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ORIGINAL RESEARCH

A prospective observational study of residual neuromuscular blockade in a post-anaesthetic care unit

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ABSTRACT

Aim: The present study aimed to assess the incidence of residual neuromuscular blockade in a post-anaesthetic care unit. **Methods:** One hundred patients with physical statuses ranging from I to III, according to the American Society of Anesthesiologists (ASA), were prospectively recruited before they were scheduled to have either elective or emergency surgery from August 2023 to August 2024. **Results:** Male patients with RNMB had a shorter duration of anaesthesia, had higher doses of muscle relaxant, and had a shorter time gap between the final dosage of relaxant administration and arrival in the PACU. A higher percentage of individuals with residual neuromuscular blockade (RNMB) needed assistance with their airway compared to those with a train-of-four ratio (TOFR) greater than 0.9. **Conclusion:** The PACU has common RNMB, according to this research. Anaesthetists should quantify neuromuscular blockade and optimize reversal utilization since RNMB may predispose to postoperative problems. Anaesthetists should be aware that even with intermediate-acting neuromuscular blockade drugs, RNMB may occur after over an hour between relaxant doses.

Keywords: Incidence, residual neuromuscular blockade (RNMB), post-anaesthetic care unit (PACU)

INTRODUCTION

General anesthesia is often accomplished by maintaining a balance between three components: analgesic, hypnotic, and neuromuscular blocking agents (NMBAs). While NMBAs enhance surgical circumstances and aid in tracheal intubation, their use may be linked to residual neuromuscular blockade (RNMB). The residual action of these drugs is causing this RNMB, which is occurring at a time when full reversal of the effect would be preferable[1-7]. The documented prevalence of residual neuromuscular blockade (RNMB) ranges from 16% to over 70%, depending on the specific criteria utilized (such as a train-of-four [TOF] ratio below 0.7 or below 0.9), the kind of neuromuscular blocking agent (NMBA) used, the type of reversal agent used, and the time of the measurements[5].The use of neuromuscular blocking agents (NMBAs) with a moderate duration, monitoring of NMB during surgery, and pharmacological reversal of neuromuscular blockade seem to contribute to a reduction, although not complete elimination, of residual neuromuscular blockade (RNMB) 3, 8, 9.

The accepted measure for sufficient recovery of neuromuscular function has been a TOF ratio of 0.7 or above for a number of years. Nevertheless, there is data indicating that significant indications and symptoms of residual neuromuscular blockade (RNMB) may continue to exist until a train-of-four (TOF) ratio of 0.9. Hence, the prevailing standard for satisfactory reversal of residual neuromuscular blockade (RNMB) is a train-of-four (TOF) ratio of 0.9 or above specifically measured at the thumb adductor muscle. The post anesthesia care unit (PACU) may experience five clinical consequences as a result of residual neuromuscular blockade (RNMB). These consequences include impaired airway protective reflexes, dysfunction in the pharynx, and a reduced response to low oxygen levels, which can lead to an increase in postoperative complications such as oxygen desaturation, airway obstruction, reintubation, and pneumonia[10, 11].

A Portuguese study determined the occurrence rate of postoperative residual neuromuscular blockade (RNMB). The research found that upon arrival at the post-anesthesia care unit (PACU), 26% of patients had a global TOF ratio of less than 0.9[12].

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Neuromuscular monitoring, specifically train-of-four (TOF) monitoring, is a reliable method for detecting the presence of the RNMB. This strategy, as stated by Murphy et al.[13], is widely utilized in clinical practice. During the recovery phase after the administration of neuromuscular blocking drugs (NMBDs), this approach is used to assess the patient's muscle function objectively. It involves the use of electrical stimulation on nerves and the measurement of muscle responses, known as the TOF ratio[14].A TOF ratio of ≥ 0.90 is regarded the benchmark for determining sufficient neuromuscular recovery, whereas a TOF ratio of < 0.90 indicates the presence of residual neuromuscular blockade (RNMB)[13].Hence, the RNMB might potentially expose patients to a heightened susceptibility to critical respiratory episodes (CREs) in the post-anesthesia care unit (PACU). Observational studies provide evidence indicating that TOF ratios below 0.90 are typically linked to the occurrence of certain complications, such as insufficient recovery of lung function, obstruction of the upper airway, impaired reflexes in the throat, reduced muscle coordination, impaired response to low oxygen levels, and an elevated risk of inhaling foreign substances[15-17].

