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Original Article

Comparison of Efficacy and Safety Between Sugammadex and Neostigmine in Reversal of Vecuronium Induced Neuromuscular Blockade in Adults

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ABSTRACT

Introduction: A Reversal agents restore neuromuscular function after muscle relaxants; neostigmine has side effects, while sugammadex specifically reverses aminosteroidal neuromuscular blockers. **Aim**: To compare the recovery time, haemodynamic stability and complications between neostigmine of 70 mcg/kg + glyco 10mcg/kg & sugammadex - 4 mg /kg in antagonizing the effects of vecuronium in adults. **Methodology** : This prospective randomized,double - blinded controlled trail included 60 adult patients (18-70 years)undergoing surgery under general anaesthesia requiring vecuronium. Patients were randomly allocated into 2 groups: Group N: neostigmine (70mcg/kg with glycopyrrolate 10mcg/kg)& Group S: sugammadex (4mg/kg).
Neuromuscular monitoring was performed using acceleromyography with train - of-four(TOF)stimulation. Recovery time from reversal administration at TOF count 4, haemodynamic parameters, post extubation complications were recorded. **Results** : The mean recovery time was significantly longer in the neostigmine group (11.26±3.53 mins) compared to the sugammadex group(5.6±1.56 mins) with a mean difference of 5.66 mins with significant p value($p<0.01$). Haemodynamic fluctuations and heart rate changes were more pronounced in the neostigmine group.Post operative complications like nausea ,vomiting and sweating occurred only in the neostigmine group. **Conclusion**: Sugammadex provides faster neuromuscular recovery, better haemodynamic stability and fewer complications than neostigmine for reversal of vecuronium -induced neuromuscular blockade in adult patients.

Keywords: *Neostigmine, Sugammadex, General Anaesthesia , Vecuronium, Train of Four monitoring, Recovery time.*

INTRODUCTION

Neuromuscular blocking agents (NMBAs) are commonly used during general anaesthesia to facilitate tracheal intubation, mechanical ventilation, and adequate muscle relaxation for surgical procedures[1]. Following surgery, reversal agents are administered once neuromuscular function begins to recover, in order to fasten recovery and prevent postoperative residual neuromuscular blockade (PRNB)[2,3]. However, the use of NMBAs carries a risk of PRNB, which may lead to airway obstruction, pulmonary complications, hypoxia, and increased postoperative morbidity and mortality[4–6].

Several strategies are used to reduce the incidence of residual blockade. One approach is allowing spontaneous recovery combined with clinical assessment of neuromuscular function. However, clinical tests such as head lift, leg lift, or hand grip are unreliable and do not provide objective assessment of neuromuscular recovery[7]. Quantitative neuromuscular monitoring, particularly train-of-four (TOF) count and ratio, offers a more accurate and practical method to assess the depth of blockade and recovery prior to reversal. Although not routinely used, TOF monitoring significantly reduces the incidence of residual blockade and associated complications[8–10] and guides the need for pharmacological reversal.

Neostigmine, an anticholinesterase inhibitor, has been widely used since the 1970s to reverse both aminosteroidal and benzylisoquinoline NMBAs. However, acetylcholinesterase inhibitors such as neostigmine and edrophonium are associated with muscarinic side effects, necessitating the concurrent use of anticholinergic agents[11,12]. Despite their use, residual neuromuscular blockade remains common in both adult and paediatric populations[13–15].

Sugammadex is a modified γ-cyclodextrin sodium salt and the first selective relaxant-binding agent, introduced in 2008. It selectively reverses aminosteroidal NMBAs—most effectively rocuronium, followed by vecuronium and pancuronium—by encapsulating the drug in a stable 1:1 water-soluble complex. This creates a concentration gradient that rapidly removes the NMBA from the neuromuscular junction, preventing binding to nicotinic receptors. Due to its low dissociation rate, sugammadex produces rapid and reliable reversal without associated muscle weakness[16–19].

The purpose of this study is to compare the efficacy and safety of sugammadex and neostigmine in the reversal of vecuronium induced neuromuscular blockade, as sugammadex is selectively reverses aminosteroidal NMBAs,by assessing the time of recovery from neuromuscular blockade to reappearance of train-of-four (TOF) count 4 among sugammadex and neostigmine,incidence of hemodynamic adverse effects (tachycardia, bradycardia, hypertension and hypotension) and adverse affects (nausea, vomiting, shivering)

MATERIALS AND METHODS

The present clinical comparative study was conducted on 60 patients posted for elective surgery selected randomly at Alluri sitarama raju academy of medical sciences, Eluru. After receiving ethical committee approval and informed consent from patients,the study was carried out.

Following criteria were adopted for selecting the patients.

Inclusion criteria:-

- ASA grade 1,2 & 3.
- Age 18-70 years
- Patients getting general anaesthesia for elective surgery.

Exclusion criteria:- ASA grade 4, 5 &6

- Patients with anticipated difficult airway
- H/O neuromuscular disorders
- H/O malignant hyperthermia
- H/O significant renal and hepatic dysfunction
- H/O muscle relaxants allergy, sugammadex neostigmine and glycopyrrolate
- Pregnant women and lactating mothers
- Patients who refused giving consent.

Patients were selected after through pre-anaesthetic assessment and investigations.Based on past studies,the sample size was determined to be 30 in each group.During the preoperative evaluation, the study details were explained to all the patients. Informed consent were obtained from all those patients who volunteered the study. Using the closed envelope technique,they were randomly assigned to one of the two groups.

