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Original Article

Comparative Evaluation of Effectiveness of Rocuronium Bromide vs. Succinyl Choline on Quality of Intubating Conditions during General Anesthesia

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Abstract

Objectives: To compare the quality of intubating conditions and hemodynamic responses to the administration of Rocuronium Bromide and Succinyl Choline during general anesthesia.

Methods: This was a comparative study conducted at the anesthesiology department of a tertiary care medical college. Sixty patients undergoing various surgeries under general anesthesia were included in this study based on predefined inclusion and exclusion criteria. Patients were divided into Group S (receiving succinylcholine) and Group R (receiving rocuronium). In all patients, the quality of intubating conditions was assessed. Excellent or good conditions were considered to be acceptable intubating conditions, whereas fair and poor conditions were considered unacceptable.

Results: Mean age, weight, gender distribution, and ASA grades were comparable in both groups. The overall quality of intubation was found to be better in group S than in group R, and the difference was statistically significant ($p=0.004$). The duration of action was significantly longer in group R than in group S ($p<0.001$). Hemodynamic stability was comparable in both the groups, except for heart rate at 10 min, which was higher in Group R than in Group S. Incidence of fasciculation was significantly more in Group S as compared to Group R, and the difference was found to be highly significant ($p=0.0001$).

Conclusion: Succinylcholine for rapid sequence intubation is associated with better intubation conditions than rocuronium.

Keywords: Intubation, muscle relaxant, rocuronium, succinylcholine

Introduction

Rapid and safe endotracheal intubation is of paramount importance in practice of general anesthesia. Adequate intubating conditions are required to avoid airway trauma and adverse sympathetic responses. With the advent of muscle relaxations, the anesthesia practice changed drastically for better. First muscle relaxant for surgery, d-tubocurarine, was introduced in 1942.[1] With this relaxant, jaw relaxation could easily be obtained to facilitate the orotracheal intubation. Soon afterwards, this invention had inspired R.R. Macintosh to invent the famous Macintosh laryngoscope in 1943.[2] Although d-tubocurarine could produce jaw relaxation to facilitate orotracheal and nasotracheal intubation, it brought with it, its own drawback. It produced muscarinic block and ganglion block leading to tachycardia and hypotension.[3] The onset of action was also delayed, taking up to 3 minutes to produce good intubating condition. This created a problem in emergency cases and full stomach cases, where rapid procurement of airway is priority to avoid regurgitation

and aspiration. Soon after, in 1954, studies have reported manifold increase in mortality in patients receiving dTC than those who had not received muscle relaxation, thereby underlining the risks involved in using muscle relaxants for intubation.[4] Succinyl choline has been a famous muscle relaxant available for rapid sequence induction of anesthesia where securing the airway quickly, such as in cases with full stomach requiring emergency surgeries, is of critical importance.[5] However, the use of depolarizing muscle agents, such as, succinylcholine was found to be associated with risk of hyperkalemia, variable increase in the intracranial pressure and intraocular pressure. Moreover, succinyl choline is also contraindicated in patients suffering from burns, crush injuries, muscular dystrophies, severe denervation syndrome, malignant hyperthermia, abdominal sepsis, or allergy to succinyl choline in susceptible patients and development of phase II block after a large dose or continuous infusion. The duration of succinylcholine chloride was prolonged in patients with pseudo cholinesterase deficiency. All these conditions, where the use of succinyl choline was contraindicated, has led scientists to look for newer drugs which can be used as an alternative to succinyl choline.[6] In 1967, a first study that reported on clinical administration of the synthetic amino steroid pancuronium was published. The intermediate-acting neuromuscular blocker was built on the compound's metabolism and resulted in the introduction of vecuronium, an amino steroid which is also a mono-quaternary analogue of pancuronium and atracurium that is a benzylisoquinolinium, into clinical practices in the 1980s. However, none of these nondepolarizing muscle relaxants could match succinyl choline with respect to the onset of action.[7] Although various methods, such as the use of the "priming" (divided dose) technique and the use of larger doses of atracurium and vecuronium, had been tried in an attempt to reduce the onset time of these neuromuscular blockers, these methods had either proved to be unsuccessful or hazardous to the patient, as in the case of the priming technique, or resulted in a long duration of action with the use of larger doses. In 1990, a new non-depolarizing muscle relaxant, Rocuronium Bromide, which challenged the onset time of Succinyl choline in facilitating safe and rapid endotracheal intubation, was introduced.[8] Rocuronium bromide is safe as there are no side effects such as histamine release, which is unlike other non-depolarizing muscle relaxants. This drug also maintains cardiovascular stability and is known for rapid recovery. It provides intubating conditions similar to those of succinyl choline 60 to 90s after administration. The dose of rocuronium usually defines onset time, duration, and intubating conditions. This study aimed to evaluate the quality of intubating conditions with rocuronium bromide and to compare it with that of succinylcholine for use in general anesthesia in adult patients.

