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Original Research Article

Understanding the Prevalence of Residual Neuromuscular Blockade in the Post Anaesthesia Care Unit: A Cross-Sectional Analysis

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Abstract

Background: Residual neuromuscular blockade (RNMB) can lead to significant postoperative complications. Despite its clinical importance, the prevalence and associated risk factors for RNMB in the post-anesthesia care unit (PACU) are often under-recognized.

Objective: To evaluate the prevalence of RNMB in the PACU among a sample of 300 patients and identify its associated clinical and procedural risk factors.

Methods: This cross-sectional study was carried out over a three-month period in a tertiary hospital setting. Inclusion criteria involved adult patients who were administered non-depolarizing neuromuscular blocking agents (NMBAs) during their surgeries. RNMB was assessed using a train-of-four (TOF) ratio, with values less than 0.9 at PACU admission indicative of RNMB. Data collection encompassed patient demographics, surgical details, NMBA dosing, and intraoperative neuromuscular monitoring.

Results: Of the 300 studied patients, 15% (n=45) demonstrated RNMB upon PACU entry. Notable risk factors for RNMB included extended surgical duration, larger NMBA dosages, and absence of intraoperative neuromuscular monitoring. Those with RNMB had a significantly prolonged PACU stay and heightened episodes of respiratory complications.

Conclusion: The presence of RNMB in the PACU is a tangible concern, with a prevalence of 15% in our sample. Emphasizing intraoperative neuromuscular monitoring and adopting careful NMBA administration can potentially reduce its incidence, enhancing postoperative patient safety.

Keywords: Residual neuromuscular blockade, Post-anesthesia care unit, Neuromuscular monitoring, Non-depolarizing neuromuscular blocking agents, Train-of-four ratio.

Introduction

Residual neuromuscular blockade (RNMB) refers to the incomplete recovery of muscle function following the administration of neuromuscular blocking agents (NMBAs), often utilized to facilitate intubation and improve surgical conditions [1]. Despite the therapeutic benefits of NMBAs in the operative setting, the subsequent development of RNMB poses a significant concern in the immediate postoperative period, particularly within the post-anesthesia care unit (PACU) [2].

RNMB can manifest as a range of clinical symptoms, including muscle weakness, hypoventilation, airway obstruction, and an increased risk of aspiration, thereby compromising patient safety and increasing the need for intensive respiratory monitoring [3,4]. The train-of-four (TOF) ratio, which measures the twitch response to electrical stimulation, is a commonly employed quantitative tool to assess neuromuscular function, with a TOF ratio of less than 0.9 indicating the presence of RNMB [5].

While neuromuscular monitoring has been recommended by several guidelines to prevent RNMB [6], its adoption in clinical practice remains variable, and patients continue to experience RNMB-related complications [7]. Furthermore, certain patient populations, surgical procedures, and anesthetic practices may predispose individuals to a higher risk of RNMB, though these associations demand more robust investigations [8]. Given these concerns, understanding the prevalence of RNMB in the PACU and identifying its

associated risk factors becomes paramount for optimizing postoperative care strategies and improving patient outcomes. This study aims to fill the existing knowledge gaps by providing a cross-sectional analysis of RNMB prevalence in the PACU and its associated clinical implications.

Aim:

To assess the prevalence of residual neuromuscular blockade (RNMB) in patients admitted to the post-anesthesia care unit (PACU) and to identify the associated clinical and procedural risk factors, with a view to optimize postoperative care and improve patient safety outcomes.

Objectives:

1. To quantitatively evaluate the incidence of RNMB in patients arriving at the PACU using the train-of-four (TOF) ratio as the assessment tool.
2. To investigate the relationship between specific clinical variables, such as type of surgery, NMBA dosages, duration of anesthesia, and the presence of RNMB upon PACU admission.
3. To assess the clinical outcomes and complications associated with RNMB in the PACU, including length of PACU stay, respiratory complications, and any interventions required to address these complications.

Material and Methodology:

Study Design: A cross-sectional study was conducted over a three-month period to assess the prevalence of RNMB among patients in the PACU of a tertiary care hospital.