Group N: Neostigmine 70µg/kg and glycopyrolate 10µ/kg diluted in 10ml

Group S: Sugammadex 4mg/kg diluted in 10ml

Investigations:

- Complete Hemogram
- Blood sugar levels
- Renal function test
- ECG
- Chest X –ray
- Coagulation profile

Premedication:

All of the patients were examined the day before surgery, and pre anaesthetic counseling was done. All patients received alprazolam 0.5mg orally on the night before surgery and Ranitidine 150mg on the day of surgery.

Study procedure:- Patient was shifted to operation theatre and an IV cannula was placed into a vein of the forearm. Electrocardiograph, noninvasive arterial blood pressure measurements and pulse oximetry were used as part of standard monitoring. Endtidal CO2 and isoflurane as well were measured.

Induction of general anaesthesia was done by using IV opioid and IV propofol and maintenance of anaesthesia by using isoflurane 1-2vol%. Opioids were given according to need of each patients . Monitoring of neuromuscular activity was commenced using a peripheral nerve stimulator (TOFWatch ,NS-100)at the adductor pollicis muscle after induction of anaesthesia but before injection of vecuronium, train of four(TOF) stimulation was administered to the ulnar nerve at the wrist until the the baseline TOF count 4 was recorded. In pharmacodynamic studies of NMBD,TOF-Watch was stabilised and calibrated according to excellent clinical research practise. The patient‘s lungs were ventilated through face mask with oxygen /air at normocapnia at that period(3-10 minutes). After the TOF-Watch was setup and stabilised,a single blooms dose of IV vecuronium 0.1mg/kg was given as a fast running infusion,and tracheal intubation was performed after full blockage was achieved. TOF count was monitored to ensure adequate neuromuscular achieved with TOF count of 1-2.

Maintaining the anaesthesia with O_2 + N_2O (50%+50%) + inhalational agent isoflurane , vecuronium (0.02–0.03mg/kg) dose when required when TOF count was ≥ 3 .

Reversal:
Group N- Neostigmine 70 mcg/kg and glycopyrolate 10 mcg/kg diluted to 10 ml
Group S- Sugammadex 4mg/kg diluted to 10ml
TOF count will be observed at adductor pollicis muscle and will be assessed after giving reversal for every 15 sec.
TOF count of 4 will be considered as adequate reversal.
Hemodynamic parameters (HR, SBP, DBP, MBP) will be assessed every
minute until extubation, and every 5min for 30 min after extubation.

- HR< 60 will be considered as bradycardia and will be treated with inj atropine 0.6 mg bolus
- HR > 100 will be considered as tachycardia and will be treated with inj esmolol 0.5 mg/kg bolus
- SBP< 20% from baseline will be considered hypotension and will be treated with inj mephenteramine 3mg bolus
- Other adverse effects (eg. nausea, vomiting, shivering) will be noted.

Parameters studied are:
1. Time of recovery from the neuromuscular block to reappearance of TOF count four after giving reversal.
2. Incidence of hemodynamic adverse affects (tachycardia bradycardia, hypertension, and hypotension).
3 .Incidence of other side effects (nausea, vomiting and shivering).

STATISTICAL ANALYSIS:
The information collected regarding all the cases was recorded in a Master sheet. Data analysis was done with the help of computer using MS-Excel, SPSS 22.0 (Trail version). Using this software, frequencies, percentage, range, mean, standard deviation. Chi- test, ANOVA-test and p_values were calculated. A p_value<0.05 is shown to have significant relationship.
Terms used for Statistical significance
NS: not significant
S: significant
HS: highly significant

OBSERVATION AND RESULTS
DEMOGRAPHIC DATA

Table 1: Age-Wise Distribution of study groups

Age in years	**NEOSTIGMINE**		**SUGAMMADEX**		**t* val ue**	**p value**	**Significance**
	No.	**%**	**No.**	**%**			
15-30	10	33.3	10	33.3			
31-45	14	46.7	12	40			
46-60	6	20	8	26.7	**0.293**	**0.385**	Not Significant
TOTAL	30	100	30	100			

Samples are age matched with p value of 0.385 (p>0.05), hence statistically not significant. So, the age distribution in the both groups is comparable.

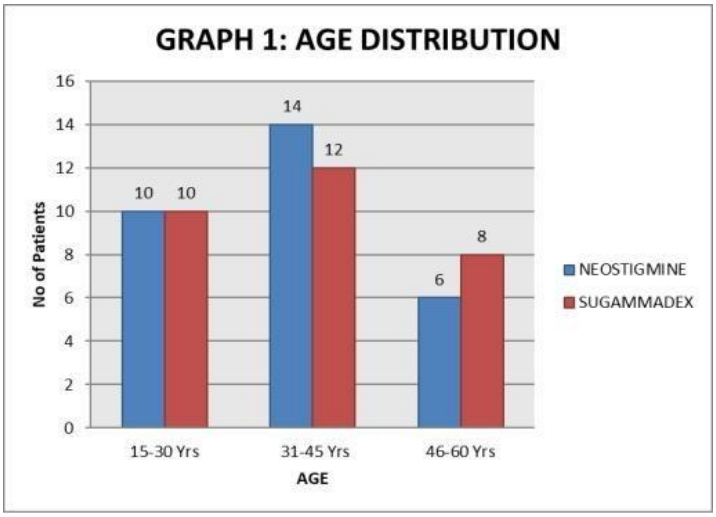
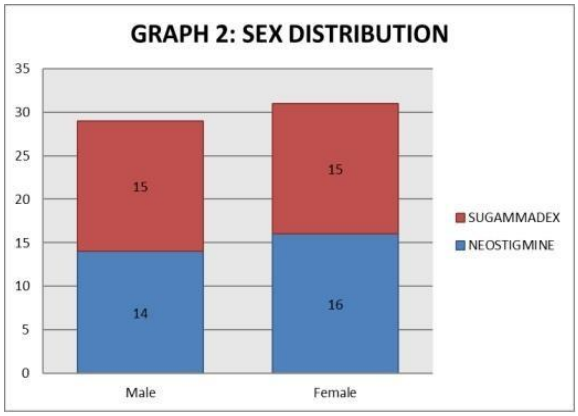