Methods

This was a comparative study performed at the anesthesiology department of a tertiary care medical college in Maharashtra, India. The duration of study was 2 years, from January 2021 to December 2022. Sixty (60) patients undergoing various surgeries under general anesthesia during that period, such as laparoscopic appendectomy, laparoscopic cholecystectomy, tonsillectomy, laparoscopic ovarian cystectomy, and modified radical mastectomy. Patients who underwent elective surgeries under general anesthesia with ASA Grades I and II and Mallampati score of I and II were included in this study. Patients who refused to participate, those with Mallampati score of I and II as well as patients with ASA grade III and above were excluded from the study. Patients with known allergies to anesthetic drugs and serious comorbids were also excluded from the study. The institutional ethical committee approved the study and written informed consent was obtained from all the participants. The sample size was calculated on the basis of a pilot study done by Panda *et al*. by assuming 90% power and 95% confidence interval. The sample size required was 19 patients per arm (total n=38). Based on the central limit theorem, sample size was determined to be adequate if it was more than 25; thus, 30 patients were included in each group. Computer based randomization was used for randomization and anesthetists were blinded to the allocation information. Group S received intravenous Succinylcholine 1.5mg/kg while Group R received intravenous Rocuronium bromide 0.6mg/kg. All patients were thoroughly evaluated and intravenous cannula was secured with a 20G IV line. Patients were transferred to the operating room and IV fluid was started. Continuous monitoring of patients for heart rate, systolic and diastolic blood pressures, ECG, SPO2, and ETCO2 was also started. Patients were also premedicated with Inj. Glycopyrrolate 4 mcg/kg IV, as well as

with Inj.Midazolam0.05mg/kg IV and Fentanyl 2mcg/kg. Preoxygenation of 3 minutes was followed by induction with Inj. Propofol 2mg/kg IV Both drugs, either rocuronium bromide (Group R) or succinyl choline (Group S), were given to patients depending on the assigned group. Surgery commenced at 60 seconds in every patient. Patients were intubated with a cuffed endotracheal tube no. 7.0/8.0. In all patients, the quality of intubating conditions was assessed by using Cooper *et al.*[9] scoring system. The intubating conditions were divided into excellent (jaw relaxed, vocal cords apart and immobile, no diaphragmatic movements), good (jaw relaxed, vocal cords apart and immobile, some diaphragmatic movements), fair (jaw relaxed, vocal cords moving, "bucking"), or poor (jaw not relaxed; vocal cords closed). Excellent or good conditions were considered acceptable intubating conditions, while poor and inadequate conditions were regarded as unacceptable intubating conditions. During surgery, the anesthesia was maintained with oxygen, nitrous oxide (33:67), isoflurane, and intermittent positive pressure ventilation. The hemodynamic stability was then assessed by continuous monitoring of HR, saturation, and mean arterial pressure preoperatively and immediately after intubation, followed by monitoring at 10 min, 20 min, 30 min and 40 min after intubation. The side effects such as tachycardia, bradycardia, histamine release and laryngospasm, arrhythmia, and muscle fasciculation were noted in all cases. Duration of action of muscle relaxants was considered to be extending until recovery of spontaneous respiration. At the end of the procedure, all patients were reversed using neostigmine 0.04 mg/kg and Glycopyrrolate 0.005 mg/kg titrated to response and patient was extubated. SPSS 23.0 was used for data analysis. Descriptive statistics were elaborated in the form of means and standard deviations for continuous variables, while frequencies and percentages were used for categorical variables. Group comparisons were made using independent sample t-test for continuously distributed data and chi-square test for categorical data. Repeated observations were compared using paired t-test or repeated measures ANOVA as applicable. A P-value of less than 0.05 was taken as statistically significant.