The objective of this research was to evaluate the occurrence of residual neuromuscular blockade (RNMB) in a post-anaesthetic care unit (PACU) in a tertiary hospital.

MATERIALS AND METHODS

The present observational study prospectively recruited 100 patients with American Society of Anesthesiologists (ASA) physical status I to III who were scheduled to undergo elective or emergency surgery at Madha Medical College, Kovur, Chennai, Tamil Nadu, India, from August 2023 to August 2024. Inclusion criteria were the planned use of NMB and the ability of the patient to provide informed consent.

Exclusion criteria were patient refusal, allergy and known neuromuscular disease.

METHODOLOGY

The anaesthetists were unaware of the patients' engagement in the trial, and the enrolled patients were instructed not to disclose their participation to their attending anaesthetist. The administration of anesthesia, including the selection of muscle relaxant and the use of neuromuscular monitoring, was left to the judgment of the anesthesiologist. In order to maintain the anaesthetists' unawareness of their involvement in the trial, we refrained from observing the use or analysis of TOFRs throughout the surgery. Every patient was removed from the ventilator in the operating room before being transferred to the Post-Anesthesia Care Unit (PACU).

The main measure of interest was the occurrence of residual neuromuscular blockade (RNMB), which was defined as a train-of-four (TOFR) ratio of less than 0.9 at any point throughout the patient's stay in the post-anesthesia care unit (PACU). Upon arrival at the Post-Anesthesia Care Unit (PACU), two electrodes were positioned on the skin to cover the ulnar nerve. A submaximal stimulus of 30 milliamperes was then administered in the form of a train-of-four. The motor response in the adductor pollicis muscle was assessed using a Datex electromyographic monitor from Datex Instrumentation Corp. in Helsinki, Finland. This was done in order to accurately evaluate the train-of-four ratio (TOFR). Prior validation has confirmed the accuracy of using submaximal stimuli to assure patient comfort while measuring TOFRs in this setting[18].The measurements were iterated until two successive TOFRs differed by no more than 10% from each other, and these values were then averaged for analysis. If the measurement was affected by the movement of the patient, the value was not considered and the stimulation was repeated. For individuals who did not produce a train-of-four response with a 30-mA stimulus, the intensity of the stimulus was progressively raised (in increments of 5 mA) until consistent readings were achieved. The train-of-four stimulations were conducted at five-minute intervals until the TOFR reached a value greater than 0.9. If a patient's TOFR remained consistently below 0.7 for more than 10 minutes, their attending anaesthetist was notified and requested to evaluate the administration of neostigmine. As part of routine care, the PACU nurses ensured that all patients' core body temperature remained above 35°C by closely monitoring and regulating it.

Based on these data, patients were categorized into two groups based on whether they had or did not have residual neuromuscular blockade (TOFR <0.9). The groups were compared in terms of secondary outcomes relevant to the PACU stay. These outcomes included the requirement for airway support (defined as the use of techniques such as jaw thrust, insertion of nasopharyngeal, oropharyngeal or laryngeal mask airway, or reintubation), the occurrence of desaturation (defined as an oxygen saturation level below 90% while receiving oxygen via a Hudson mask), the duration from arrival in the PACU to meeting the criteria for discharge (defined as an Aldrete score greater than 9), and the time taken for actual discharge. The groups were also compared based on patient and perioperative variables that were considered potential factors associated with RNMB. These variables included weight, gender, ASA score, procedural acuity (elective/emergent), duration of surgery, administration of reversal (neostigmine), elapsed time between last dose of neuromuscular blocking agent and arrival in PACU, and the cumulative dose of neuromuscular blocking agent administered (adjusted for the duration of the operation).

The groups were compared using unpaired t-tests for continuous variables and chi-square or Fisher's exact tests for categorical variables. Statistical significance

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was determined for differences when the value of P was less than 0.05.

