https://doi.org/10.48047/AFJBS.6.15.2024.870-877

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

COMPARISON OF NEOSTIGMINE WITH TRAIN-OF-FOUR MONITORING VERSUS WITHOUT TRAIN-OF-FOUR MONITORING IN REVERSAL OF NEUROMUSCULAR BLOCKADE AND INCIDENCE OF POSTOPERATIVE PULMONARY COMPLICATIONS: RANDOMIZED CONTROLLED TRIAL IN A TERTIARY CARE CENTRE, CHENGALPATTU

Dr. Manohar Paneer[1], Dr. Muthuselvan Murugesan[2], Dr. Raajaram Muthukrishnan[3], Dr. Deepa Gautham[3], Dr. Uma Priyadharshini Thompson[4], Dr. Priyanka Dhanasekaran[5], Dr. Murali Manoj M[6]

FIRST & CORRESPONDING AUTHOR- Dr. Manohar Paneer, Professor, Department of Anaesthesiology, Karpaga Vinayaga Institute of Medical Sciences& Research Centre, GST Road, Chinna Kolambakkam, Madhuranthagam Taluk, Chengalpattu District – 603308, India.

SECOND AUTHOR- Dr. Muthuselvan Murugesan, Post Graduate, Department of Anaesthesiology, Karpaga Vinayaga Institute of Medical Sciences& Research Centre, GST Road, Chinna Kolambakkam, Madhuranthagam Taluk, Chengalpattu District – 603308, India.

THIRD AUTHOR- Dr. Raajaram Muthukrishnan, Associate Professor, Department of Anaesthesiology Karpaga Vinayaga Institute of Medical Sciences& Research Centre, GST Road, Chinna Kolambakkam, Madhuranthagam Taluk, Chengalpattu District – 603308, India.

THIRD AUTHOR: Deepa Gautham, Assistant Professor, Department of Anaesthesiology, Karpaga Vinayaga Institute of Medical Sciences& Research Centre, GST Road, Chinna Kolambakkam, Madhuranthagam Taluk, Chengalpattu District – 603308, India.

FOURTH AUTHOR: Dr. Uma Priyadharshini Thompson, Senior Resident, Department of Anaesthesiology, Karpaga Vinayaga Institute of Medical Sciences& Research Centre, GST Road, Chinna Kolambakkam, Madhuranthagam Taluk, Chengalpattu District – 603308, India.

FIFTH AUTHOR: Dr. Priyanka Dhanasekaran, Senior Resident, Department of Anaesthesiology, Karpaga Vinayaga Institute of Medical Sciences& Research Centre, GST Road, Chinna Kolambakkam, Madhuranthagam Taluk, Chengalpattu District – 603308, India.

SIXTH AUTHOR: Dr. Murali Manoj M, Professor, Department of Anaesthesiology, Karpaga Vinayaga Institute of Medical Sciences & Research Centre, GST Road, Chinna Kolambakkam, Madhuranthagam Taluk, Chengalpattu District – 603308, India.