Table 2: Gender Comparison between study groups

Gender	Study Group		p value	Significance
	NEOSTIGMINE	SUGAMMADEX		
Male	14	15	0.795	Not Significant
Female	16	15		

In table 2 and graph 2, the gender distribution (male: female ratio) in
Neostigmine was 14:16 while in Sugammadex, it was 15:15. P value was 0.795 (p>0.5). Hence, it is not significant and the groups are comparable.

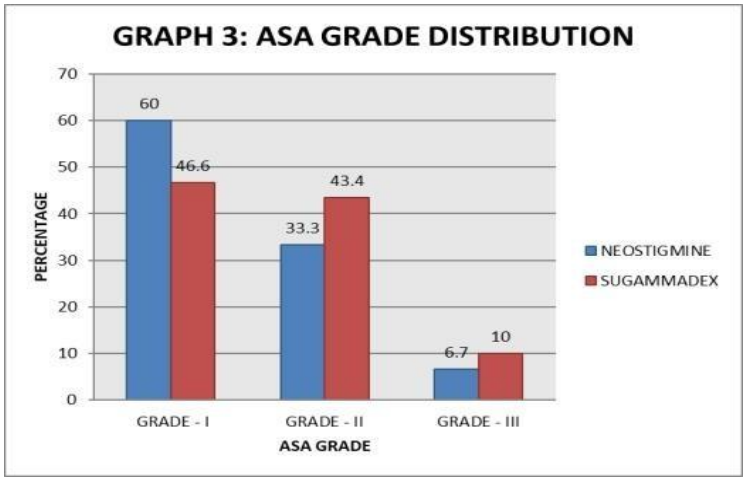


In table 3 and graph 3 comparison of two groups in terms of ASA grading was done and it was not significant and hence groups were similar in terms of choosing patients.

Table 3: Comparison of Neostigmine and Sugammadex NMB based on ASA Grade:

ASA GRADE	Study Groups	
	NEOSTIGMINE (%)	SUGAMMADEX (%)
GRADE - I	18 (60 %)	14 (46.6%)
GRADE - II	10 (33.3 %)	13 (43.4%)
GRADE - III	2 (6.7 %)	3 (10 %)
TOTAL	30 (100%)	30 (100%)

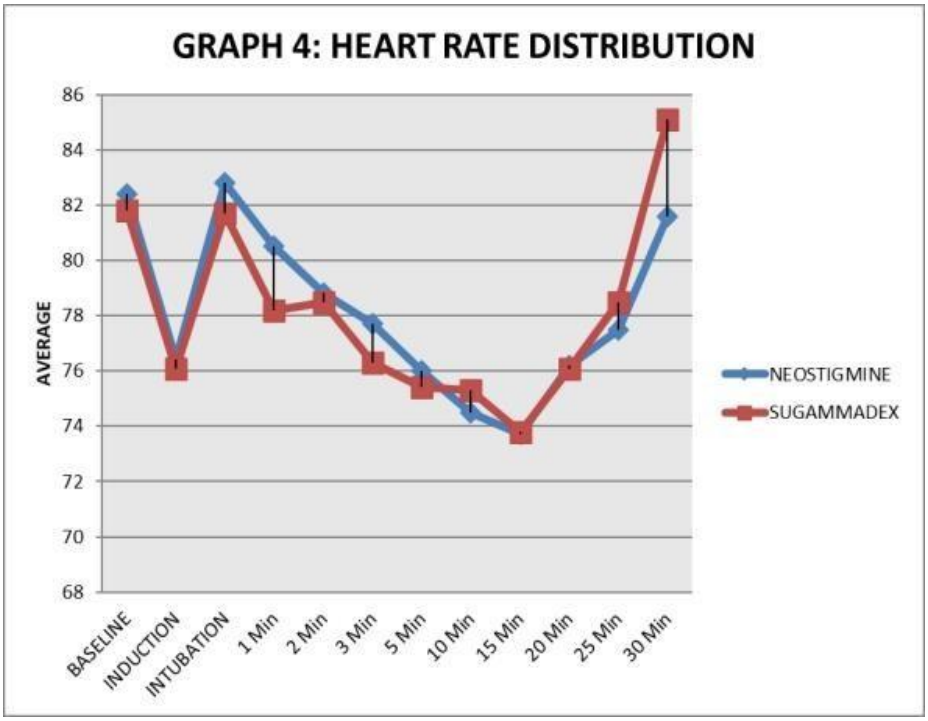
Chi Square test Not Significant: p- value 0.579 (>0.05)



Student's unpaired t test NS = Not Significant (p value > 0.05)
Table 4 and graph 4 shows, there is no significant change in the heart rate between the 2 groups. (p>0.05), in 30 Min there is a significant change in two groups p value is 0.04 (p<0.05).