Results

The two groups were compared for mean age, weight, gender distribution, and ASA Grades. The mean age of cases in group R and group S was found to be 35.12 +/- 7.46 and 32.34 +/- 6.98 years, respectively. The mean weight of patients in group R and S was found to be 62.34 +/- 7.86 kg and 60.12 +/- 6.98 kg, respectively. The mean age, weight, gender distribution, and ASA grades were found to be comparable in both groups with no statistically significant difference in any of these parameters. The Mallampati classification score of both the groups were also found to be comparable in both groups with no statistically significant difference ($p>0.05$; Table 1).

The most common surgery performed among participants in group R was laparoscopic appendectomy (33.33%) whereas in group S, laparoscopic cholecystectomy (36.67%) was more common. Overall, the most common surgery was laparoscopic cholecystectomy (33.33%), which was followed by laparoscopic cholecystectomy (31.67%). Other surgeries undertaken were Laparoscopic ovarian cystectomy (13.33%), tonsillectomy (11.67%), and Modified radical mastectomy (10%) (Fig. 1).

The comparison of the quality of intubating

Table 1 Comparison of Mean Age, Weight, Gender, ASA and MPC Grades in Patients

		Group R	Group S	p-value
Mean Age		35.12 +/- 7.46	32.34 +/- 6.98	0.079
Gender Distribution	Males	22 (73.33%)	17 (56.7%)	0.279
	Females	8 (26.66%)	13 (43.3%)	
Weight		62.34 +/- 7.86	60.12 +/- 6.98	0.079
ASA Grade	Grade I	22 (73.33%)	24 (80 %)	0.902
	Grade II	8 (26.66%)	6 (20%)	
MPC Grade	MPC I	16 (53.33%)	21 (70%)	0.288
	MPC II	14 (46.66%)	9 (30%)	

Table 2 Comparison of Quality of Intubating Conditions in Studied Cases

		Group			Fisher's Exact Test	
		R (n=30)	S (n=30)	Total (n=60)	$\chi 2$	P Value
Jaw Relaxation	Score 0	0	0	0	-	-
	Score 1	0	0	0	-	-
	Score 2	5 (16.7%)	0 (0.0%)	5 (8.3%)	5.455	0.052
	Score 3	25 (83.3%)	30 (100.0%)	55 (91.7%)		
Vocal Cord Position	Score 0	0	0	0	13.098	<0.001
	Score 1	4 (13.3%)	0 (0.0%)	4 (6.7%)		
	Score 2	13 (43.3%)	4 (13.3%)	17 (28.3%)		
	Score 3	13 (43.3%)	26 (86.7%)	39 (65.0%)		
Intubation Response	Score 0	0	0	0	8.182	0.012
	Score 1	6 (20.0%)	0 (0.0%)	6 (10.0%)		
	Score 2	12 (40.0%)	10 (33.3%)	22 (36.7%)		
	Score 3	12 (40.0%)	20 (66.7%)	32 (53.3%)		

conditions between the two groups showed that better jaw relaxation was seen in Group S, when compared to Group R; however, this difference was not found to be statistically significant. However, the analysis of two other parameters, vocal cord position and intubation response, showed that both parameters were better in Group S when compared to Group R, and the difference was statistically significant ($p<0.05$; Table 2).