Corresponding email id- drmanoth@gmail.com

Article History

Received: 04 June 2024

Accepted: 22 July 2024

Published: 26 August 2024

doi: 10.48047/AFJBS.6.15.2024.870-877

ABSTRACT

Background- Applying Train-of-four (TOF) monitoring resulted in less residual paralysis in the postoperative room. The purpose of this study was to determine whether neostigmine reversal optimization without TOF monitoring was comparable to reversal with TOF monitoring. **Methods:** Eighty patients between the ages of 18 and 60 undergoing Elective Laparoscopic surgery under General Anaesthesia, (vecuronium and sevoflurane). Randomization was used to split Anaesthesia with intubation into two groups: Group A (n = 40) that used an improved neostigmine reversal method without TOF monitoring and a quantitative TOF monitoring as a neostigmine reversal approach (group B, n = 40). According to protocol The incidence of residual paralysis in the postoperative room was compared between the two pairs. **Results:** In the postoperative room, group A experienced six residual paralysis, while there was one instance in group B. The Comparative analysis showed that the 95% confidence interval of this study was outside the range of equivalence margin (15%). The absolute difference was 13.9% standard error (SE) =0.068 (P = 0.107; 95% confidence interval (CI): 1%, 27.2%). In both groups, no patients had TOF ratio < 0.70 in the postoperative room. The TOF ratio in the postoperative room did not differ between the two groups (mean difference: −2.58; P = 0.05; 95% CI: −5.20, 0.29). One respiratory adverse event occurred in this study. **Conclusion:** Our study demonstrated that, in order to prevent residual paralysis in the postoperative room after using vecuronium as a neuromuscular blocking agent and sevoflurane as maintanence anaesthesia, optimised reversal strategy without Train-Of-Monitoring is different from a reversal strategy based on quantitative Train-Of-Monitoring.Further studies are needed to confirm it

Keywords: Vecuronium, Sevoflurane, Residual paralysis, Train-of-Four Monitoring, Optimised Reversal

INTRODUCTION

Vecuronium, a frequently employed neuromuscular blocking medication for aiding intubation under general anesthesia, carries the potential for residual paralysis. Approximately 64% of patients experience residual paralysis following Vecuronium blocking in the recovery room. This can lead to an increased risk of airway obstruction, hypoxemia, postoperative pulmonary problems [1,2] and delayed departure from the postoperative room[3] . Nevertheless, despite these potential hazards, it has not garnered much attention as a critical issue in patient safety (4). Quantitative neuromuscular monitoring led to a decrease in residual paralysis [5,6]. Nevertheless, the technology is not readily accessible, as it is only utilized by a small percentage of doctors (9.4-22.7%) that incorporate quantitative train-of-four (TOF) monitoring into their practice[7,8]. Neostigmine, a long-standing medication used to reverse neuromuscular blockade, might enhance the chances of effective reversal when delivered optimally, even in situations when TOF monitoring is not easily available[9]. According to recent research, reversal-extubation time and the depth of blockade-based neostigmine dose play a significant part in lowering the events of residual paralysis.[10,11,12] The tidal volume characteristics may be used to establish the blockage depth. 8 Studies done in different regions showed, there was no statistical significance (but clinically significant). So we would like to do it in our settings.

The study aimed to determine whether optimizing neostigmine reversal with TOF monitoring is as effective as reversal without TOF monitoring in reducing postoperative residual paralysis.

METHODOLOGY

The study was conducted after getting Institutional Ethical Committee Approval. Informed written consents were obtained from all patients before participating in this study. People aged between more than 18 to 60 years belonging to both genders undergoing elective Laparascopic surgeries under General Anaesthesia in Karpaga Vinayaga Institute of Medical Sciences And Research Centre, Mathuranthakam, Chengalpattu, Tamil Nadu. Data was collected with purposive sampling and sample size 80. Using eighty opaque sealed envelopes—each group consists forty—that indicates the detailed anesthetic technique as well as group assignment, simple randomization was carried out.

People between the age of more than 18 and less than 60 years, both gender, American Society of Anaesthesiologists(ASA physical status 1 and 2) who are willing to participate in the study, in cases of elective laparascopic surgeries like Lap cholecystectomy, Lap hernioplasty and Lap appendectomy were included in the study. During the process of awakening from anesthesia or after being admitted to the postoperative room following surgery, several factors may be considered. Exclusion criteria includes having a BMI (Body mass index) more than 30 kg/m2, chronic liver disease and chronic kidney

disease.