Table 4: Comparison of Neostigmine and Sugammadex NMB on the basis of heart rate (beats / min

Time of Assessment	Mean+/- SD		Mean ference	t* Value	p Value	Signifi cance
	NEOSTIGMINE	SUGAMMADEX				
BASELINE	82.4±7.8	81.8±6.6	0.6	0.33	0.36	NS
INDUCTION	76.4±10.8	76.1±6.9	0.3	0.16	0.43	NS
INTUBATION	82.8±9.6	81.7±6.9	1.1	0.53	0.29	NS
AFTER ADMINISTRATION OF REVERSAL						
5 Min	80.5±9.1	78.2±7.8	2.3	1.06	0.14	NS
10 Min	78.8±8.4	78.5±7.6	0.3	0.11	0.45	NS
15Min	77.7±8.1	76.3±6.1	1.4	0.74	0.23	NS
AFTER EXTUBATION						
5 Min	76±7.7	75.4±5.5	0.6	0.32	0.37	NS
10 Min	74.5±7.6	75.3±5.1	0.8	0.47	0.31	NS
15 Min	73.7±7.5	73.8±5.9	0.1	0.52	0.36	NS
20 Min	76.2±7.8	76.1±7.2	0.1	0.29	0.31	NS
25 Min	77.5±8.1	78.5±7.6	1	0.47	0.32	NS
30 Min	81.6±7.76	85.1±7.2	3.5	1.75	0.04	S**



As shown in the table 5 and graph 5, there is no significant change in the Mean arterial pressure between the 2 groups. ($p>0.05$) but only at 20 Min there is a significant change in two groups p value is 0.03 ($p<0.05$)

Table 5: Comparison of Neostigmine and Sugammadex NMB based on Mean arterial pressure (mm Hg)

Time of Assessment	Mean+/- SD		Mean Difference	t* Value	p Value	Significance
	NEOSTIGMINE	SUGAMMADEX				
BASELINE	82±7.7	81.8±6.4	1	0.09	0.46	NS
INDUCTION	76±11.1	75.8±7.1	0.2	0.08	0.45	NS
INTUBATION	83.1±7.8	79.6±15.2	3.5	1.05	0.14	NS
AFTER ADMINISTRATING REVERSAL						
5 Min	85.1±7.8	83.6±6.9	1.5	0.72	0.23	NS
10Min	83.5±7.7	82.9±6.5	0.6	0.07	0.42	NS
15Min	82.2±7.4	82.4±6.2	0.2	0.08	0.45	NS
AFTER EXTUBATION						
5 Min	82.5±7.2	81.9±6.3	0.6	0.05	0.41	NS
10 Min	82.4±6.7	82.6±5.4	0.2	0.12	0.44	NS
15 Min	83.1±6.1	83.1±7.1	0	0.03	0.48	NS
20 Min	86.1±6.8	82.9±6.7	3.2	1.83	0.03	S**
25 Min	88.4±5.6	88.6±7.3	0.2	0.07	0.41	NS
30 Min	93±7.5	95.3±7.3	2.3	1.2	0.11	NS

Student's unpaired t test NS = Not Significant (p value > 0.05)

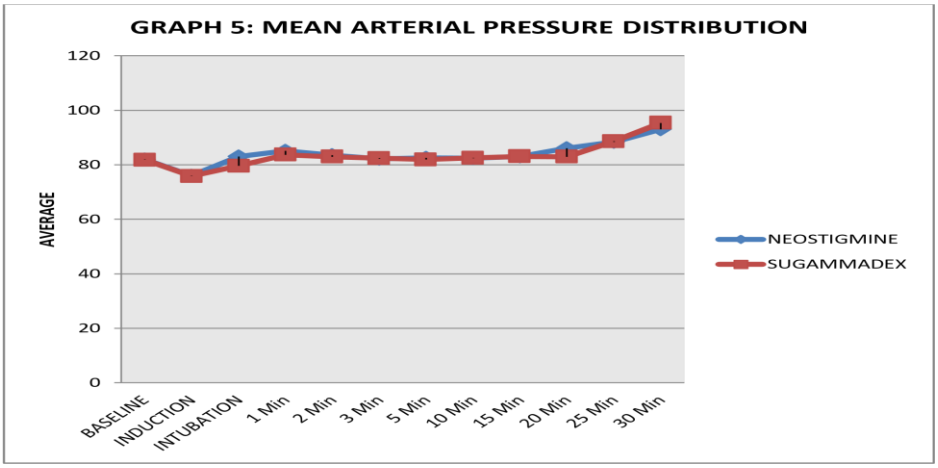


Table 6 and graph 6 shows, there is no significant change in the End tidal carbon dioxide between the 2 groups. (p>0.05), but at time of Induction, 15 min post reversal, and 10 min, 20 min & 30 min post extubation there is a significant change in two groups p values (p<0.05).

Table 6: Comparison of Neostigmine and Sugammadex NMB based on End tidal carbon dioxide

Time of Assessment	Mean+/- SD		Mean Differen ce	t* Value	p Value	Signifi cance
	NEOSTIGMINE	SUGAMMADEX				
BASELINE	33.4±2.3	33.2±2.3	0.2	0.33	0.3	NS
INDUCTION	33.3±2.1	31.9±1.9	1.4	2.06	0.004	S**
INTUBATION	32.4±2.1	32.8±1.6	0.4	0.8	0.2	NS
AFTER ADMINISTERING REVERSAL						
5 Min	33.3±1.7	32.7±1.3	0.6	0.5	0.6	NS
10 Min	33.6±2.4	33.2±2.4	0.4	0.9	0.8	NS
15Min	33.5±1.9	31.8±1.8	1.7	3.4	0.001	S**
AFTER EXTUBATION						
5 Min	33.8±2.4	32.9±2.2	0.9	1.1	0.7	NS
10 Min	33.2±1.9	31.9±1.9	1.3	2.5	0.005	S**
15 Min	33.8±2.4	32.9±2.2	1.2	1.4	0.07	NS
20 Min	33.4±1.8	31.8±1.8	1.6	0.36	0.35	S**
25 Min	33.4±2.3	32.6±2.3	0.8	0.7	0.9	NS
30 Min	33.2±1.9	31.9±1.9	1.3	2.5	0.005	S**