Comparison of both groups on the basis of total score for quality of intubation showed that the mean total scores in Group R and Group S was 7.33 +/- 1.37 and 8.50 +/- 0.68, respectively. Group S had a better total score as compared to Group R, and the difference between the two groups in terms of Total Score was found to be significant (W=222.000, p=<0.001) The analysis of patients in both groups on the basis of duration of action (in minutes) of muscle relaxants showed that the mean durations of action in group R and group S were 22.93 +/- 5.45 and 11.97 +/- 1.71, respectively. The duration of action was longer in group R when compared to group S, and the difference was significant ($p<0.001$; Table 3).

The comparison of both the groups on the basis of quality of intubation showed that most of the patients in Group S had excellent

Table 3 Comparison of Mean Score of Quality of Intubation and Duration of Action in Both Groups

Mean Score of Quality of Intubation and Duration of Action		Group		Wilcoxon-Mann- Whitney U Test	
		R	S	W	p-value
Mean Score of Quality of Intubation	Mean (SD)	7.33 +/- 1.37	8.50 +/- 0.68	222.000	<0.001
	Median (IQR)	8 (6-8)	9 (8-9)		
	Range	5–9	7–9		
Duration of Action (Minutes)	Mean (SD)	22.93 +/- 5.45	11.97 +/- 1.71	899.000	<0.001
	Median (IQR)	22 (18.25–25)	12 (11–13)		
	Range	15–38	7–15		

Table 4 Comparison of Groups on the Basis of Overall Quality of Intubation and Acceptable Grades

Overall Quality of Intubation and Acceptable Grade		Group			Fisher's Exact Test	
		R (n=30)	S (n=30)	Total (n=60)	χ2	p-value
Overall Quality of Intubation	Excellent	16 (53.3%)	27 (90.0%)	43 (71.7%)	10.583	0.004
	Good	10 (33.3%)	3 (10.0%)	13 (21.7%)		
	Fair	4 (13.3%)	0 (0.0%)	4 (6.7%)		
Acceptable Grade	Yes	26 (86.7%)	30 (100.0%)	56 (93.3%)	4.286	0.112
	No	4 (13.3%)	0 (0.0%)	4 (6.7%)		

quality of intubation (90%) whereas good and fair quality was seen in 13 (21.7%) and 4 (6.7%) patients, respectively. In group R, excellent quality of intubation was seen in 16 (53.3%) patients. Overall quality of intubation was found to be better in group S as compared to group R, and the difference was statistically significant (P=0.004). Fisher's exact test was used to explore the association between the 'Group' and 'Acceptable Grade'. In group R, 26 (86.7%) patients had acceptable grades, whereas in group S, all 30 (100%) patients were found to have acceptable grades. Though comparatively less patients had acceptable grades in group R as compared to group S, the difference between groups in terms of distribution of acceptable grade was not found to be significant (χ2=4.286, p=0.112) (Table 4). Both groups were compared for heart rate, SPO2, and also mean arterial pressure pre-operatively and postoperatively, and until 12 hours. The heart rate was found to be comparable at all times, except for the rate at 15 minutes (P<0.05). Mean arterial pressure and SPO2 were found to be comparable in both groups at all the times with no statistically significant difference at any point in time (p>0.05; Table 5).

The analysis of side effects in both groups and their comparison showed that in group R 28 (93.33%) patients did not have any adverse effects while two (6.66%) patients developed tachycardia. In group S, one (3.33%) patient developed bradycardia. Muscle fasciculation's were seen in 24 (80%) of the patients in group S, whereas no patient in Group R developed fasciculation. Incidence of fasciculation was significantly more in group S when compared to Group R, and the difference was found to be highly significant (P=0.0001). Other side effects were comparable in both the groups.