An anesthesiologist revealed the treatment allocation by opening the next envelope in the sequence prior to inducing anesthesia. This anesthesiologist did not participate in the preoperative or postoperative data gathering or patient anesthesia care; they merely prepared the research drugs. Relevant history taking regarding the Age, sex, body weight, Comorbidities will be taken and the data derived was filled by the principal investigator in the specific questionnaire. The devices required are pulse oximetry, Non-invasive Blood pressure cuffs, End Tidal CO2 connector, Electrocardiogram leads, Laryngoscope blade of sizes 3 and 4, Endotracheal tube of sizes 6.0,6.5,7.0,7.5,8.0,8.5 ID, Anatomical face mask, Hudson's mask, Stimpod NMS450 AMK Kit (1.8); quantitative NMT Monitor. A few examples of parameters are the length of the anesthesia operation, the total amount of vecuronium administered, how often it is administered, when it was last administered, and the total amount of neostigmine administered, Time spent reversing and extubating, TOF in the recovery area, and persistent paralysis.

Patients were randomized into group A & B.

In **Group A**, Time since last vecuronium and spontaneous breathing effort was noted. If the time since last vecuronium injection administration < 30 minutes and no spontaneous breathing effort, delayed giving Injection Neostigmine. If the time since last intravenous vecuronium injection administration > 30 minutes and without evidence of spontaneous breathing effort: inj.neostigmine 50 microgram/kg Intravenous route and inj. glycopyrollate 10 microgram intravenous route given.

Suppose if patient had minimal spontaneous breathing, and time since last vecuronium injection administration < 30 minutes, 30-40 microgram /kg of inj. Neostigminei.v and injection Glycopyrollate 10 microgram/kg I.v was given. If patient had minimal spontaneous breathing and the time since last vecuronium injection administration > 30 minutes, 20-30 microgram/kg of inj. Neostigmine iv and inj. Glycopyrollate 10 microgram/kg iv and if the patient had sufficient spontaneous breathing effort, inj. Neostigmine 10 microgram/kg iv and injection glycopyrollate 10 microgram/kg iv given. After surgical procedure completion, patient was extubatedatleast 10 minutes after reversal attempt.TOF value recored in the recovery room.

In G**roup B**, in accordance with measured value of TOF, Injection Neostigmine has been given. All patients had two electrodes on the forearm. Distal electrode was placed at the wrist crest, proximal electrode was placed 3-6cm proximal from distal electrode. TOF Watch SX device cables were then connected to the electrodes and transducer was tapped to the distal phalanx of thumb. 50 mA of TOF stimulation was used without calibration. Measurements were conducted out in 12 seconds cycle mode.

1. TOF 0-1 (Intense block); delayed giving inj. Neostigmine i.v
2. TOF Ratio 0.40-0.70 (minimal block); inj. Neostigmine 20-30 μg/kg and glycopyrollate10 μg/kgi.v
3. TOF Ratio 0.70-0.90 (minimal block): inj. Neostigmine 10 μg/kg and glycopyrollate10 μg/kgi.v.

After surgical prpcedure completed, extubate the patient after TOF ratio is more than or equal to 0.90.

The primary outcome was proportion of patients who had residual paralysis in the postoperative room based on the threshold TOF Value < 0.90 in both groups. TOF Value was measured by a second Researcher who did not know the type of intervention given. Measurements were done twice consecutively over 12s. The resultant value was used as an average of both values. All subjects were monitored for airway problems, respiratory patterns, oxygen saturation, nausea, vomiting during 30 min in the recovery room.

Data was expressed in terms of numbers and percentages, median and ranges, mean and standard deviations. Data between two groups

Were analysed for differences using independent t tests for numerical data and fisher’s exact tests for categorical data. Data was

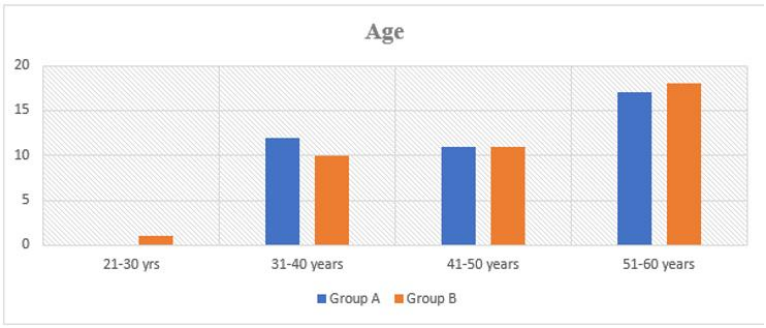
collected and entered in Microsoft excel 2007 and analysed by using SPSS software.

