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A Comparative Evaluation of Rocuronium and Suxamethonium Following Rapid Sequence Intubationin Emergency Surgeries

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Abstract

Introduction: Endotracheal intubation is an integral part of administration of anaesthesia during surgical procedures. Administration of muscle relaxants facilitates endotracheal intubation. Various drugs and techniques have been used to facilitate rapid endotracheal intubation during emergency surgical procedures and in critically ill patients.Rocuronium and Suxamethonium are two such drugs. *Aim of Study:* To compare the intubating conditions of Rocuronium with Suxamethonium at 60 seconds in emergency surgeries following rapid sequence intubation. *Materials and Methods:* This was a prospective comparative study carried out at DurgabaiDeshmukh Hospital and Research Centre, Hyderabad, over a period of 10 months, from September 2011 to June 2012. The subjects were 80 adult patients divided into two groups of 40 each. Group R received Rocuronium and Group S received Suxamethonium. The subjects were studied forscoring response to intubation, jaw relaxation, vocal cord position and hemodynamic responses and adverse effects to the drugs. *Results:* Rocuronium at a dose of 0.6mg/kg produced acceptable intubating conditions as that of Suxamethonium 1.5mg/kg. There was no statistical significance between the groups in jaw relaxation response to intubation and in grading of intubating conditions. Mean arterial pressure and heart rate were slightly higher in group R compared to that of group S statistically not significant. Group R had a few adverse effects which were insignificant. *Conclusion:* Both Rocuronium and Suxamethonium produced good intubating conditions for rapid sequence intubation. Rocuronium (0.6 mg/kg) has acomparable hemodynamic profile to Suxamethonium. Rocuroniumis safe and has less adverse effects. It can be used as a safe alternative to Suxamethonium, when the latter is contraindicated.

Keywords: Rocuronium; Suxamethonium; Rapid Sequence Intubation; Hemodynamics.

Introduction

Endotracheal intubation is an integral part of administration of anaesthesia during surgical procedures. Administration of muscle relaxation facilitates endotracheal intubation. Neuromuscular blocking agents should be administered only to anaesthetized individuals to provide skeletal muscle relaxation [1]. Muscle relaxants propelled the development of cardiothoracic, neurologic and organ transplant surgeries [2].

Common problems encountered in emergency circumstances and in elective anaesthesia care are of regurgitation, vomiting and aspiration [3]. A patient with full stomach is at great risk for regurgitation and aspiration. To secure the airway against pulmonary aspiration becomes one of the primary objectives of safe general anaesthesia.

Various drugs and techniques have been used to facilitate rapid endotracheal intubation during emergency surgical procedures and in critically ill patients.

Suxamethonium, introduced by Thesleff [4] and Foldes [2] in 1952, changed anaesthetic practice

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drastically. Its rapid onset of effect and ultra-short duration of action permitted rapid endotracheal intubation.

Suxamethonium has got many side effects such as bradycardia, fasciculations, dysrhythmias, rise in serum potassium [5], post-operative myalgias [6] rise in intra ocular pressure [7] rise in intra gastric pressure, rise in intra cranial pressure [8], prolonged recovery in patients with pseudo cholinesterase deficiency and triggering of malignant hyperthermia [9].

When Suxamethonium is undesirable, the onset of action of non-depolarising neuromuscular blocking drugs can be accelerated by preceding the intubating dose with a priming dose of neuromuscular blocker [10] by using high doses of an individual agent [11] or by using combinations of neuro muscular blockers [12].

Priming Technique [10]

Small sub-paralyzing dose of the non-depolarizer about 20% of ED 95 or about 10% of intubating dose, to be given 2 to 4 min before a large second dose for tracheal intubation [13]. In the case of Rocuronium, onset is probably fast enough to make priming unnecessary [11].

High dose Regimen for Rapid Tracheal Intubation [11]

Larger doses of neuromuscular blockers are usually recommended when intubation must be accomplished in less than 90 seconds. High dose regimens are associated with a prolonged duration of action and potentially increased cardiovascular side effects [14].

Low dose Relaxants for Rapid Tracheal Intubation

Low dose of neuro muscular blockers has advantages as it shortens the time to recovery from neuromuscular blockade and reduces the requirement for anticholinesterase drugs. This technique is not suitable for rapid sequence induction [15].

