vecuronium provided the best intubation conditions at a dose of 0.1 mg/kg.[18,19] Schramm et al. reported no hemodynamic changes with vecuronium at the same dose[20] and Lin et al. observed no adverse effects.[19] Russo et al. determined that increasing doses of vecuronium bromide (up to

0.150 mg/kg) did not significantly shorten the onset time, leading us to choose vecuronium 0.1 mg/kg IV as the induction dose.[21]

Schultz et al. compared rocuronium at doses of 0.6 mg/kg, 0.9 mg/kg, and 1.2 mg/kg and found no further improvement in intubation conditions at 60 s with an increase from 0.9 mg/kg to 1.2 mg/kg.[22] Savidhan et al. compared intubation conditions with 0.6 mg/kg and 0.9 mg/kg of rocuronium bromide for rapid sequence intubation, concluding that rocuronium at 0.6 mg/kg provided adequate intubation conditions at 60 s with a shorter duration of action, whereas 0.9 mg/kg provided good to excellent conditions at 60 s but with a prolonged duration of action.[23]

In the present study, the onset of neuromuscular block was assessed on the AP muscle using a TOF stimulus every 15 s to the ulnar nerve. The onset of action was defined as the time taken from the complete injection of the muscle relaxant to the abolition of the visual response to the TOF stimulus.

Lee et al. compared the AP, orbicularis oculi, and corrugator supercilii (CS) muscles as indicators of the adequacy of muscle relaxation for tracheal intubation. They concluded that twitch monitoring at the orbicularis oculi allows for faster intubation but is associated with inadequate intubating conditions. Excellent intubating conditions were observed most frequently with AP monitoring, although with the longest delay before attempting intubation.[24]

In the present study, the mean onset of action in Group A was 99.60 s (SD±12.03), which aligns with the findings of Barve and Sharma, who used rocuronium at a dose of 0.6 mg/kg for intubation and reported an onset of action of 101.5±29.47 s.[25] Similarly, Lee et al. used rocuronium 0.6 mg/kg for intubation and assessed the onset of action at the CS muscle, finding it to be 1.70±0.68 min (i.e., 102±40.8 s), which correlates with our study.[24]

Conversely, Booth et al. reported an onset of action of rocuronium 0.6 mg/kg at 60 s, indicating a faster onset than observed in our study.[26] In Group B, the mean onset of action was 231 s (SD±13.21). This is approximately in line with the findings of Schramm et al., and Virmani et al., who used vecuronium at 0.1 mg/kg for intubation and reported onset times of around 192±64 s and 144.8±46.1 s, respectively.[18,20] Conversely, Booth et al. found the onset of action of vecuronium 0.1 mg/kg to be 96 s.[26]

The onset of action in Group A was significantly faster compared to Group B (P<0.001). Hemodynamic changes in surgical patients followed similar trends during the intubation and post-intubation periods in both Group A and Group B. These findings are consistent with studies by Booth et al., Lin et al., and Parasa et al., who compared the onset of action of equipotent doses of rocuronium and vecuronium and found that rocuronium had a more rapid onset of action with P=0.0001, <0.05, and 0.011, respectively.[5,19,26]

Intubation conditions comparison

Intubation conditions in the present study were assessed using the Cooper score, which classifies conditions as excellent, good, fair, or poor. In our study, 72% of patients in Group A (rocuronium) experienced excellent intubation conditions, compared to 56% in Group B (vecuronium). Good intubation conditions were observed in 26% of patients in Group A and 34% in Group B. Overall, intubation conditions were significantly better in Group A compared to Group B (P<0.001). These findings are consistent with the study by Parasa et al., who also used the Cooper score to assess intubation conditions. They found that 100% of patients in the rocuronium group had excellent intubation conditions, compared to 70% in the vecuronium group.[5] Similarly, Van den Broek et al., concluded that intubation conditions are superior with rocuronium compared to vecuronium.[27]

In summary, our study supports the conclusion that rocuronium provides better intubation conditions than vecuronium, as reflected in the higher percentage of excellent ratings and the overall better intubation scores.

Hemodynamic parameters comparison

In our study, baseline measurements for pulse rate and blood pressure were similar between Group A (vecuronium) and Group B (rocuronium). However, slight differences emerged at various critical phases of the procedure. Despite these variations, no statistically significant differences were observed in mean pulse rate, SBP, and DBP between the two groups across all time points.

Pulse rates

Group A exhibited significantly higher mean pulse rates during certain phases compared to Group B. This finding aligns with the study by Barve and Sharma, which reported that rocuronium leads to a more rapid onset of action, potentially resulting in transient increases in heart rate immediately following administration.[25]

SBP

The mean SBP values for Group A and Group B were nearly similar at baseline (Group A: 118.28±9.94 mmHg and Group B: 120.62±6.48 mmHg) and during sedation, intubation, and at 2, 3, 4, 5, 10, and 20 min post-intervention. However, during induction, laryngoscopy,

and at 1 and 30-min post-intervention, Group A showed slightly higher mean SBP compared to Group B (Group A: 126.84±7.00 mmHg and Group B: 124.40±5.17 mmHg). These findings are consistent with the study by Lee et al., which reported that rocuronium can cause a slight but significant increase in SBP during the induction phase. The study highlights the need for careful blood pressure management when using rocuronium, especially during critical phases such as laryngoscopy and intubation, where significant blood pressure increases were observed in both groups.[24]

DBP

The mean DBP values for Group A and Group B were nearly identical at baseline (Group A: 81.16±6.89 mmHg and Group B: 81.24±5.54 mmHg), during induction, laryngoscopy, and at 1, 4, 5, and 10-min post-intervention. However, during sedation, intubation, and at 2, 3, 20, and 30-min post-intervention, Group A exhibited slightly higher mean DBP compared to Group B (Group A: 83.20±6.55 mmHg and Group B: 81.68±5.57 mmHg). Similar findings were reported by Virmani et al., who noted that rocuronium can result in higher diastolic pressure during these phases.[18] Schramm et al. also observed that vecuronium tends to have a more stable profile in terms of DBP changes, aligning with our observations of Group B's more stable diastolic pressures post-induction.[20]

Limitations of the study

The study may have excluded patients with significant comorbidities or those undergoing emergency surgeries, limiting the generalization of the findings to healthier or elective surgery populations. Further, the study primarily focused on immediate intubation conditions and short-term hemodynamic effects. It did not evaluate long-term outcomes, such as postoperative recovery or the potential for residual neuromuscular blockade.

CONCLUSION

From our study, we concluded that rocuronium provides earlier excellent and good intubating conditions than vecuronium with similar cardiovascular stability at intubation and post-intubation period. It is evident from the above study that rocuronium had a more rapid onset of action and provided conditions suitable for more rapid tracheal intubation than vecuronium during general anesthesia with endotracheal intubation in surgical patients.

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