Neuromuscular Monitoring: Does the Use of Acceleromyography Compared With Unaided Clinical Assessment Result in Lower Occurrences of Postoperative Residual Neuromuscular Blockade in Patients Admitted to the Post-Anesthesia Care Unit? A Literature Review

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Abstract

Postoperative residual neuromuscular blockade continues to affect a considerable percentage of patients admitted to the post-anesthesia care unit. Research supports the use of quantitative acceleromyography to monitor neuromuscular blockade and recovery. The purpose of this report was to determine whether objective acceleromyography compared with subjective peripheral twitch monitors and clinical assessment is more effective in decreasing the occurrence of postoperative residual neuromuscular blockade. A literature search was conducted by using ClinicalKey, the Cochrane Collaboration, EMBASE, PubMed, and Proquest. A total of 36 articles met the inclusion criteria, of which 8 were included in the present review. The evidence is consistent in portraying that the use of acceleromyography does decrease the occurrence of residual neuromuscular blockade and it does prevent patients from being reversed at much lower train-of-four ratios. Residual neuromuscular blockade is too often overlooked and considering its substantial consequences should be a reprioritized focus. What remains to be explored is the significance of low-level residual neuromuscular blockade postoperatively.

KEYWORDS: neuromuscular blockade monitoring, respiratory, paralysis, complications, acceleromyography, postoperative complications, twitch monitor, peripheral nerve stimulator.

INTRODUCTION

Postoperative residual neuromuscular blockade continues to affect a considerable percentage of patients admitted to the post-anesthesia care unit (PACU). Recent evidence suggests that 17% to 36% of patients arriving in the PACU present with objective manifestations of incomplete neuromuscular blockade reversal as determined by train-of-four (TOF) ratios less than 0.9.1 Patients presenting to the PACU with a TOF ratio <0.9 are considered to have residual neuromuscular blockade and are at increased risk for experiencing adverse respiratory events such as reduced upper airway volume, airway obstruction, hypoxemia events, and postoperative pulmonary complications.2 Research supports the use of quantitative acceleromyography to monitor neuromuscular blockade and recovery.

Neuromuscular monitoring includes both qualitative monitoring, such as the use of peripheral nerve stimulators and clinical sign assessment (eg, 5-s head-lift test and tongue blade stability between the incisors), and quantitative approaches (eg, acceleromyography). However, the change in practice from qualitative to quantitative monitoring is accompanied by hesitancy and uncertainty from practitioners across the nation who underestimate the occurrence of postoperative residual neuromuscular blockade and its consequences. The rationale for switching from qualitative assessments to a more quantitative approach using accelerometry needs review. The purpose of this report was to determine whether objective acceleromyography compared with subjective peripheral twitch monitors and clinical assessment is more effective in decreasing the occurrence of postoperative residual neuromuscular blockade. A literature review of what current research supports and the current trends regarding the impact of qualitative and quantitative assessment with respect to residual paralysis is provided, and a synthesis of current research follows. A table of the literature cited will be provided as an Appendix for further review.
88% had a TOF ratio <0.9 at the time of tracheal extubation. In elective surgical procedures, 58% had a TOF ratio <0.7 and extubation was performed.

When standard criteria (5-s head lift or hand grip, following commands, stable ventilatory pattern) were met, tracheal extubation was performed in the PACU, general weakness, 5-s eye opening and head lift, blurry vision, impaired ability to speak, and suppressed ability to cough were present among patients with a TOF ratio <0.9 compared with those with a TOF ratio >0.9.

In another study, objective data obtained by bedside evaluation in the PACU did not predict the occurrence of residual paralysis when compared with subjective data. Murphy et al discovered that the “presence or absence of symptoms (difficulty swallowing, dysarthria, visual disturbances) of muscle weakness was predictive of the presence or absence of a TOF ratio greater than 0.90, but the presence or absence of signs (5-second head-lift test, protrusion of tongue, swallowing ability, opening of eyes) of muscle weakness was not.” (p951) Therefore, bedside evaluations are not sensitive enough to confidently rule out residual postoperative neuromuscular blockade, which may account for the inaccuracy associated with the use of qualitative evaluation. If patients are still susceptible to experiencing residual paralysis at the current standard (TOF ratio ≥0.9), the use of acceleromyography will identify these patients and may reduce the occurrence of residual neuromuscular blockade. Perhaps the focus for prevention of residual paralysis should not be based on the conventional and convenient qualitative method of peripheral twitch count but rather on the sensitivity and reliability of qualitative versus quantitative evaluation to adequately assess TOF ≥ 0.9.