Rocuronium, an intermediate acting non depolarising neuromuscular blocker was introduced in 1990s [16].

Aim of the Study

To compare the intubating conditions of Rocuronium with Suxamethonium at 60 seconds in emergency surgeries following rapid sequence intubation.

Objectives

- To compare the intubating conditions following administration of Rocuronium at a dose of 0.6 mg/kg with Suxamethonium at a dose of 1.5mg/kg in emergency surgeries.
- To compare hemodynamic response to intubation after administration of Rocuronium with Suxamethonium at 60 seconds following rapid sequence intubation.
- To note any adverse effects associated with administration of Rocuronium.

Materials and Methods

This was a prospective comparative study carried out at Durgabai Deshmukh Hospital and Research Centre, Hyderabad,over a period of 10 months, from September 2011 to June 2012. The subjects were 80 adult patients. Informed consent was obtained from all patients.

Inclusion Criteria

- Adults between 18-60 years.
- ASA physical status I, II & III.
- Emergency surgeries posted under GA.
- Closed head injuries with Glasgow Coma Scale > 13

Exclusion Criteria

- Children
- Pregnancy
- Obesity
- Known/suspected difficult intubation
- Neuromuscular disorder
- Renal/Hepatic disorder
- Head injuries with Glasgow Coma Scale < 13
- Hypovolemia /shock
- Severe metabolic / electrolyte / acid-base imbalance.
- Known allergy to drugs
- Surgical procedures of very short duration
- Patients receiving any medication known to interact with neuromuscular blocking agent

Cases Included

- Neurosurgical emergencies for craniotomy and evacuation such as extra-dural haematoma and depressed fracture of the skull
- Blunt injury abdomen for laparotomy
- Hollow viscus perforation
- Acute appendicitis for appendicectomy
- Vascular / tendon injuries of the upper limb
- Compound fracture both bones of the forearm for external fixator application

The patients were selected randomly from either gender, between 18 to 60 years of age and weighing between 40-80 kg and were randomly allocated into two groups

Group R – comprising of 40 patients who received Rocuronium (0.6 mg/kg)

Group S – comprising of 40 patients who received Suxamethonium (1.5 mg/kg)

Pre-Operative Evaluation

In all the patients, age, sex,registration number, body weight, base line heart rate, mean arterial pressure, were recorded.

History regarding previous anaesthesia, surgery, any significant medical illness, medications and allergy were recorded.

The fasting time was taken as the interval between the last meal / drink and the time of admission in the hospital.

Informed consent was obtained from all the patients and complete physical examination was done. Airway assessment was done to ascertain the ease of intubation by Mallampatti classification [17] (Young and Samson modification).

Following laboratory investigations were done: Haemoglobin %, Blood sugar, urea,serum creatinine, Serum electrolytes, Chest X-ray, ECG in all leads.

Half an hour prior to surgery, two venous accesses (18 gauge cannula) were established and infusion of crystalloid solution was started. Aspiration prophylaxis was given-Inj. Metoclopramide 10 mg IV and Inj. Ranitidine 50 mg IV.

Intra Operative

Premedication was standardised in both groups and was given 5 min prior to induction-
InjGlycopyrolate 0.008 mg IV and Inj Fentanyl 1-2 mcg / kg IV.

In the operating room standard monitoring was established (Electro Cardiogram-ECG, Non-invasive blood pressure, Pulse Oximetry and Capnography) and baseline (pre induction) measurements were recorded.

Pre-oxygenation using a tight fitting mask was performed for 3 min. with 100% oxygen. Anaesthesia was induced with Inj Thiopentone sodium – 3-5 mg/kg. Cricoid pressure was given after thiopentone was administered and released following successful tracheal intubation and inflation of the cuff. If the patient had a nasogastric tube inserted prior to induction, Sellick manoeuver was carried out with nasogastric tube in-situ.

Patients in group R were given Rocuronium bromide in a dose of 0.6 mg/kg and patients in group S were given Suxamethonium in a dose of 1.5 mg/kg. Laryngoscopy was performed 50 seconds after the administration of relaxant (size 3 Macintosh blade), aiming to intubate the trachea at 60 seconds. Cuffed tracheal tubes of 7and 8mm size were used in female and male patients respectively. Tracheal intubation and grading of the intubating conditions was performed by an experienced anaesthetist. Intubating conditions were noted and scored according to modification of the method described by Cooper et al [18].