RESULTS

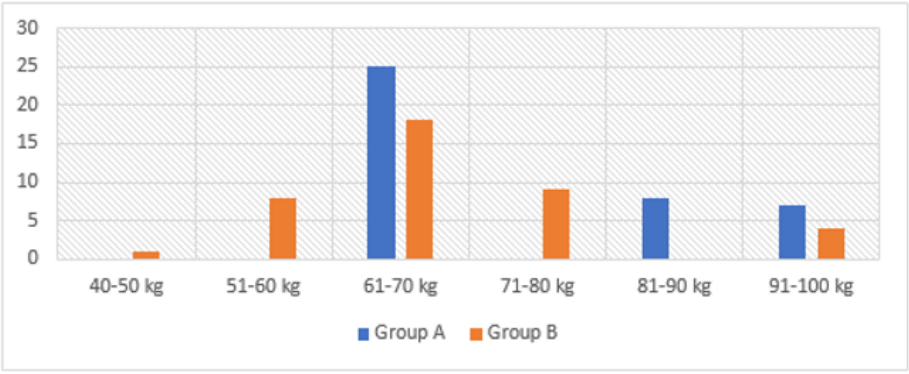
A total of 80 patients included in the study. No patient excluded. So Randomisation was done on 80 patients into Group A and B. In

Both groups, Majority of subjects were from age group 51-60 years. The gender breakdown in groups A and B was as follows: 85%

men and 15% women in group A while 75% men and 25% women in group B.



Graph 1: Distribution of patients based on the age



Graph 2: Showing Distribution of Weight

Table 1: Demographic Data using Chi square test

Parameters	Mean ± SD		
	Group A	Group B	PValue
Age (years)	52.5±11.31	49.02±12.02	0.07
Weight (kg)	68.05±12.23	66.71±9.18	0.26
Height (cm)	157.26±6.77	155.96±7.5	0.183
BMI (kg/m^2)	27.41±3.87	27.53±3.16	0.43
Duration of surgery (h)	1.64±0.62	1.40±0.41	0.09

Table 2: Showing Distribution of ASA in both groups

ASA		Groups		
		Group A	Group B	P Value
1	Count %	18 (45%)	26 (65%)	0.06
2	Count %	20 (50%)	14 (35%)	
TOTAL	100	40	40	

In current study 18 (45%) were grade 1 ASA, 26 (65%) were grade 2 ASA, in group A while 26 (65%) were grade 1 ASA, 14 (35%) were grade 2 ASA in group B. Also, p value was calculated using Fischer exact test and found both groups are comparable as shown in Table 2.

Table 3: Showing Distribution of duration of Surgery

Group	t Value	Mean	Std. Deviation	P value
Group A	50.585	66.7317	8.4	0.06
Group B	55.688	42.1000	4.7	

As the above table illustrates, the length of surgery in each category was similar between the two groups.

Table 4: Showing Distribution of Duration of Action From Induction To TOF>/=2(MINS)

Duration of Action from Induction To TOF>/=2(MINS)	Groups	
	Group A	Group B

Duration of Action from Induction To TOF>/=2(MINS)	30-40 mins	Count %	0(0%)	17 (42.5%)
	40-50 mins	Count %	0(0%)	23 (57.5%)
	51-60 mins	Count %	14 (35%)	0(0%)
	61-70 mins	Count %	17 (42.5%)	0(0%)
	71-80 mins	Count %	7 (17.5%)	0(0%)
	81-90 mins	Count %	0(0%)	0(0%)
	91-100 mins	Count %	0(0%)	0(0%)
TOTAL		100	40	40

Distribution of Duration of Action from Induction To TOF>/=2(MINS) was recorded and in group A we found 51-60 mins in 35% of
subjects, 61-70 mins in 42.5% subjects and 71-80 mins among 17.5% subjects. Similarly in group B 30-40 mins in 42.5% subjects
and 40-50 mins in 57.5% subjects. ComparisonofdurationofAnaesthesiabetweenthetwogroups.Both groups had similar anesthetic
durations across all categories.