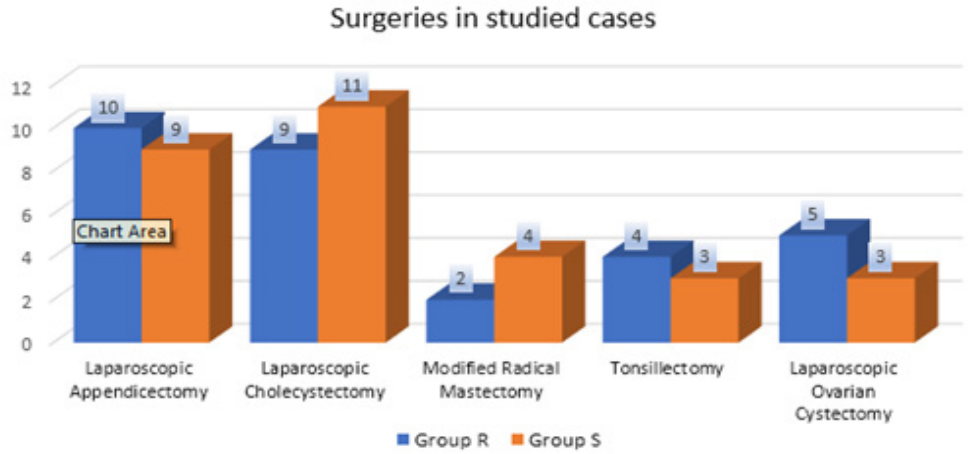

Fig. 1 Types of Surgeries in Studied Cases

Table 5 Comparison of Mean Heart Rate, Mean Arterial Pressure, and SPO_2

Heart Rate(BPM)		Group		P value (Wilcoxon-Mann- Whitney Test)
		Group R Mean (SD)	Group S Mean (SD)	
Heart Rate (BPM)	0 Min	84.12 +/- 8.98	82.36 +/- 8.12	p>0.05
	15 Min	86.28 +/- 9.12	76.42 +/- 8.34	p=0.0001
	30 Min	84.30 +/- 9.80	86.34 +/- 9.12	p>0.05
	1 Hr	82.07 +/- 9.04	84. 36 +/- 9.90	p>0.05
	2 Hr	83.74 +/- 8.18	82.46 +/- 8.86	p>0.05
	3 Hr	81.83 +/- 10.12	84.62+/- 8.12	p>0.05
	4 Hr	80.12 +/- 9.90	82.42 +/- 7.98	p>0.05
	5 Hr	82.86 +/- 10.12	84.34 +/- 8.84	p>0.05
	6 Hr	80.46 +/- 9.70	80.12 +/- 9.12	p>0.05
	7 Hr	78.34 +/- 9.34	80.34 +/- 8.12	p>0.05
	8 Hr	82.30 +/- 10.30	78.64 +/- 6.34	p>0.05
	9 Hr	84.12 +/- 6.82	82.34 +/- 6.58	p>0.05
	10 Hr	80.34 +/- 5.54	82.66 +/- 7.14	p>0.05
	11 Hr	78.54 +/- 6.12	80.12 +/- 6.78	p>0.05
	12 Hr	76.86 +/- 5.90	78.34 +/- 7.10	p>0.05
Mean Arterial Pressure	0 Min	90.92 +/- 8.34	89.03 +/- 8.10	p>0.05
	15 Min	92.34 +/- 8.24	96.87 +/- 10.24	p>0.05
	30 Min	96.96 +/- 9.12	93.37 +/- 9.48	p>0.05
	1 Hr	94.34 +/- 8.48	92.50 +/- 8.68	p>0.05
	2 Hr	96.24 +/- 9.34	91.70 +/- 7.78	p>0.05
	3 Hr	95.34 +/- 8.34	90.73 +/- 7.24	p>0.05
	4 Hr	92.20 +/- 9.84	94.40 +/- 8.12	p>0.05
	5 Hr	90.94 +/- 8.86	88.68 +/- 8.34	p>0.05
	6 Hr	88.34 +/- 9.12	86.34 +/- 9.12	p>0.05
	7 Hr	86.68 +/- 9.34	84.68 +/- 9.02	p>0.05
	8 Hr	88.54 +/- 9.12	90.34 +/- 10.34	p>0.05
	9 Hr	92.34 +/- 9.46	92.46 +/- 8.98	p>0.05
	10 Hr	90.86 +/- 8.24	90.34 +/- 9.46	p>0.05
	11 Hr	91.34 +/- 9.12	90.48 +/- 10.02	p>0.05
	12 Hr	90.56 +/- 9.02	88.62 +/- 9.90	p >0.05
Spo2	0 Min	99.6 +/- 0.48	99.4 +/- 0.86	p>0.05
	15 Min	99.4 +/- 0.86	99.54 +/- 0.74	p>0.05
	30 Min	99.6 +/- 0.48	99.60 +/- 0.48	p>0.05
	1 Hr	99.6+/- 0.48	99.20 +/- 0.72	p>0.05
	2 Hr	99.4 +/- 0.86	99.60 +/- 0.48	p>0.05
	3 Hr	99.2 +/- 0.74	99.40 +/- 0.86	p>0.05
	4 Hr	99.6 +/- 0.48	99.60 +/- 0.48	p>0.05