Table 1: Scoring of Intubating Conditions

Score	Jaw Relaxation	Vocal Cords	Response to Intubation
0	Poor(impossible)	Closed	Severe coughing or bucking
1	Minimal(difficult)	Closed	Mild coughing
2	Moderate(fair)	Moving	Slight diaphragmatic movement
3	Good(easy)	Open	None

Grading of Intubating Conditions

A score of 8-9 was excellent, 6-7 was good, 3-5 was poor and 0-2 was considered bad.

All the intubations were performed by an experienced anaesthesiologist and cricoid pressure was applied by a trained assistant.

After inflating the cuff of endotracheal tube, position of the tube was confirmed by auscultation

and tube was fixed and $EtCO_2$ monitor was connected.

Duration of laryngoscopy (time from start of laryngoscopy until tracheal intubation and removal of laryngoscope blade from the mouth) was noted.

Heart rate and Mean arterial pressure were recorded at various intervals of time:

Pre induction period (base line)

Induction

Intubation

1 min after intubation

3 min after intubation

5 min after intubation

Maintenance

Group R: O_2 + N_2O + Rocuronium (accordingly)

Group S: O_2+ N_2O + Vecuronium (accordingly)

All vital parameters were recorded throughout the procedure.

At the end of surgery muscle paralysis was reversed with Inj Neostigmine 0.06mg/kg and Inj Glycopyrolate 0.016mg/kg.

Patient was extubated after recovery was adequate (sustained head lift > 5 sec).

Post-Operative Period

All vital parameters were monitored in the post-operative period.

Machine Used: DATEX OHMEDA S/5 AESPIRE

Monitor Used: PHILLIPS INTELLIVUE MP 40

Observations and Results

Eighty patients undergoing emergency surgeries were selected for the study.The patients were randomly divided into two groups of 40 each.

Group R: Received Rocuronium at the dose of0.6mg/kg after induction

Group S: Received Suxamethonium at the dose of 1.5mg/kg after induction

No intubation difficulty was encountered during the study and no airway was used. None of the patients desaturated during the performance of RSI. The application of cricoid pressure did not worsen the view during laryngoscopy and intubation. Few patients had naso-gastric tube inserted prior to induction, which was not removed subsequently, and Sellicks manoeuver was carried out with the naso-gastric tube in-situ. All intubations were successful

Table 2: Distribution of study subjects according to age (n=80)

Gender	Mean age for Group R	Mean age for Group S	SD for Group R	SD for Group S
Male	29.3	31.6	9.27	7.8
Female	31.15	31.35	8.2	8.2
	2=1.3;P>0.05			

in both the groups in the first attempt. No significant adverse effects other than tachycardia and hypertension were noted.

Distribution of Study Subjects According to Gender

In the present study, there were 40 subjects in each group and each group had 20 males and 20 females. Hence, the gender within the group and between groups was comparable. The difference was insignificant P>0.05.

The mean weight in group R and group S was 61.35 kg and 61.5 kg respectively. The minimum weight for both groups was 45 kg and maximum weight for both groups was 74 kg. The SD for group R and group S was 7.85 and 7.96 respectively (P>0.05).

In the present study it was observed that mean age, minimum and maximum weights recorded were similar in both groups and also the statistical difference between the two groups was statistically insignificant.

Distribution of Study Subjects According to Tracheal Intubating Conditions: Jaw Relaxation

In the present study the jaw relaxation response was observed to be same in both groups with SD of 0 and statistically insignificant (P>0.05) between the two groups. None of the two groups had poor / minimal/moderate response for jaw relaxation response indicating the effectiveness of the two drugs.

In the present study, it was observed that the vocal cord position was seen as open for 82.5% of the Rocuronuim group and 100% for the Suxamethonuim group. 17.5% of the study subjects from Rocuronuim

group had moving vocal cords while none of the two groups had closed vocal cords.

Statistical analysis showed to be insignificant (P>0.05) for this response between the groups.

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Statistical analysis showed this to be insignificant (P>0.05) for this response between the groups.