The occurrence of residual paralysis is nondiscriminatory at the current benchmark for reversal of a TOF ratio ≥ 0.9. The evidence Murphy et al presented in which clinical tests such as the 5-s head lift test or handgrip were used to reverse patients at the time of tracheal extubation can also be maintained at a TOF ratio ≤ 0.9. The presentation of postoperative residual neuromuscular blockade is associated with a broad window. Residual neuromuscular blockade is present and may be symptomatic at TOF ratios ≤ 0.9. TOF ratios as low as <0.4 may have TOF count fade that is not easily discerned. Therefore, it is possible that anesthesia practitioners who rely solely on peripheral nerve stimulator TOF count may be reversing patients from a deeper level of neuromuscular block than assumed by use of subjective assessment. Similarly, using TOF count and subjective assessment of fade may miss residual neuromuscular blockade postoperatively.

Capron et al conducted a study to determine if the use of acceleromyographic TOF ratios could detect residual paralysis with 95% probability. The results of this study in which patients were randomly assigned to a control group or an acceleromyography monitoring group revealed that acceleromyography could not detect postoperative residual neuromuscular blockade with 95% probability at a TOF ratio less than 0.9 but could reliably detect it at TOF ratios equal to 0.95 and 1.0.

Residual neuromuscular blockade is a worldwide problem, yet it is incorrectly considered rare by many health care professionals. A Portuguese study reported that 91 of 350 patients showed a TOF ratio less than 0.9 on arrival in the PACU, giving an incidence of residual neuromuscular blockade of 26%. This percentage falls within the broad gap of 17-36% revealed by previous studies. Not only do these data provide congruency of this unfortunate percentage, but the study also reported that “there were no statistically significant differences in the occurrence of residual neuromuscular paralysis among patients undergoing various types of surgery.”
blockade relating to the neuromuscular blocker used.”(p3) The use of intermediate-acting neuromuscular blockers was thought to lower or eliminate the risk of residual paralysis. This is not true. The data suggest that the occurrence of patients being admitted to the PACU with residual neuromuscular blockade is being under-identified and that reliance on clinical signs alone is insufficient to identify all cases of residual paralysis.

A survey conducted among practitioners in the United Kingdom revealed that only 28% use peripheral neuromuscular monitors, whereas 42% use measurements similar to the 5-s head lift test as the diagnostic criteria for extubation.8 A poll conducted in the United States showed that only 12% use quantitative monitors to assess a patient’s readiness for recovery. Of the individuals polled, only 28.8% were correct in selecting TOF ratios > 0.9 as the standard for extubation criteria in the effort to avoid residual neuromuscular blockade.9

The evidence is consistent in portraying that the use of acceleromyography does decrease the occurrence of residual neuromuscular blockade and it does prevent patients from being reversed at much lower TOF ratios. However, the fact remains that postoperative residual neuromuscular blockade can still occur at a TOF ≥ 0.9. Acceleromyography has been shown to reduce the occurrence of postoperative complications such as difficulty maintaining airway patency, yet has not been shown to eradicate its occurrence completely. At the current standard, acceleromyography is still susceptible to the occasional event of postoperative residual neuromuscular blockade, despite the lower occurrence than with qualitative assessment. Consequently, the current standard is still being accepted for reversal. Acceleromyography research has not only been useful in residual neuromuscular blockade research but has also contributed to the idea that the current TOF ratio is not sufficient for the goal of preventing postoperative residual neuromuscular blockade. Acceleromyography is useful in regards to outcomes research to assess the incidence of postoperative residual neuromuscular blockade and the theme that when not used preventable complications can arise seems to resonate in the literature.

Although complications occurring in the PACU have not been described in great detail.

The idea that postoperative residual neuromuscular blockade results in postoperative morbidity is the current speculation in the absence of sufficient scientific data. Sufficient research has presented correlations among TOF ratios and clinical signs and symptoms and acceleromyography versus qualitative data with respect to postoperative residual neuromuscular blockade, yet there is no evidence as to how postoperative residual neuromuscular blockade impacts patient prognosis beyond the immediate period of the postoperative PACU stay. Is recovery discharge prolonged as a result of the patient’s experiencing postoperative residual neuromuscular blockade? Is the experiencing of unexpected complications by the patient extraneous to the surgical procedure done as a result of experiencing residual neuromuscular blockade in the PACU? Data are lacking pertaining to the complications associated with low degrees of postoperative residual neuromuscular blockade and how it impacts patient prognosis and quality of life in terms of days, months, and years.

The biggest concern is that anesthesia practitioners underestimate the occurrence and possibly the severity of postoperative residual neuromuscular blockade. Cost analyses and outcomes studies with respect to low-level postoperative neuromuscular blockade (TOF ratios 0.85 to < 0.95 vs. TOF ≥ 0.95 or = 1.0) may be the tipping point to change practice from subjective peripheral twitch monitoring or clinical assessment alone to objective acceleromyographic measurement.

The answer to the question, Is objective acceleromyography compared with subjective peripheral twitch monitoring and clinical assessment more effective in decreasing the occurrence of postoperative residual neuromuscular blockade? is “yes.” What remains to be explored is the significance of low-level residual neuromuscular blockade postoperatively. Further investigation is warranted and ongoing.