Table 5: Duration of Recovery from Last Dose (mins)

	T	Mean	Standard Deviation	Mean Difference	P value
Group A	65.528	40.3250	3.89205	40.32500	
Group B	57.611	42.2381	4.75143	42.23810	1.000

A comparison of duration of Recovery from Last Dose between the two groups was carried out and found that findings were comparable.

Table 6 -Varoius Parameters

Post Extubation-Group A						
Parameters	T Value	Mean	Standard Deviation	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
HR	63.863	84.9512	8.51749	84.95122	82.2628	87.6397
SBP	106.354	123.3171	7.42442	123.31707	120.9736	125.6605
DBP	62.362	81.4878	8.36696	81.48780	78.8469	84.1287
MAP	95.531	94.9756	6.36588	94.97561	92.9663	96.9849
SPO2	1677.966	99.8293	.38095	99.82927	99.7090	99.9495
EtCO2	36.606	37.5122	6.56171	37.51220	35.4411	39.5833
Temperature	802.212	35.1293	.28040	35.12927	35.0408	35.2178

Post Extubation- Group B						
Parameters	T Value	Mean	Standard Deviation	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
HR	59.667	82.5122	8.85472	82.51220	79.7173	85.3071
SBP	99.903	123.3902	7.90847	123.39024	120.8940	125.8865
DBP	57.815	78.5610	8.70071	78.56098	75.8147	81.3073
MAP	87.018	93.2683	6.86303	93.26829	91.1021	95.4345
SPO2	709.525	99.4878	.89783	99.48780	99.2044	99.7712
EtCO2	35.130	33.3415	6.07705	33.34146	31.4233	35.2596
Temperature	496.088	35.3976	.45688	35.39756	35.2534	35.5418

Table 7: Comparisonofneuromuscularblockadeandrecoverycharacteristicsintheboth groups

Parameters	Group A (n=40)	Group B (n=40)	p-value
Onset of NMB (minutes)	5.56±1.30	3.80±1.58	0.12

DurationofNMB(minutes)	35.60±4.08	62.65±2.28	0.06
Mean25%recovery(minutes)	31.84±1.99	48.62±4.94	0.06
Meantimeofrecovery(minutes)	2.68±0.20	2.62±0.20	0.08
Reversal- Extubation time (min)	17.4	12.3	0.02

NMB;Neuromuscular Blockade,* significant($p<0.05$)

Table 8: Correlation between onset time, duration of action, and time to TOF4

	Group A		Group B		Overall	
	R*	P	R	P	R	P
ST0	-0.02	0.879	-0.197	0.170	-0.224	0.25
PTC1	-0.008	0.956	0.17	0.238	0.181	0.72
TOF1	0.238	0.111	0.182	0.206	0.320	0.08
TOF4	-0.083	0.537	0.155	0.282	0.082	0.37

*ST=single twitch, TOF=train of four. *R represents the Pearson's correlational coefficient*

Similarly, the duration of neuromuscular blockade was comparable with group B (62.65±2.21 mins.) in comparison to group A (36.70±4.58 mins.) (p=0.06). Group B and group A were statistically similar in terms of the average 25% recovery of neuromuscular blockade (p=0.06). Group B and group A had similar mean times for neuromuscular blockade recovery (p=0.08).Six cases of residual paralysis in the postoperative room in group A, whereas one case occurred in group B. There was no significant differences in proportion of residual paralysis in both groups (P= 0.107). The Comparative analysis showed that the 95% confidence interval of this study was outside the range of equivalence margin (15%). The absolute difference was 13.9% standard error (SE) =0.068 (P = 0.107; 95% confidence interval (CI): 1%, 27.2%). In both gropus,no patients had TOF ratio < 0.70 in the postoperative room. . The TOF ratio in the recovery room did not differ between the two groups (mean difference: −2.58; P = 0.05; 95% CI: −5.20, 0.29). One respiratory adverse event occurred in this study.