* Student's unpaired t test NS = Not Significant (p value > 0.05)

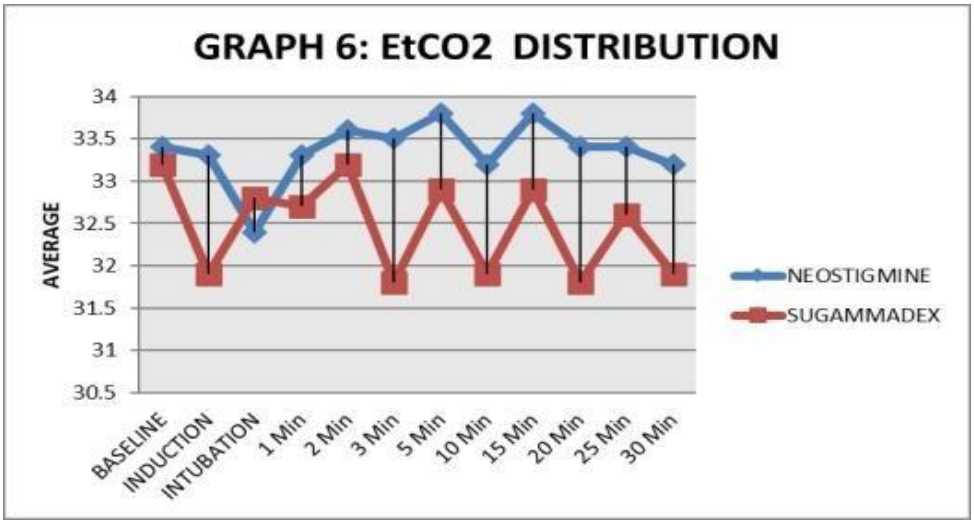
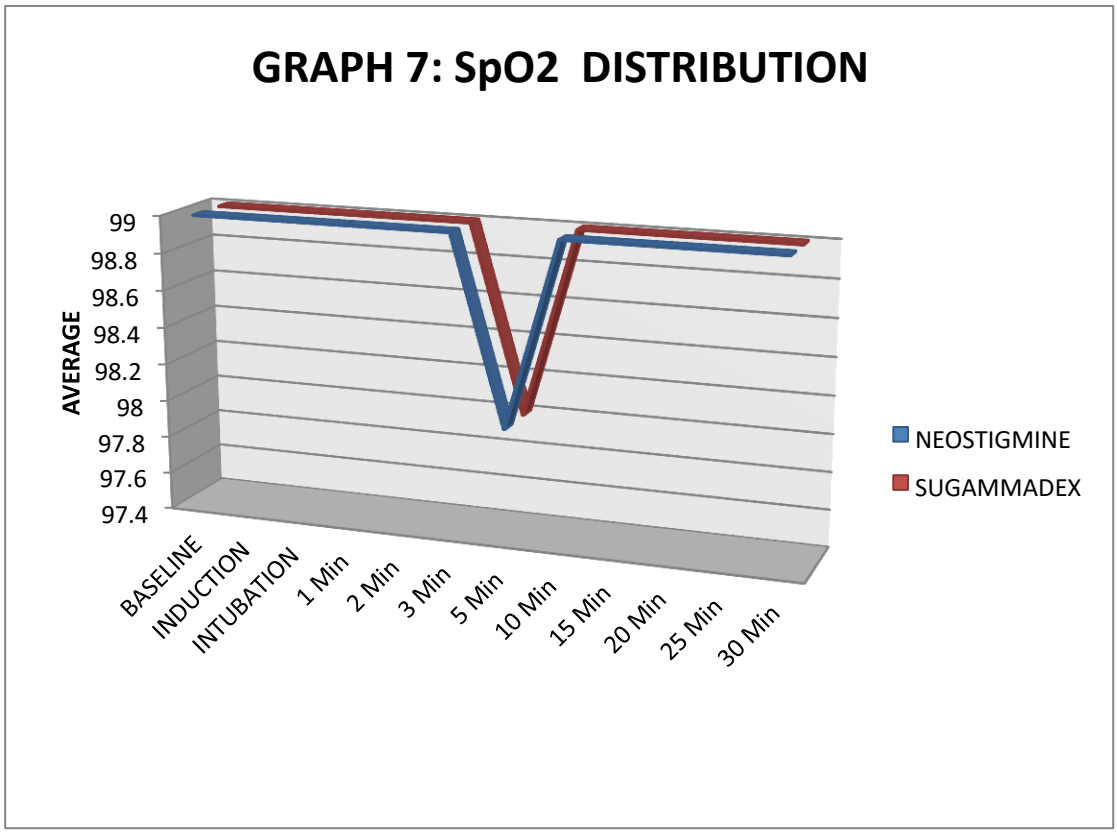


Table 7 and graph 7 shows, there is no significant change in the Peripheral capillary oxygen saturation between the 2 groups. (p>0.05)

Table 7: Comparison of Neostigmine and Sugammadex NMB based on Peripheral capillary oxygen saturation