Table 5 (Continued)

	Heart Rate(BPM)	Group R Mean (SD)	Group S Mean (SD)	P value (Wilcoxon-Mann- Whitney Test)
Spo2	5 Hr	99.0 +/- 0.98	99.4 +/- 0.86	p>0.05
	6 Hr	98.80 +/- 1.12	99.2 +/- 0.74	p>0.05
	7 Hr	99.40 +/- 0.86	99.40 +/- 0.86	p>0.05
	8 Hr	99.60 +/- 0.48	98.12 +/- 0.74	p>0.05
	9 Hr	99.40 +/- 0.86	99.40 +/- 0.86	p>0.05
	10 Hr	99.60 +/- 0.48	99.60 +/- 0.48	p>0.05
	11 Hr	99.40 +/- 0.86	99.46 +/- 0. 46	p>0.05
	12 Hr	99.60 +/- 0.48	99. 34 +/- 0.84	p>0.05

Discussion

Rapid and safe endotracheal intubation is of paramount importance in practice of general anesthesia. The only muscle relaxant famous for its rapid onset of action was succinyl choline until the discovery of rocuronium bromide. The quest to find alternatives to succinyl choline has led scientist to look for new drug, and that is when rocuronium bromide, non-depolarizing muscle relaxant became famous for its comparable time of onset of action.[10] The newer drug also help overcome the side effects associated with succinyl choline, such as bradycardia, arrhythmias, hyperkalemia, variable increase in intraocular, intragastric and intracranial pressures. In the effort to compare the effectiveness of Rocuronium Bromide and Succinyl Choline, intubating conditions were assessed in this study. In this study, the comparison of quality of intubating conditions showed that vocal cord position and intubation response showed that both of these parameters are better in Group S than in Group R, and the difference is statistically significant (p<0.05). Tran DT *et al.* conducted an extensive literature review to determine whether rocuronium creates intubating conditions comparable to those of succinylcholine during RSI intubation.[11] For this purpose, they reviewed 37 randomized controlled trials (RCTs) or controlled clinical trials (CCTs) related to the use of rocuronium and succinylcholine. The study discovered that, overall, succinylcholine is superior to rocuronium for achieving excellent intubating conditions(RR 0.86 [95% CI, 0.81 to 0.92; n=4151] and clinically acceptable intubation conditions (RR 0.97, 95% CI, 0.95 to 0.99; n = 3992, 48 trials]). On the basis of these findings they concluded thatsuccinylcholine created superior intubation conditions to rocuronium in achieving excellent and clinically acceptable intubating conditions. Similar findings are also reported by other authors such as Guihard B *et al*[12] and Chavan SG *et al*.[13]