Discussion

The reversal technique that did not involve TOF monitoring, despite being optimized, did not achieve the same results as the reverse strategy that did involve TOF monitoring. This discovery reinforces the most recent agreement on the utilization of perioperative TOF monitoring instruments.[13] A comparative analysis of the two techniques, comparable to our own study, revealed a nearly same occurrence of residual paralysis (TOF ratio ≤0.80) when compared to our findings. Specifically, the incidence was 3.3% in the TOF group and 16.7% in the clinical group.[14] Nevertheless, all patients in the clinical group who still had paralysis had notably low TOF ratios, with a median value of 0.69. The brief duration of time between reversal and extubation (5 minutes) could account for the clinically unsatisfactory TOF ratio (<0.70) observed in the recovery room. In another trial, neostigmine was administered to all patients at a dose of 50 μg/kg IV, regardless of the depth of blockage. The reversal-extubation time was 9 minutes, and the incidence rate of adverse events was identical at 15.4%. However, three occurrences were observed where the TOF ratio was less than 0.70.[15]

Group B had a single instance "of residual paralysis (TOF value 0.87), even though the TOF value of 0.90 had been confirmed prior to extubation. This outcome may be the consequence of the measurement devices' variability or the paradoxical effect of neostigmine causing muscle weakness. On the other hand, new evidence does not show a paradoxical impact when neostigmine is given after a TOF ratio" of 0.90 or higher.[16]

In group B, 77% of the participants reached a TOF ratio = 0.90 within 15 minutes as well as this percentage grew to 86% after 20 minutes. In group A, the maximum time for reversal extubation among participants without residual paralysis was half an hour. Studies that showed neostigmine reversal required a delay of 30 minutes before extubation supported this conclusion[17,18]. Hence, to enhance the effectiveness of the reversal strategy in inhalation anesthesia without TOF monitoring, it is recommended to prolong the extubation duration to 30 minutes following the injection of neostigmine.

In this investigation, the combination of sevoflurane and N2O extended the duration of Effect of vecuronium; as a result, even though group B individuals had last administered vecuronium 30, 60, and 120 minutes ago, respectively, 91.6%, 77.8%, and 38.9% of them still experienced neuromuscular blockade. This finding confirmed that patients under inhalation anesthesia cannot be reversed based on how long it has been since they last received vecuronium.

A single occurrence of respiratory distress caused by bronchospasm was observed in this investigation. Patients who have a previous medical condition of asthma may still have bronchospasm even after being given anticholinergic medication. In the absence of a history of asthma, certain individuals encountered bronchospasm as a result of insufficient dose of Neostigmine Glycopyrollate. This was done to prevent an imbalance in the concentration of acetylcholine following the administration of 3 mg of neostigmine.[19]

Our study did not report any notable instances of bradycardia. Out of the total number of individuals, only 7, which accounts for 10% of the sample, experienced bradycardia within 15 minutes after receiving neostigmine. A previous study

administered a single dose "of neostigmine (50 μg/kg IV) and found that all participants (n = 67) experienced bradycardia 10 minutes after the reversal. Out of these, 5 cases were deemed clinically significant.[18]The neostigmine dose used in our study ensures the avoidance of bradycardia" risk by maintaining precision.

This reversal strategy optimization has not been previously investigated. This study closely reproduces the majority of procedures carried out at the research site, specifically focusing on the assessment of the restoration of neuromuscular function using clinical means and the utilization of vecuronium. The electric current stimulation utilized in this study, with an intensity of 50 milliamperes (mA), is considered to deliver supramaximal stimulation, meaning it exceeds the maximum level required to activate the nerves. However, it is not viewed as unpleasant by patients who are in the process of recovering from anesthesia.[18,19]

This study had multiple constraints. Initially, there was a disparity in the age of the participants between the two groups. Nevertheless, it is improbable that this age difference would impact "the duration of action of vecuronium, given only the newborn and geriatric age groups have been seen to be linked with an extended duration of action of"vecuronium.