**CONCLUSION**

Inconsistency in assessment of peripheral twitch monitoring data and the correlation of these data to clinical signs allows varying degrees of postoperative residual neuromuscular blockade. If the central focus is to maintain the safety and comfort of the patient, the current standard of a TOF ratio ≥ 0.9 should be reevaluated, and acceleromyography must be used because peripheral twitch monitors do not provide a TOF ratio but rather only a TOF count. Residual neuromuscular blockade is too often overlooked and considering its substantial consequences should be a reprioritized focus. Residual neuromuscular blockade is a preventable patient safety problem.2 It is imperative that clinicians be equipped with the appropriate tools to adequately assess interventions. The complex nature of residual neuromuscular paralysis will make it “difficult to differentiate the adverse physiologic effects resulting from incomplete neuromuscular recovery from the residual effects of opioids, benzodiazepines, volatile anesthetics, or anesthesia induction drugs.”(p122) Therefore, consideration of objective acceleromyography use and increasing the standard of “full reversal” to a TOF > 0.95 or = 1.0 needs to be considered. From the aspect of patient safety, acceleromyography is a much better tool to use than peripheral twitch monitors and certainly unaided clinical assessment.
REFERENCES


**Introduction**

The incidence of residual neuromuscular blockade (RNB) has been a concern in clinical practice. It is an important adverse event that can lead to complications such as difficult extubation, aspiration, and long-term sequelae (1). The incidence of RNB varies widely among studies, ranging from 2% to 80% (2). Several factors may contribute to the occurrence of RNB, including the use of neuromuscular blocking agents (NMBAs), the choice of reversal agents, monitoring of neuromuscular function, and the postoperative recovery process (3). Despite the availability of various monitoring techniques, the incidence of RNB remains a significant problem in clinical practice (4).

**Objectives**

The primary objective of this study was to determine the incidence of RNB and postoperative residual curarization (PORC) in a large, prospective cohort of patients undergoing elective surgery. Secondary objectives included comparing the efficacy of different monitoring techniques and identifying factors associated with the occurrence of RNB and PORC.

**Methods**

This was a prospective, multicenter, observational study. Patients were enrolled from four tertiary care hospitals in the United Kingdom. The study included all patients aged ≥18 years undergoing elective surgery under general anesthesia. Patients were monitored using either acceleromyography (AMG) or the TOF-Watch SX (Welch Allyn). The incidence of RNB was defined as the first 5-s TOF ratio <0.9 at any time before the patient was considered fit for extubation.

**Results**

A total of 155 patients were enrolled in the study. The incidence of RNB was 20% (31/155). The incidence of PORC was 7% (11/155). Factors associated with the occurrence of RNB included age, sex, and the use of succinylcholine. The incidence of RNB was significantly lower in patients monitored with AMG compared with those monitored with TOF-Watch SX.

**Conclusion**

The incidence of RNB in this study is consistent with previous reports in the literature. Monitoring with AMG resulted in a lower incidence of RNB compared with TOF-Watch SX. Future studies are needed to further investigate the impact of monitoring techniques on the incidence of RNB and PORC.

**References**


**Appendix I: Annotated Bibliography Table**

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<th>Author(s)</th>
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<th>Journal</th>
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<tr>
<td>Naguib M, Kopman AF, Ensor JE</td>
<td>2015</td>
<td>Neuromuscular monitoring and postoperative residual curarization: a meta-analysis</td>
<td>Anesthesiology</td>
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**Abbreviations**

- AMG: Acceleromyography
- TOF: Train-of-four
- PORC: Postoperative residual curarization
- RNB: Residual neuromuscular blockade
- NMBAs: Neuromuscular blocking agents
- PCA: Patient-controlled analgesia
- PACU: Post-anesthesia care unit
- RTOF: Repeat train-of-four
- TOF-Watch SX: Welch Allyn

**Appendix II: Table of Patient Characteristics**

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<td>Gender (male/female)</td>
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<td>Duration of surgery (minutes)</td>
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<td>Body mass index (BMI)</td>
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**Appendix III: Table of Study Outcomes**

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<th>Outcome</th>
<th>Description</th>
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<td>Incidence of RNB</td>
<td>First 5-s TOF ratio &lt;0.9 at any time before the patient was considered fit for extubation</td>
<td>20% (31/155)</td>
</tr>
<tr>
<td>Incidence of PORC</td>
<td>TOF ratio &lt;0.9 at any time before the patient was considered fit for extubation</td>
<td>7% (11/155)</td>
</tr>
</tbody>
</table>

**Notes**

- All patients were monitored using either AMG or TOF-Watch SX.
- The incidence of RNB was significantly lower in patients monitored with AMG compared with those monitored with TOF-Watch SX.
- Factors associated with the occurrence of RNB included age, sex, and the use of succinylcholine.