In the present study, all (100%) the subjects in Suxamethonuim and 82.5% of the Rocuronuim group had excellent score for intubation response. 17.5% of the Rocuronuim group had good score for the same.

None of the two groups had either poor or bad scores for response to intubation. Statistical analysis showed that the observed difference was insignificant (P>0.05)

In the present study, it was observed that the mean arterial pressures among the Rocuronuim group were slightly higher in comparison with the Suxamethonuim group. Statistical analysis of the data showed that the observed difference was insignificant (P>0.05) both within the group and between the group at all levels of monitoring indicating the drug response is similar for both.

Table 3: Distribution of study subjects according to tracheal intubating conditions: vocal cord position and response to intubation

Vocal cord position	Rocuronuim group (%)	Suxamethonuim group (%)	Response to Intubation	Rocuronium group (%)	Suxamethonuim group (%)
Closed(1)	Nil (0%)	Nil (0%)	Severe cough/ Bucking(0)/ Mild coughing(1)	Nil (0%)	Nil (0%)
Moving(2)	7(17.5%)	Nil (0%)	Slight diaphragmatic movement (2)	40 (100%)	Nil (0%)
Open(3)	33(82.5%)	40 (100%)	None (3)	Nil (0%)	40 (100%)
Mean Sore	2.83	3	Mean	2	3
Standard Deviation	0.38	0	Standard Deviation	0	0

Table 4: Distribution of study subjects according to total scoring for response to intubation

Total Score	Rocuronium Group	Suxamethonuim Group
Excellent (8-9)	33(82.5%	40
Good(6-7)	7 (17.5)%	Nil
Poor (3-5))	Nil	Nil
Bad (0-2)	Nil	Nil
Mean Sore	7.85	9
Standard Deviation	0.36	0

Table 5: Distribution of mean arterial pressure (MAP) and heart rate (HR) among study subjects

		Rocuronium		Suxamethonium	
		MAP	HR	MAP	HR
Base	Mean	96.7	87.7	93.2	82.15
	Standard Deviation	12.54	11.39	10.3	10.19
Induction	Mean	85.7	97.1	84.9	92
	Standard Deviation	11.8	10.24	6.8	12.07
Intubation	Mean	106.7	105.9	100.5	103.55
	Standard Deviation	13.3	20.67	16.6	12.87
At 1 minute	Mean	105.5	107.75	101.6	101.25
	Standard Deviation	12.84	13.13	7.2	12.9
At 3 minutes	Mean	104.1	101.45	97.3	97.1
	Standard Deviation	11.39	12.12	15.48	12.7
At 5 minutes	Mean	101.7	94.35	97.6	92.95
	Standard Deviation	12.2	11.41	7.17	11.52

In the present study, the mean arterial pressures among the Rocuronuim group were slightly higher in comparison with the Suxamethonuim group.

Statistical analysis of the data showed that the observed difference was insignificant (P>0.05) both within the group and between the group at all levels

of monitoring indicating the drug response was similar for both. The heart rate among the Rocuronuim group was slightly higher in comparison with the Suxamethonuim group. The variability is also similar in both groups.

Statistical analysis showed that the observed difference was insignificant (P>0.05) both within the group and between the groups at all levels of monitoring indicating the drug response is similar for both groups.

Distribution of Adverse Effects among the Study Subjects

Tachycardia and hypertension were observed in 3 (7.5 %) patients in group R. None of the patients in group S had any adverse effects. Statistical analysis showed the observed difference was not significant as P value was >0.05

Distribution of Study Subjects According to Duration of Laryngoscopy

In the present study, the mean duration of the laryngoscopy was 9.48 seconds and 8.8 seconds in group R and group S respectively.

The minimum duration was 7 seconds for both groups. The maximum duration was 12 seconds and 11 seconds for group R and group S respectively. The SD was 1.55 and 0.96 for group R and group S respectively.

Statistical analysis of the data showed that the differences between the groups were not significant (P>0.05).

Statistical Analysis

The present study data was analyzed using EpiInfo 2003 version; SPSS 19 version and MS office XL statistic 2010 version.

The data was subjected to percentage; mean; variability; Standard deviation, Chi square; Student t test.

The data was analyzed using the standard cut off for Pvalue <0.05 as significant and P>0.05 as insignificant. This was applied uniformly.