[20,21]Furthermore, ventilation that is controlled was selectively administered to subjects based on certain indications, rather than being universally delivered to all subjects. Hence, the timing of the final injection of vecuronium in this trial was approximately 2 hours. Furthermore, half of the participants were administered vecuronium solely for the purpose of "facilitating intubation. Additionally, 66.7% of the participants in group B were given a reversal agent when the level of neuromuscular blockade was no more than modest. The majority of participants in group A (83.4%) similarly exhibited equal depth of blockage at reversal. They could perhaps contribute to the low occurrence of residual paralysis in this study. Furthermore, we failed to maintain the core and upper extremities within a designated range during the anesthesia operation. Both central and peripheral surface cooling have the ability to decrease the measured TOF ratio. [22]Furthermore, the TOF value measurement was not standardized. A fresh suggestion has been made to raise the non-normalized TOF ratio to 1.0 as the minimum level for residual paralysis when utilizing the accelerometer technique.[23] Finally, our study did not evaluate the superiority of utilizing TOF monitoring for reversal" compared to not using TOF monitoring for reversal.

This study demonstrated that administering neostigmine dose by the level of neuromuscular blockade can be considered a reliable method for reversing the effects of vecuronium blockade. Nevertheless, the evaluation of the extent of blocking should rely on quantitative TOF monitoring. In the absence of a TOF monitoring device, it is advisable to administer neostigmine to all patients who are administered vecuronium, as there is no assurance that the patient would not experience lingering paralysis in the recovery area. In the upcoming trial, the duration of reversal-extubation time should be increased to 30 minutes in the group that does not undergo the TOF monitoring. Further research should include the measurement of the normalized TOF value.

CONCLUSION

Our study demonstrated that,in order to prevent residual paralysis in the postoperative room after using vecuronium as a neuromuscular blocking agent and sevoflurane as maintanence anaesthesia,the optimised reversal strategy without Train-Of-Monitoring is different from a reversal strategy based on quantitative Train-Of-Monitoring.Further studies are needed to confirm it.

REFERENCES

1. **Wardhana, Ardyan; Kurniawaty, Juni; Uyun, Yusmein, *et al.*** Optimised reversal without train-of-four monitoring versus reversal using quantitative train-of-four monitoring; An equivalence study. ***Indian Journal of Anaesthesia*** **63(5):p 361-367, May 2019.**
2. Meseret Firde a, Tikuneh Yetneberk a, Seid Adem b, Girmay Fitiwi b, Tadesse Belayneh,etal. Neuromuscular blockade in resource-limited settings: Systematic review and guideline.Ethiopia.
3. Fortier LP, McKeen D, Turner K, de Médicis É, Warriner B, Jones PM, *et al.* The RECITE Study: A Canadian prospective, multicenter study of the incidence and severity of residual neuromuscular blockade. *AnesthAnalg.* 2015;121:366–72.
4. Murphy GS, Szokol JW, Marymont JH, Greenberg SB, Avram MJ, Vender JS. Residual neuromuscular blockade and critical respiratory events in the postanesthesia care unit. *AnesthAnalg.* 2008;107:130–7.
5. Butterly A, Bittner EA, George E, Sandberg WS, Eikermann M, Schmidt U. Postoperative residual curarization from intermediate-acting neuromuscular blocking agents delays recovery room discharge. *Br J Anaesth.* 2010;105:304–9.
6. Kopman AF. Managing neuromuscular block where are the guidelines. *AnesthAnalg.* 2010;11:9–10.
7. Gatke MR, Viby-Mogensen J, Rosenstock C, Jensen FS, Skovgaard LT. Postoperative muscle paralysis after rocuronium: Less residual block when acceleromyography is used. *ActaAnaesthesiol Scand.* 2002;46:207–13.
8. Murphy GS, Szokolm JW, Avram MJ, Greenberg SB, Marymont JH, Vender JS, *et al.* Intraoperative acceleromyography monitoring reduces symptoms of muscle weakness and improves quality of recovery in the early postoperative period. *Anesthesiology.* 2011;115:946–54.