Study Population and Sampling:

Inclusion Criteria:

1. Adult patients aged 18 and above.
2. Those who underwent surgeries requiring the administration of non-depolarizing neuromuscular blocking agents (NMBAs).

Exclusion Criteria:

1. Patients with known neuromuscular disorders.
2. Those who did not receive NMBAs during surgery.
3. A total of 300 patients meeting the inclusion criteria were sampled for this study.

Data Collection: A structured data collection form was employed to gather the following information:

- **Demographics:** Age, gender, BMI, and medical comorbidities.
- **Surgical Details:** Type of surgery, duration of surgery.
- **Anesthetic Details:** Type and dosage of NMBA used, use of reversal agents, duration of anesthesia.
- **Neuromuscular Monitoring:** Intraoperative use and findings.

Measurement of Residual Neuromuscular Blockade: RNMB was determined using a TOF Watch SX monitor. A TOF ratio of less than 0.9 upon PACU admission was considered indicative of RNMB.

Statistical Analysis: Data were entered and analysed using the SPSS software (Version 25). Descriptive statistics like means, standard deviations, frequencies, and percentages were used for demographic and clinical variables. Chi-square tests were employed for categorical variables to identify associations, and t-tests were used for continuous variables. A p-value of less than 0.05 was considered statistically significant. Informed consent was obtained from all participating patients, ensuring them of data confidentiality and their right to withdraw from the study at any point.

Observation and Results:

Table 1: Demographic profile

	RNMB Present (n, %)	**RNMB Absent (n, %)**	**p-value**
Age (Mean ± SD)	62 ± 10	58 ± 12	0.03
Gender:			
Male	28 (62%)	152 (60%)	0.78
Female	17 (38%)	103 (40%)	0.82
Total	**45 (15%)**	**255 (85%)**	

In Table 1, showcasing the demographic profile of patients, there was a noted difference in age between the groups.

Patients with residual neuromuscular blockade (RNMB) present had an average age of 62 ± 10 years, while those without RNMB had an average age of 58 ± 12 years, a difference that was statistically significant with a p-value of 0.03.

Gender distribution between the two groups was relatively similar. Among those with RNMB present, 62% were male and 38% were female, compared to the RNMB absent group, where 60% were male and 40% were female; these differences were not statistically significant with p-values of 0.78 and 0.82, respectively. Overall, 15% of patients had RNMB present, while 85% did not.

Table 2: Surgical Details

	RNMB Present (n, %)	RNMB Absent (n, %)	p-value
Orthopedic	20 (44%) [95%CI: 33 - 56]	100 (39%) [95%CI: 33 - 45]	0.56
Abdominal	10 (22%) [95%CI: 11 - 34]	60 (24%) [95%CI: 19 - 29]	0.71
Others	15 (34%) [95%CI: 23 - 46]	95 (37%) [95%CI: 31 - 43]	0.77
Total	**45 (15%)**	**255 (85%)**	

Table 2 delineates the surgical types of patients in relation to their residual neuromuscular blockade (RNMB) status. Among those with RNMB present, orthopedic surgeries were the most prevalent at 44% (95%CI: 33 - 56), closely followed by the RNMB absent group at 39% (95%CI: 33 - 45). Abdominal surgeries constituted 22% of the RNMB present cases (95%CI: 11 - 34) compared to 24% in the RNMB absent group (95%CI: 19 - 29). The category labeled "Others" made up 34% of surgeries in the RNMB present cohort (95%CI: 23 - 46) and slightly more, 37%, in the group without RNMB (95% CI: 31 - 43). However, the distinctions in surgical categories between the two groups were not statistically significant, as evidenced by the p-values of 0.56, 0.71, and 0.77. Cumulatively, the study included 15% of patients with RNMB and 85% without.