The analysis of patients in both groups on the basis of duration of action of muscle relaxants showed that the mean durations of action in group R and group S was 22.93 +/- 5.45 and 11.97 +/- 1.71 minutes, respectively. The longer duration of action was observed in group R as compared to group S, and the difference was highly significant (p<0.001). Magorian T *et al* undertook a study to compare rocuronium, succinylcholine, and vecuronium for rapid-sequence induction of anesthesia in adult patients.[14] In their study, fifty patients, ASA 1-3, were randomly designated to receive one of three intravenous doses of rocuronium (0.6, 0.9, and 1.2 mg/kg), vecuronium (0.1 mg/kg), or succinylcholine (1.0 mg/kg). Also, the time from injection of muscle relaxant until complete ablation of T1 (onset) and recovery of T1 to 25% (duration) were also recorded. The study found that the clinical duration of action was longest with 1.2 mg/kg rocuronium, which was similar with 0.6 and 0.9 mg/kg rocuronium, and vecuronium, and was least with succinylcholine. These findings are similar to this present study's findings. Similar findings were also reported by authors such as Li G *et al.*[15] and Sparr HJ *et al*.[16] The comparison of hemodynamic parameters in both groups demonstrated that the heart rate was found to be comparable at all the times, except at 10 minutes (p<0.05). Mean arterial pressure and SPO2 were found to be

comparable in both groups at all the times with no statistically significant difference at any point in time (p>0.05). Lenin *et al*.[17] undertook a study to compare the onset time, duration of action, intubating condition, and the hemodynamic effects of rocuronium bromide at the dose of 0.8 mg/kg and Succinylcholine at the dose of 1.5 mg/kg. The study found that both drugs raised mean heart rate, systolic blood pressure, diastolic blood pressure, and MAP from intubation to subsequent intervals; however, despite being comparable, this increase is not statistically significant different between the groups. Similar hemodynamic comparability between succinylcholine and rocuronium is also reported by other authors such as Sorensen *et al*.[18] and Li *et al*.[19] The analysis of cases on the basis of adverse effects showed that the incidence of fasciculation is significantly more in group S as compared to Group R, and the difference is highly significant (p=0.0001). Other side effects are comparable in both groups. Twenty four (24, 80%) patients in group S experienced muscle fasciculation, while none in group R experienced this. Similar findings are also reported by Zhang *et al*.[20]

Small number of cases and the use of fixed dose of rocuronium are the limitations of our study. A similar study with larger cohort will further substantiate the findings of this study. In conclusion, the use of succinylcholine for rapid sequence intubation is found to be associated with better intubation conditions as compared to rocuronium.

References

1. Spirova EN, Ivanov IA, Kasheverov IE, et al. Curare alkaloids from Matis Dart Poison: Comparison with d-tubocurarine in interactions with nicotinic, 5-HT3 serotonin and GABAA receptors. PLoS One. 2019; 14(1):e0210182. doi:10.1371/journal.pone.0210182.
2. Bhat R, Sanickop CS, Patil MC, Umrani VS, Dhorigol MG. Comparison of Macintosh laryngoscope and C-MAC video laryngoscope for intubation in lateral position. J Anaesthesiol Clin Pharmacol. 2015;31(2):226–9. doi:10.4103/0970-9185.155221.
3. Patel S, Shukla J, Jain S, Paliwal V, Tripathi N, Paliwal S, et al. Repositioning of tubocurarine as analgesic and anti-inflammatory agent: Exploring beyond myorelaxant activity. Biochem Pharmacol. 2022;205:115248. doi:10.1016/j.bcp.2022. 115248
4. Martini CH, Honing GHM, Bash LD, Olofsen E, Niesters M, van Velzen M, et al. The use of muscle relaxants and reversal agents in a setting without cost restrictions: experience from a Tertiary Academic Hospital in the Netherlands. Ther Clin Risk Manag. 2022;18:379-90. doi:10.2147/TCRM.S350314.
5. Bohringer C, Moua H, Liu H. Is there still a role for succinylcholine in contemporary clinical practice?. Transl Perioper Pain Med. 2019; 6(4):129-35. doi:10.31480/2330-4871/100
6. Luxen J, Trentzsch H, Urban B. Rocuronium und Sugammadex in der Notfallmedizin: Anforderungen an ein Muskelrelaxans für die “rapid sequence induction” [Rocuronium and sugammadex in emergency medicine: requirements of a muscle relaxant for rapid sequence induction]. Anaesthesist. 2014; 63(4):331–7. doi:10.1007/s00101-014-2303-1
7. Mørk EL, Kristensen ML, Stokholm JB, Söderström CM, Madsen MV, Gätke MR. Resistance towards nondepolarising muscle relaxants: prolonged onset time: A systematic review. Eur J Anaesthesiol. 2019; 36(7):477–85. doi:10.1097/EJA.0000000000000991
8. Tachikawa M, Asai T, Okuda Y. Rocuronium bromide intravenous solution maruishi is more suitable than ESLAX intravenous during rapid-sequence induction of anesthesia. J Anesth. 2019; 33(5):600–3. doi: 10.1007/s00540-019-02673-x.
9. Cooper R, Mirakhur RK, Clarke RS, Boules Z. Comparison of intubating conditions after administration of Org 9246 (rocuronium) and suxamethonium. Br J Anaesth. 1992; 69(3):269–73. doi:10.1093/bja/69.3.269
10. Yuan H, Zhang S, Yin L, Luo T, Zhang R, Wu S. The safety of high-dose rocuronium bromide in general anesthesia for spinal surgery and its effects on muscle relaxation. Am J Transl Res. 2021;13(7):8110–7.
11. Tran DT, Newton EK, Mount VA, Lee JS, Wells GA, Perry JJ. Rocuronium versus succinylcholine for rapid sequence induction intubation. Cochrane Database Syst Rev. 2015;2015(10):CD002788. doi:10.1002/14651858.CD002788.pub3
12. Guihard B, Chollet-Xémard C, Lakhnati P,