9. Naguib M, Kopman AF, Lien CA, Hunter JM, Lopez A, Brull SJ. A survey of current management of neuromuscular block in the United States and Europe. *AnesthAnalg.* 2010;111:110–9.
10. Grayling M, Sweeney BP. Recovery from neuromuscular blockade: A survey of practice. *Anaesthesia.* 2007;62:806–9.
11. Thilen SR, Bhananker SM. Qualitative neuromuscular monitoring how to optimize the use peripheral nerve stimulator to reduce the risk of residual neuromuscular blockade. *CurrAnesthesiol Rep.* 2016;6:164–9.
12. Kopman AF. Residual neuromuscular blockade and adverse postoperative outcomes: An update. *CurrAnesthesiol Rep.* 2016;6:178–84.
13. Naguib M, Brull SJ, Kopman AF, Hunter JF, Fülesdi B, Arkes HR, *et al.* Consensus statement on perioperative use of neuromuscular monitoring. *AnesthAnalg.* 2018;127:71–80.
14. Gatke MR, Viby-Mogensen J, Rosenstock C, Jensen FS, Skovgaard LT. Postoperative muscle paralysis after rocuronium: Less residual block when acceleromyography is used. *ActaAnaesthesiol Scand.* 2002;46:207–13.
15. Nemes R, Fulesdi B, Pongracz A, Asztalos l, SzaboMaak Z, Lengyel S, *et al.* Impact of reversal strategies on the incidence of postoperative residual paralysis after rocuronium relaxation without neuromuscular monitoring: A partially randomized placebo-controlled trial. *Eur J Anaesthesiol.* 2017;34:609–16.
16. Murphy GS, Szokol JW, Avram MJ, Greenberg SB, Shear TD, Deshur MA, *et al.* Neostigmine administration after spontaneous recovery to a train-of-four ratio of 0.9 to 1.0: A randomized controlled trial of the effect on neuromuscular and clinical recovery. *Anesthesiology.* 2018;128:27–37.
17. Geldner G, Niskanen M, Laurila P, Mizikov V, Hübler M, Beck G, *et al.* A randomized controlled trial comparing sugammadex and neostigmine at different depths of neuromuscular blockade in patients undergoing laparoscopic surgery. *Anaesthesia.* 2012;67:991–8.
18. Tajaate N, Schreiber J, Fuchs-Buder T, Jelting Y, Kranke P. Neostigmine-based reversal of intermediate acting neuromuscular blocking agents to prevent postoperative residual paralysis: A systematic review. *Eur J Anaesthesiol.* 2017;34:1–9.
19. Bourgain JL, Debaene B, Meistelman C, Donati F. Respiratory mechanics in anaesthetized patients after neostigmine-atropine. A comparison between patients with and without chronic obstructive pulmonary disease. *ActaAnaesthesiol Scand.* 1993;37:365–9.
20. Helbo-Hansen HS, Bang U, Nielson HK, Skovgaard LT. The accuracy of a train of four monitoring at various stimulation currents. *Anesthesiology.* 1992;76:199–203.
21. Fisher DM, Castagnoli K, Miller RD. Vecuronium kinetics and dynamics in anesthetized infants and children. *ClinPharmacolTher.* 1985;37:402–6.
22. Suzuki T, Kitajima O, Ueda K, Kondo Y, Kato J, Ogawa S. Reversibility of rocuronium induced profound neuromuscular block with sugammadex in younger and older patients. *Br J Anaesth.* 2011;106:823–6.
23. Heier T, Caldwell JE. Impact of hypothermia on the response to neuromuscular blocking drugs. *Anesthesiology.* 2006;104:1070–80.