Time of Assessment	Mean+/- SD		Mean Difference	t* Value	p Value	Significance
	NEOSTIGMINE	SUGAMMADEX				
BASELINE	99±0.008	99±0.009	0	0.29	0.38	NS
INDUCTION	99±0.008	99±0.009	0	0.28	0.36	NS
INTUBATION	99±0.008	99±0.009	0	0.25	0.32	NS
AFTER ADMINISTRATION OF REVERSAL						
5 Min	99±0.008	99±0.009	0	0.27	0.32	NS
10Min	99±0.008	99±0.009	0	0.25	0.31	NS
15 Min	99±0.008	99±0.009	0	0.26	0.34	NS
AFTER EXTUBATION						
5 Min	98±0.013	98±0.011	0	0.10	0.45	NS
10 Min	99±0.008	99±0.009	0	0.21	0.36	NS
15 Min	99±0.008	99±0.009	0	0.28	0.34	NS
20 Min	99±0.008	99±0.009	0	0.29	0.31	NS
25 Min	99±0.008	99±0.009	0	0.25	0.36	NS
30 Min	99±0.008	99±0.009	0	0.27	0.34	NS

* Student's unpaired t test NS = Not Significant (p value > 0.05)



As shown in the table 8 and graph 8, there is highly significant change in the TOF Count between the 2 groups. (p>0.05)

Table 8: Comparison of Neostigmine and Sugammadex NMB based on the TOF Count

Time of Assessment	Mean+/- SD		Mean Difference	t* Value	p Value	Significance
	NEOSTIGMINE	SUGAMMADEX				
BASELINE	4±0	4±0	0	0	0	--
INDUCTION	0	0	0	0	0	--
INTUBATION	0	0	0	0	0	--
AFTER ADMINISTERING REVERSAL						
5 Min	2.3±1.3	4±0	1.7	6.6	0.000	HS
10 Min	2.8±1.04	4±0	1.2	5.5	0.000	HS
15 Min	3.9±0.18	4±0	1.1	1	0.16	NS
AFTER EXTUBATION						
5 Min	4±0	4±0	0	0	0	--

10 Min	4±0	4±0	0	0	0	--
15 Min	4±0	4±0	0	0	0	--
20 Min	4±0	4±0	0	0	0	--
25 Min	4±0	4±0	0	0	0	--
30 Min	4±0	4±0	0	0	0	--

Student's unpaired t test HS = Highly Significant (p value < 0.01)

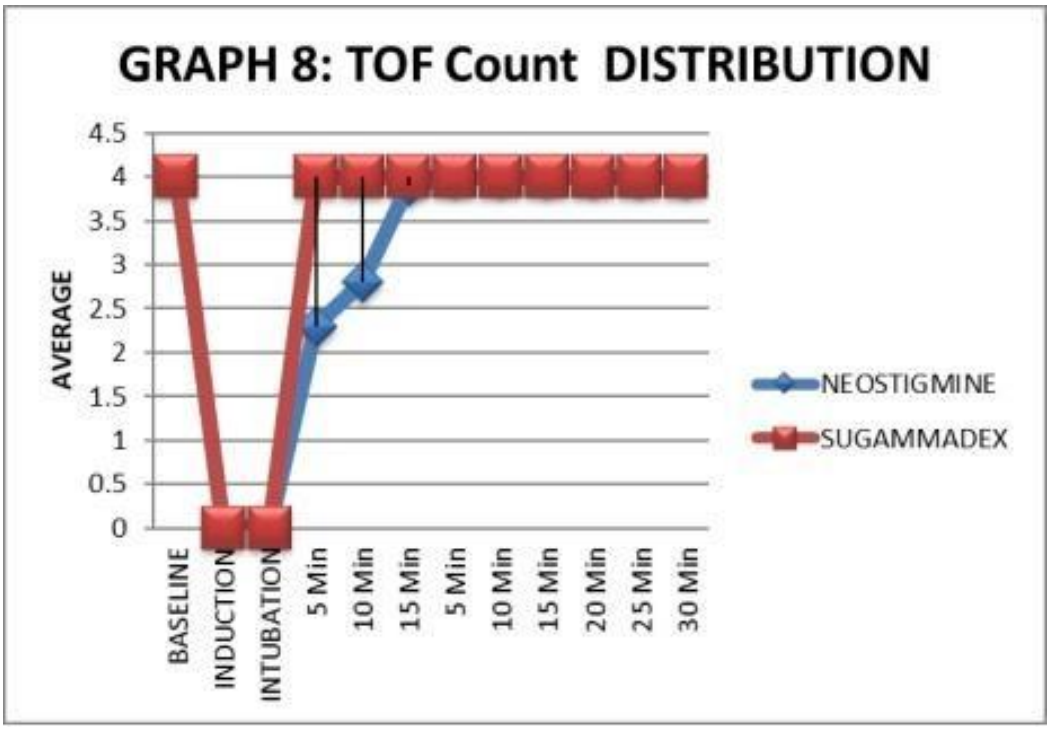
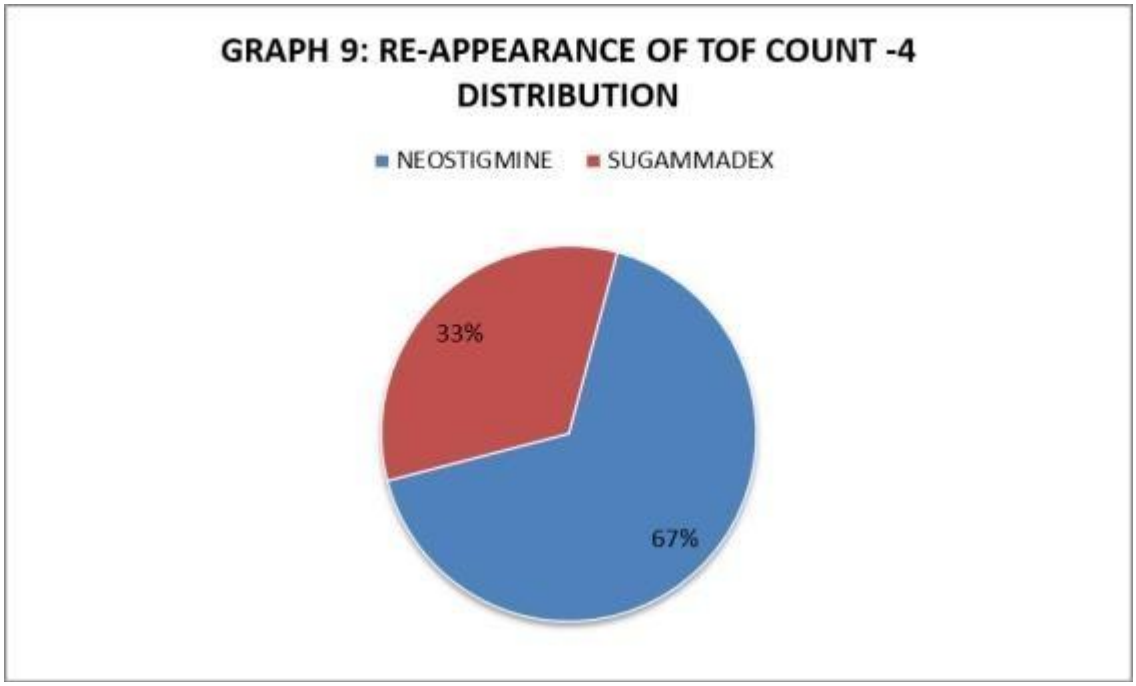