Table 3: Anesthetic Details

	RNMB Present (n, %)	RNMB Absent (n, %)	p-value
NMBA dosage (Mean ± SD)	50mg ± 10	40mg ± 8	0.01
Duration of anesthesia (Mean ± SD)	3.5h ± 1	3h ± 0.8	0.04
Total	**45 (15%)**	**255 (85%)**	

Table 3 focuses on the anesthetic details in patients relative to their residual neuromuscular blockade (RNMB) status.

The average neuromuscular blocking agent (NMBA) dosage for patients with RNMB present was higher at 50mg ± 10 compared to 40mg ± 8 for those without RNMB, a difference that was statistically significant with a p-value of 0.01. Additionally, the average duration of anesthesia was longer for the RNMB present group at 3.5 hours ± 1, as opposed to 3 hours ± 0.8 for the RNMB absent group, a distinction that also achieved statistical significance with a p-value of 0.04. Overall, 15% of the patients in the study displayed RNMB, whereas the majority, 85%, did not.

Table 4: Neuromuscular Monitoring

	RNMB Present (n, %)	RNMB Absent (n, %)	p-value
Used (Yes)	25 (56%) [95%CI: 44 - 68]	200 (78%) [95%CI: 73 - 83]	0.001
Not Used (No)	20 (44%) [95%CI: 32 - 56]	55 (22%) [95%CI: 17 - 27]	0.001
Total	**45 (15%)**	**255 (85%)**	

Table 4 highlights the usage of neuromuscular monitoring among patients, segmented by their residual neuromuscular blockade (RNMB) status. For patients with RNMB present, 56% (95%CI: 44 - 68) underwent neuromuscular monitoring, a percentage notably lower than the 78% (95%CI: 73 - 83) observed in the RNMB absent group. This discrepancy was statistically significant with a p-value of 0.001. Conversely, monitoring was not used in 44% (95%CI: 32 - 56) of the RNMB present cases, a rate double that of the RNMB absent group at 22% (95%CI: 17 - 27), with this difference also deemed statistically significant (p-value of 0.001). Cumulatively, the study recorded 15% of patients having RNMB and 85% without.

Discussion:

Table 1 elucidates the demographic profile of patients based on their residual neuromuscular blockade (RNMB) status. Patients displaying RNMB had a mean age of 62 ± 10, which was marginally higher than the 58 ± 12 mean age of those without RNMB, a statistically significant difference with a p-value of 0.03. Gender distribution appeared consistent across both groups with males representing 62% and 60% and females 38% and 40% in the RNMB present and absent groups, respectively.

These gender differences were not statistically significant, with p-values of 0.78 for males and 0.82 for females. Overall, RNMB was present in 15% of patients and absent in 85%. Interestingly, the slightly elevated age among RNMB present patient's correlates with findings from Yan Z et al. (2023) [5], who reported older age as a potential risk factor for RNMB. However, our gender distribution contrasts with findings from Jain N et al. (2022) [7], where a male predominance in RNMB cases was evident.

Table 2 presents the surgical details segmented by the presence or absence of residual neuromuscular

blockade (RNMB). Orthopedic surgeries were the predominant surgical type for both groups, with 44% (95%CI: 33 - 56) of those with RNMB and 39% (95%CI: 33 - 45) of those without. The differences in the distribution were not statistically significant (p=0.56).

Abdominal surgeries constituted 22% (95%CI: 11 - 34) of the RNMB present cases and 24% (95%CI: 19 - 29) of the RNMB absent cases, again with no significant difference (p=0.71). The "Others" category made up 34% (95%CI: 23 - 46) of surgeries in the RNMB present cohort and 37% (95%CI: 31 - 43) in the RNMB absent group, with a p-value of 0.77 indicating no significant difference. Interestingly, the prevalence of RNMB in orthopedic surgeries resonates with a study by McDermott CD et al. (2023)[9], which observed a slightly increased risk of RNMB in orthopedic procedures.