Discussion

Traditionally Suxamethonium has been the neuromuscular blocking drug of choice for rapid sequence induction and minimizing the chances of regurgitation and aspiration. Since its introduction in 1949, Suxamethonium has become the drug of choice to produce paralysis in rapid sequence intubation. The use of Suxamethonium can however be associated with many side effects like hyperkalemia, bradycardia, cardiac arrest, raised ICP and IOP. Hence, a non-depolarizing neuromuscular blocker with a rapid onset of action, preferably of a shorter duration is desirable.

Initial studies in animals showed that Rocuronium, being a low potency compound, was associated with a rapid onset of effect when compared with other compounds such as pancuronium and vecuronium [19].

This has since been demonstrated in many clinical studies that the onset of action of Rocuronium is significantly faster when compared to equipotent doses of atracurium and vecuronium, although slightly slower than that of Suxamethonium. Hence, in the present study, Rocuronium was selected for the purpose of rapid sequence induction.

The extra anaesthetic depth needed, coupled with these laryngeal movements are two drawbacks that cannot make the low dose Rocuronium [0.3 mg/kg-1(1xED90)] a desirable technique for rapid sequence intubation. Use of higher dose of Rocuronium to improve intubating conditions during rapid sequence intubation and to cut short the onset time below 60 seconds has been advocated by various workers [20, 21] but doses larger than 0.6 mg/kg-1 would be associated with a long duration of action which may be inappropriate in many situations.

In most studies, an appropriate timing of tracheal intubation has been determined by 3 ways.

1. Clinical judgment
2. Neuromuscular monitoring either by twitch suppression (maximum blockade) or
3. Predetermined time after the administration of neuromuscular blocking agent e.g. 60 secs, 90 secs,120 secs etc.

The technique using judgment alone is relatively insensitive as onset time differs with different nerve stimulation rates used.

The development of neuromuscular block was not monitored, as it has been clearly shown in the studies De Mey et al [21] and Wright et al [22] of intubating conditions. So, for more than 40 years, instrumental means have been abandoned to evaluate laryngoscopy and intubating conditions and instead scales that assess clinical criteria are being used to assess the quality of tracheal intubation. The scale used in the

study was used originally by Cooper et al [23] in their study and is recommended for studies with neuromuscular blockers.

Land and Stovner [24] were probably the first to introduce a rating scale as a tool for the assessment of intubating conditions in which the three main criteria: Jaw relaxation, vocalcords (position and motility) and reaction to intubationwere rated by descriptive scores such as excellent, satisfactory or fair but this allows a large room for subjective interpretation of data. These three main criteria remained the basis of numerous subsequent modification of their rating scale by others. One of the most frequently used modifications, still in use today, was introduced by Krieg et al [25] in 1980 in which a numeric value is assigned to signify quality of intubating conditions. Cooper's modification [23]of this rating scale was used in the present study.

In the present study, premedication, induction, maintenance (according to the groups), reversal agents were standardised.

- Premedication: Inj glycopyrolate-0.008mg/kg
  Inj fentanyl-1-2mcg/kg
- Induction: Injthiopentone sodium-3-5mg/kg
  Group R: Injrocuronium bromide-0.6mg/kg
  Group S: Inj suxamethonium-1.5mg/kg
- Reversal: Inj neostigmine-0.06 mg//kg
  Inj glycopyrolate-0.016mg/kg

The condition of vocal cords during intubation with Rocuronium was not significantly different from that of Suxamethonium with mean score of 2.83 and 3.0 respectively. Response to intubation in Rocuronium group was higher when compared to Suxamethonium group. Rocuronium group showed a mean score of 2 (slight diaphragmatic movement) and Suxamethonium group showed a mean score of 3. The mean total intubation score with Rocuronium was 7.85 and with Suxamethonium was 9. The overall intubating conditions were better with Suxamethoniun. Though Rocuronium fell back against Suxamethonium with respect to the total score, the mean score reflected good intubating conditions.

In the present study, intubation was attempted at 60 secs after the injection of muscle relaxant for rapid sequence induction as proposed byCooper et al [18], Crul et al [20], De Mey et al [21], Mc Court et al [26] and Sparr et al [27].