Table 9 and graph 9 shows , there is highly significant change in the RE-APPEARANCE OF TOF COUNT -4 between the 2 groups. (p<0.01)

Table 9: Comparison of Neostigmine and Sugammadex NMB based on the recovery time from last dose of muscle relaxant to RE-APPEARANCE OF TOF COUNT -4

Study Group	Mean±SD (hrs)	Mean Difference	t* value	p value	Significance
NEOSTIGMINE	11.26±3.53	5.66	8.03	0.0001	Highly Significant
SUGAMMADEX	5.6±1.56				

Student's unpaired t test Highly significant - p<0.01



As shown in table 10 there were no adverse effects in group sugammadex whereas group neostigmine had 2 patients each with vomiting and shivering as side effects.

Table 10: Comparison of Neostigmine and Sugammadex NMB based on the Adverse Effects.

Adverse Effects	**NEOSTIGMINE**	**SUGAMMADEX**
NO	26 (86.8%)	30 (100%)
Vomiting	2 (6.6%)	0
Shivering	2 (6.6%)	0
TOTAL	30 (100%)	30 (100%)

DISCUSSION:

The introduction of sugammadex in 2008 marked a milestone in anesthetic pharmacology. Unlike acetylcholinesterase inhibitors such as neostigmine, sugammadex is a modified γ-cyclodextrin that selectively encapsulates aminosteroid neuromuscular blocking agents, including rocuronium and vecuronium. By forming a tight complex with these molecules, sugammadex rapidly reduces their free plasma concentration, creating a concentration gradient that promotes dissociation from the neuromuscular junction and leads to prompt reversal. This mechanism overcomes many of the limitations associated with neostigmine, including dependence on partial spontaneous recovery and cholinergic adverse effects.

In the present study, we compared the efficacy and safety of sugammadex and neostigmine for reversal of vecuronium-induced neuromuscular blockade. The primary endpoint was the time required for reappearance of TOF count 4. Sugammadex was administered at a dose of 4 mg/kg, and adequate reversal was defined as achieving TOF count 4 within a mean time of 5 minutes. Reversal failure was defined as inability to achieve TOF count 4 within 30 minutes. Secondary outcomes included hemodynamic changes and postoperative adverse effects.

Our findings demonstrate that sugammadex provides significantly faster reversal compared to neostigmine. In the sugammadex group, the mean recovery time to TOF count 4 was 5.6 ± 1.56 minutes, whereas in the neostigmine group it was 11.26 ± 3.53 minutes, with a highly significant difference ($p < 0.01$). All patients receiving sugammadex achieved successful reversal within the defined time frame, and 80% recovered within 5 minutes. In contrast, none of the patients receiving neostigmine recovered within 5 minutes, and a substantial proportion required more than 15 minutes. These findings indicate not only faster reversal with sugammadex but also greater predictability.

Pharmacological differences may explain these results. Sugammadex has a higher binding affinity for rocuronium than for vecuronium; therefore, adequate dosing is essential when reversing vecuronium-induced blockade. The association constant for sugammadex is lower with vecuronium than with rocuronium, and the dissociation constant is relatively higher, indicating that a greater concentration of sugammadex is required to achieve effective complex formation. Consequently,

low doses may be insufficient to bind all circulating vecuronium molecules, increasing the risk of recurrent paralysis. In our study, the use of 4 mg/kg ensured complete and stable reversal without evidence of recurarization.