Results

Table 1: Patient characteristics and anaesthetic variables in patients with and without residual neuromuscular blockade (TOFR <0.9)

Variables	TOFR <0.9 (n=30)	TOFR >0.9 (n=70)	*P* value
Age (y)	62 (18)	58 (12)	0.42
Gender (F/M)	10/20	40/30	0.017
Duration (min) of Anaesthesia	96 (64)	140 (72)	0.021
Patients givenneostigmine in OR,	23	42	0.20
Time (min) from last dose of relaxant to arrival in PACU	82(45)	110(60)	0.018
Mean cumulative dose (mg.kg-1.h-1)	0.46 (0.18)	0.29 (0.14)	0.00006

Patients with RNMB were more likely to be male, have had a shorter duration of anaesthesia, larger doses of muscle relaxant and to have had a shorter time interval between the last dose of relaxant administration and arrival in PACU.

Table 2: Relevant outcomes in patients with and without residual neuromuscular blockade

	TOFR <0.9	TOFR >0.9	*P* value
Requirement for airway support, n	7	3	0.024
Incidence of desaturation, n	1	1	0.52
Time from arrival in PACU to eligible discharge, (min) median, range	23 (0-406)	15 (0-216)	0.17
Time from arrival in PACU to actual discharge, (min) median, range	78 (33-1116)	92 (35-913)	0.80

A greater proportion of patients with RNMB required airway support than those with TOFR >0.9.

DISCUSSION

A significant number of patients have a heightened likelihood of experiencing negative outcomes in the immediate aftermath of surgery, perhaps due to the effects of anesthesia or the surgical procedures themselves. These negative occurrences include issues related to the cardiovascular or respiratory systems[19].Consequently, hospitals throughout the globe have set up specialized facilities called post-anaesthesia care units (PACU) to offer focused care and reduce the occurrence of illness and death by promptly identifying and preventing negative occurrences[20].

Neuromuscular blocking drugs (NMBDs) are often used by anaesthesiologists during general anaesthesia to provide ideal surgical circumstances via deep muscle relaxation and to aid in tracheal intubation[21].

Male patients with RNMB had a shorter duration of anesthesia, higher dosages of muscle relaxant, and a shorter time gap between the final dose of relaxant administration and arrival at the PACU. A higher percentage of individuals with Residual Neuromuscular Blockade (RNMB) needed assistance with their airway compared to those with Train-of-Four Ratio (TOFR) greater than 0.9. Extended blocking might arise from interactions with other medications, physiological factors such as temperature, and coexisting conditions such as renal or hepatic illness[22].Studies have shown that the duration of rocuronium's effects may be affected by the time of day[23].Despite ongoing discussions over the therapeutic relevance of RNMB, there is substantial data suggesting possible harm[24, 25]. This brings up the dilemma of how to provide sufficient recovery after NMB while also optimizing the usage of operating rooms. Initially, it is necessary to evaluate the extent of neuromuscular blockade (NMB) that persists after the conclusion of the operation. Nevertheless, it is important for anaesthetists to consider that even in ideal circumstances when a skilled practitioner does not see any variation in the muscle contractions caused by double-burst stimulation, there may still be a clinically meaningful neuromuscular blockade[25, 26].

Patients exhibiting residual neuromuscular blockade (RNMB) may benefit from the administration of reversal medications, which have the ability to effectively counteract the effects of partial non-depolarizing neuromuscular blockade (NMB). However, this may also pose difficulties, since prior research has been unable to establish a connection between the use of neostigmine and a reduced occurrence of residual neuromuscular blockade (RNMB) once it has already happened.[18] This may indicate the significance of the timing of neostigmine delivery. Specifically, neostigmine is not very effective in treating deep paralysis[27].It is worth mentioning that recent studies on sugammadex (Org 25969) indicate that this antidote may be given successfully, even in cases of significant rocuronium-induced paralysis[28, 29].

CONCLUSION

The current study determined that the occurrence of residual neuromuscular blockade (RNMB) in the post-anesthesia care unit (PACU) is frequent. Given that RNMB might increase the likelihood of postoperative problems, anesthesiologists should use quantitative monitoring to evaluate neuromuscular blockade and

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enhance the usage of reversal agents. Anaesthetists should be cognizant that periods beyond one hour after the administration of a relaxant do not always exclude the likelihood of residual neuromuscular blockade (RNMB), especially when using intermediate-acting neuromuscular blockade drugs.

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