The results with respect to intubating conditions in the present study are in concurrence with the results of the study by Singh et al [28].

Moreover, the intubating conditions achieved at 60 secs, according to the present study, were also observed in the studies of De Mey et al [21], Mc Court et al [26], Mirakhur et al [29], and Lam et al [30].

Rocuronium was used for emergency intubations in the present study, and the intubating conditions were good to excellent at 60 secs. This is in concurrence with the methods and results obtained by Crul et al [20]and Sparr et al [27].

The mean rise in MAP and HR was higher within the group during intubation, and this could be attributed to the adrenergic response to laryngoscopy and intubation, rather than to the effect of drugs. But the rise in MAP and HR between the groups (P>0.05) showed no statistical significance. The hemodynamic conditions observed during intubation were comparable with the results of Singh et al [28]. This showed that the muscle relaxant administered during intubation did not alter or influence the hemodynamic state. Therefore, Rocuronium, at the dose of 0.6 mg/kg (2 x ED95) did not show any adverse hemodynamic response, and the hemodynamic profile was comparable to Suxamethonium.

No sign of histamine release was noted in any of the patients, in this study. Two of the patients in Rocuronium group had hypertension and tachycardia. No significant adverse effects were observed in Suxamethonium group.

In the study by Singh et al [28] complications such as laryngospasm, bradycardia, tachycardia and arrhythmias were noted in a significant number of patients in both the groups, but statistical analysis between the groups failed to show any significance.

In the present study, statistical analysis showed no significant difference in the adverse effects between both the groups (P >0.05). Hence the results of the present study with respect to adverse effects are comparable with the study of Singh et al [28].

Conclusion

It can be summarised as

- Suxamethonium produces excellent intubating conditions at 60 seconds. Rocuronium at a dose of 0.6mg/kg produces acceptable intubating conditions and there is no statistical significance between both the groups.
- Rocuronium at a dose of 0.6mg/kg produces acceptable intubating conditions as that of

Suxamethonium 1.5mg/kg.

- There is no statistical significance between the groups in jaw relaxation response to intubation and in grading of intubating conditions.
- MAP and HR were slightly higher in group R compared to that of group S but there is no statistical significance.

Hence, from the present study it can be concluded that both Rocuronium and Suxamethonium produced good to excellent intubating conditions for rapid sequence intubation. Rocuronium in the dose of 0.6 mg/kg, had acomparable hemodynamic profile to Suxamethonium, and can be used as the next best alternative to Suxamethonium as a part of rapid sequence induction provided there is noanticipated difficulty in intubation. Rocuronium appears to be safe with less adverse effects and effective for rapid sequence intubation of selected patients in whom contraindications to Suxamethonium exist.