Vivien B, Broche C, Savary D, et al. Effect of rocuronium vs succinylcholine on endotracheal intubation success rate among patients undergoing out-of-hospital rapid sequence intubation: a randomized clinical trial. JAMA. 2019; 322(23):2303–12. doi:10.1001/jama.2019.18254

13. 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(4):379–83. doi:10.4103/1658-354X.177330
14. Magorian T, Flannery KB, Miller RD. Comparison of rocuronium, succinylcholine, and vecuronium for rapid-sequence induction of anesthesia in adult patients. Anesthesiology. 1993;79(5):913–18. doi:10.1097/00000542-199311000-00007
15. Li G, Cheng L, Wang J. Comparison of rocuronium with succinylcholine for rapid sequence induction intubation in the Emergency Department: a retrospective study at a Single Center in China. Med Sci Monit. 2021;27:e928462. doi:10.12659/MSM.928462
16. Wilson JW, Gillen JP, Maute T. Patient safety during rapid sequence intubation when using succinylcholine instead of nondepolarizing paralytic agents: should we change a common rapid sequence intubation pathway?. J Emerg Trauma Shock. 2020;13(4):264–68. doi:10.4103/JETS.JETS_92_18
17. Lenin P, Rajaraman R, Stalin R, Manikandan G. A comparative study between rocuronium and succinylcholine in evaluating endotracheal intubating conditions in day care surgeries. IAIM, 2022;9(1): 34–9.
18. Marsch SC, Steiner L, Bucher E, Pargger H, Schumann M, Aebi T, et al. Succinylcholine versus rocuronium for rapid sequence intubation in intensive care: a prospective, randomized controlled trial. Crit Care. 2011;15(4):R199. doi:10.1186/cc10367
19. Sørensen MK, Bretlau C, Gätke MR, Sørensen AM, Rasmussen LS. Rapid sequence induction and intubation with rocuronium-sugammadex compared with succinylcholine: a randomized trial. Br J Anaesth. 2012;108(4):682–9. doi:10.1093/bja/aer503
20. Zhang Z, Zhang DS, Sui W, Liu XH, Zhang L, Sun JH. Effects of pretreatment with different doses of cisatracurium on succinylcholine-induced fasciculations. Int J Clin Pharmacol Ther. 2016;54(6):426–32. doi:10.5414/CP202531