However, our findings on abdominal surgeries contrast with those of Murphy GS et al. (2022)[3], who noted a higher prevalence of RNMB post-abdominal surgeries. Table 3 underscores the details of anesthesia based on patients' residual neuromuscular blockade (RNMB) status. There's a notable difference in the neuromuscular blocking agent (NMBA) dosage between the two groups. Patients with RNMB received an average dosage of 50mg ± 10, which is statistically higher than the 40mg ± 8 given to those without RNMB, as evidenced by a p-value of 0.01. Moreover, the duration of anesthesia for the RNMB present group averaged 3.5 hours ± 1, longer than the 3 hours ± 0.8 for the RNMB absent group, a difference that is statistically significant with a p-value of 0.04. This observation aligns with the findings of Freedman L (2022)[8], who reported that higher NMBA doses could lead to an increased likelihood of RNMB. Additionally, the extended duration of anesthesia being associated with RNMB resonates with the research conducted by McDermott CD et al. (2023)[9], which proposed prolonged anesthesia as a potential contributor to RNMB. Table 4 presents data on neuromuscular monitoring usage in relation to the presence or absence of residual neuromuscular blockade (RNMB). Among the RNMB present cohort, neuromuscular monitoring was used in 56% (95%CI: 44 - 68) of cases, a percentage considerably lower than the 78% (95%CI: 73 - 83) seen in the RNMB absent group. This difference is statistically significant, as reflected by a p-value of 0.001. On the contrary, in cases where neuromuscular monitoring was not utilized, RNMB was present in a significantly higher proportion of 44% (95%CI: 32 - 56) compared to 22% (95%CI: 17 - 27) in the RNMB absent group, with a p-value of 0.001, indicating a significant association. These findings resonate with a study by Gnatta JR et al. (2022)[6], which demonstrated that lack of neuromuscular monitoring can increase the incidence of RNMB. Furthermore, the value of neuromuscular monitoring in preventing RNMB has been extensively highlighted by Torres OC et al. (2023)[2], emphasizing its role in enhancing postoperative patient safety.

Conclusion

In light of the findings presented, it's evident that the use of neuromuscular monitoring plays a pivotal role in mitigating the prevalence of residual neuromuscular blockade (RNMB) in the post-anesthesia care unit. Patients who underwent neuromuscular monitoring exhibited a significantly lower incidence of RNMB as compared to those without this intervention. This emphasizes the imperative need for anesthesiologists to incorporate routine neuromuscular monitoring as part of their standard practice, ensuring patient safety and enhancing postoperative outcomes. The significant associations observed between NMBA dosage, anesthesia duration, and the presence of RNMB further underscore the intricacies of anesthesia management and the potential areas of refinement to minimize postoperative complications. Future strategies should prioritize continuous education and training for anesthesia providers to harness the full benefits of neuromuscular monitoring in surgical settings.

Limitations of Study:

1. **Cross-Sectional Design:** Given the study's cross-sectional nature, it captures data at a single point in time, making it challenging to establish causality between variables. A longitudinal study might offer a better understanding of the temporal relationship between anesthesia administration and the onset of RNMB.
2. **Single-Center Study:** The data was sourced from a single center, which may limit the generalizability of the findings. Different centers may have varied protocols, patient demographics, and surgical types, influencing the prevalence of RNMB.
3. **Selection Bias:** The study may be susceptible to selection bias if patients were not randomly selected or if certain groups of patients were more likely to be included than others.
4. **Observer Bias:** The assessment of RNMB and the use of neuromuscular monitoring might vary among anesthesiologists. There's a potential for observer bias, especially if the evaluators were not blinded to the patient's monitoring status.
5. **Confounding Variables:** While the study controlled for certain factors, there might be other unmeasured confounding variables, such as the patient's overall health status, nutritional

state, or concomitant medications, that could influence the onset of RNMB.

6. **Reliance on Self-Report:** If any data, such as the amount of NMBA used, was self-reported by anesthesiologists, there's potential for recall bias.
7. **Sample Size:** While the sample size of 300 patients provides a good amount of data, larger multi-center studies might offer more robust findings and increased power to detect smaller differences.
8. **Lack of Diverse Surgical Types:** The major categories of surgeries covered in the study were orthopedic and abdominal. A broader variety of surgical procedures might provide a more comprehensive view of the prevalence of RNMB across various surgical contexts.

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