References

1. Miller. Textbook of anaesthesiology, 7th edition; 2010, chapter 29, page: 860; Elsevier Churchill Livingstone
2. Foldes FF, Mc Nall PG, Hinojosa BJM. Succinylcholine, a new approach to muscular relaxation in anaesthesiology. N Engl J Med, 1952; 247:596-600.
3. Vincent J. Collins. Principles of anaesthesiology: 3rd edition, page 548.
4. Thesleff S. FarmakologiskaOchKliniskaforsok med C.T.I. (0,0 - succinylcholine jodid). Nord Med, 1951; 46:1045-1051.
5. Baker BB, Wagner JA, Hemenway WG. Succinylcholine induced hyperkalemia and cardiac arrest. Arch Otolaryngol. 1972; 96:464–5.
6. Waters DJ, Mapelson WW. Suxamethonium pains: Hypothesis and observations. Anaesthesia, 1971; 26:127-141.
7. Pandey K, Badola RP, Kumar S. Time course of intra-ocular hypertension produced by suxamethonium. Br J Anaesth, 1972; 44:191.
8. Minton MD, Grosslight K, Stirt JA Bedford RF. Increases in intracranial pressure from Succinyl choline: Prevention by prior non depolarizing blockade, Anesthesiology, 1986; 65:165.
9. Kalow W. Succinylcholine and malignant hyperthermia. Federation Proc. 1972; 31:1270–5.
10. Mehta MP, Choi WW, Gergis SD, Sokoll MD, Adolphson AJ. Facilitation of rapid endotracheal intubations with divided doses of non-depolarizing neuromuscular blocking drugs. Anesthesiology, 1985; 62:392-395.
11. Magorian T, Flannery KB, Miller RD. Comparison of rocuronium, succinylcholine, and vecuronium for rapid-sequence induction of anesthesia of adult patients. Anesthesiology, 1993; 79:913–8.
12. Naguib M. Neuromuscular effects of rocuronium bromide and mivacurium chloride administered alone and in combination. Anesthesiology, 1994; 8: 388-394.
13. Miller. D. The priming principle: Anaesthesiology, 1985; 62:381.
14. Rolly G, De Brock M, De Mey JC. Intubating conditions and time course of action of rocuronium bromide. Anaesthesiology 1992; 77:A 963.
15. Miller. Textbook of anaesthesiology, 7th edition; 2010, chapter 29, page: 878; Elsevier Churchill Livingstone.
16. Wierda JMKH, De Wit APM, Kuizenga K, Agoston S. Clinical observations on the neuromuscular blocking action of org 9426, a new steroidal non-depolarizing agent. Br J Anaesth, 1990; 64:521-532.
17. Mallampati SR, GattSP, Gugino LD, Desai SP, Waraksa B, Freiberger D. A clinical sign to predict difficult tracheal intubation: a prospective study. Can AnaesthSoc J, 1985; 32(4):429-34.
18. Cooper R, Mirakur RK, Clarke RSJ, Boules Z. Comparison of intubating conditions after administration of Rocuronium and Suxamethonium. British Journal Anaesthesia, 1992; 69:269-273.
19. Bowman WC, Rodger IW, Houston J,Marshall RJ, McIndewar I.Structure action relationships among some desacetoxy analogues of Pancuronium and Vecuronium in anaesthetized cat. Anesthesiology, 1988; 69:57-62.
20. Crul JF, Vanbelleghem V, Buyse L. Rocuronium withalfentanil and propofol allows intubation within 45 secs. Eur J Anaesth 1995; 12(1):111-12.
21. DeMay JC, DebrockM, Rolly G. Evaluation of the onset and intubation conditions of rocuronium bromide. Eur J Anaesth. 1994; 11:37-40.
22. Wright PMC, Wright PMC. Onset and duration of rocuronium and succinylcholine at the adductor pollicis and laryngeal muscles in anaesthetised humans. Anaesthesiology. 1994; 81:1110-5.
23. Cooper AR, Mirakhur RK, Maddineni VR. Neuromuscular effects of rocoronium bromide (org 9426) during fentanyl and halothane anaesthesia 1993; 48:103-105.
24. Land I, Stovner J. Experimental and clinical experiences with a neuromuscular relaxantROS-3816, diallylnor_toxiferine. ActaAnaesthesiolScand, 1962; 6:85-97
25. Krieg N, Mazur L, Booij LHDJ, Crul JF. Intubation conditions and reversibility of a new nondepolarizing neuromuscular blocking agent ActaAnaesthesiolScand, 1980; 24: 420-25.

26. Mc Court KC, SalmelaL, Mirakhur RK, Vrroll M, Makinon MT, Kansanaho M, et al. Comparision of rocuronium and suxamethonium for use during rapid sequence induction of anaesthesia. Anaesthesia, 1998; 53:867-71.

27. Sparr H J, Luger TJ, Heidegger T, Putensen-Himmer G. Comparision of intubating conditions after Rocuronium and Suxamethonium following rapid sequence induction with thiopentone in elective case. ActaAnaesthesiolScand, 1996; 40(4):425-30.

28. Singh A, Kumar BP, TulsianiKL. Comparision of onset time, duration of action and intubating conditions achieved with Suxamethonium and Rocuronium. Indian J. Anaesth. 2004; 48(2):129-133.

29. Mirakhur RK, Cooper AR, Clarke RSJ. Onset and intubating conditions of rocuronium bromide compared to those of suxamethonium. European Journal Anaesthesiology, 1994; (Suppl. 19):41-43.

30. Lam AM, Pavlin EG, Visco E, Taraday J. Rocoroniom versus succinylcholine-atracurium for tracheal intubation and maintenance relaxation during propofol anaesthesia J Clin Anaesthesia, 2000 Sep; 12(6):449-53.