Previous studies support our findings. Suy et al. demonstrated dose-dependent reductions in recovery time with sugammadex compared to neostigmine in both rocuronium- and vecuronium-induced blockade. Similarly, Jain and Gandhi reported faster recovery with sugammadex in laparoscopic surgeries. Rahe-Meyer and colleagues showed that deep neuromuscular blockade could be rapidly reversed with sugammadex, with recovery times markedly shorter than spontaneous recovery. Meta-analyses have consistently shown that sugammadex achieves higher TOF ratios at extubation and is associated with a lower incidence of postoperative weakness and global adverse effects compared to neostigmine.

Postoperative pulmonary complications (PPCs) are strongly associated with residual neuromuscular blockade. Even minimal residual weakness may impair pharyngeal muscle function, compromise airway patency, and depress ventilatory drive, contributing to hypoxemia, atelectasis, pneumonia, and respiratory failure. Cohort studies have demonstrated clear associations between residual blockade and PPCs. Interestingly, 12 of the included RCTs didn‘t show a significant difference regarding the incidence of PPCs between patients receiving sugammadex versus neostigmine(Schaller et al., 2010; Geldner et al., 2012; Brueckmannet al., 2015; Koyuncu et al., 2015; Hakimoglu et al., 2016;Agha et al., 2017; Yagan et al., 2017; Alday et al., 2019; Claroni et al., 2019; Ba et al., 2020; Lee et al., 2020; Togioka et al., 2020), which may indicate the general inadequacy of the statistical power in these RCTs to find significant effect on the PPC incidence. Although many factors are associated with incidence of PPCs, residual NMB is suggested as the major determinants for the pathogenesis of PPCs (Cammu,2020). Cohort studies have confirmed clear associations between residual NMB and the risks of various types of PPCs, such as upper airway obstruction, hypoxemia, atelectasis, and pneumonia (Bulka et al., 2016; Murphy et al.,2004; Murphy et al., 2008; Stawicki & Gessner, 2018). Furthermore, it suggests that even slight residualNMB may cause pharyngeal and laryngeal dysfunction and depress pulmonary ventilation, all of which might induce PPCs (De Troyer & Bastenier-Geens, 1979; Cedborget al., 2014; FuchsBuder et al., 2016). Therefore, in view of the importance of residualNMB in the pathogenesis of PPCs, our finding suggested that sugammadexwassuperior to neostigmine for reduced PPCs and may reflect the faster and more complete NMB reversal efficacy with sugammadex in comparison with neostigmine (Hristovskaet al., 2017). Although some randomized controlled trials have not shown statistically significant differences in PPC incidence between sugammadex and neostigmine, likely due to limited statistical power, pooled analyses suggest that sugammadex may reduce the risk of postoperative respiratory failure. Our findings are consistent with this observation, as postoperative adverse reactions were more frequently noted in the neostigmine group, while no residual paralysis was observed in either group.

Neostigmine’s mechanism of action may also contribute to adverse respiratory outcomes. High doses can induce bronchospasm, and administration after substantial spontaneous recovery may paradoxically impair upper airway muscle function, potentially leading to obstruction. In contrast, sugammadex does not interfere with diaphragmatic or genioglossus muscle function and has been shown to be well tolerated even in patients with preexisting pulmonary disease. These pharmacological differences may partly explain the reduced incidence of respiratory complications observed with sugammadex. Retrospective cohort study showed that in patients with Chronic obstructive pulmonary disease who underwent abdominal surgery, the chances of getting PPCs was lower when sugammadex was applied for NMB reversal (Park et al., 2020). Results in the present study are consistent with findings of the above studies, demonstrating that NMBreversal with sugammadex result in lesser PPCs comparison to neostigmine, and sugammadex may be superior to neostigmine for patients at high risk for the development of PPCs.

Hemodynamic stability is another important consideration. In our study, both groups exhibited comparable heart rate and blood pressure profiles, although diastolic blood pressure increased more prominently shortly after neostigmine administration. Overall, sugammadex demonstrated a favorable safety profile with minimal cardiovascular effects and no major adverse events.

While the clinical advantages of sugammadex are evident, cost remains a significant limitation. The higher acquisition cost has restricted its routine use in many institutions. Nevertheless, several studies suggest that overall cost-effectiveness may improve due to reduced operating room turnover time, shorter stays in the post-anesthesia care unit, decreased incidence of complications, and improved workflow efficiency. The ability to maintain deep neuromuscular blockade until the end of surgery and achieve rapid, reliable reversal may enhance surgical conditions and patient safety while potentially offsetting initial drug costs. Besides, accumulating studies , shown that replacement of neostigmine with sugammadex for NMB reversal is associated with significantly reduced costs for NMB management (Carron et al., 2016b; Ren et al., 2020), which also supports using sugammadex in this clinical scenario. Nevertheless , not only the cost of reversal can be decreased with sugammadex. Cost -efficacy can also be improved by decreased duration of time in the post operative recovery room .of the complications related to residual muscle relaxant effect, the treatment of postoperative complications. Hospitalization costs can be reduced by avoiding these serious effects .

In summary, the present study demonstrates that sugammadex at a dose of 4 mg/kg provides faster, more predictable, and clinically reliable reversal of vecuronium-induced neuromuscular blockade compared to neostigmine. The reduced

recovery time, absence of recurarization, favorable hemodynamic profile, and potential reduction in postoperative respiratory complications support its superiority in this context. Although financial considerations remain an important factor, the improved safety and efficacy associated with sugammadex make it a valuable option for neuromuscular blockade reversal in modern anesthetic practice.

CONCLUSION

This study demonstrates that neuromuscular blockade reversal with sugammadex is faster in patients categorised as ASA physical status I-III. The finding that sugammadex providing rapid recovery vecuronium induced NMB than neostigmine suggests that sugammadex is a promising alternative to conventional reversal agents.

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