Spring 5-2024

Qualitative vs. Quantitative Train of Four

Caleb Culbreath

Executive Summary

Introduction of the Problem

Researchers have identified residual neuromuscular blockade (NMB) as the primary cause of postoperative complications in up to 50% of patients, with around 40% of these patients showing some degree of residual paralysis in the postanesthesia care unit (PACU) (Bedsworth et al., 2019). These complications, such as respiratory depression, airway obstruction, aspiration, pneumonia, hypoxemia, and respiratory failure, have been linked to prolonged PACU stays, the necessity for reintubation, and admission to the intensive care unit, increasing healthcare costs and exacerbating patient morbidity (Bedsworth et al., 2019; Saager et al., 2019). Over the past two decades, research has underscored the superiority of objective or quantitative monitoring methods over subjective assessments in detecting and preventing residual NMB (Carvalho et al., 2020). Consequently, clinical practice guidelines and consensus statements have recommended the use of objective methods to determine readiness for extubation, measure NMB depth, and guide the dosing of neuromuscular blocking agents and reversal agents (Naguib et al., 2018; Thilen et al., 2023).

The gap between the current best evidence and clinical practices at a tertiary care center in southern Illinois prompted an anesthesia group to express interest in integrating quantitative monitoring into their routine practice. A comprehensive educational PowerPoint presentation sought to increase awareness of the incidence and clinical consequences of postoperative residual NMB and the limitations of clinical tests and peripheral nerve stimulators compared to quantitative monitoring techniques. Thus, this project aimed to enhance anesthesia providers' understanding and valuation of quantitative neuromuscular monitoring to foster support for integrating quantitative monitoring into daily clinical practice at the host facility.

Literature Review

Neuromuscular Monitoring Techniques.

In the realm of neuromuscular monitoring, traditional practices have long relied on clinical signs and tests such as tidal volume, vital capacity, minute ventilation, negative inspiratory force, the ability to sustain a 5-second head lift, and grip strength to assess recovery from the neuromuscular blockade and readiness for extubation (Brull & Kopman, 2017). However, recent literature has scrutinized these methods. Thilen et al. (2023) highlight a significant gap in the ability of these clinical signs and tests to detect even mild to moderate paralysis, with none of the clinical tests proving sufficiently adequate in predicting readiness for extubation. The train-of-four (TOF) stimulation pattern, introduced in the 1970s, has been a standard subjective method for assessing muscle response to peripheral nerve stimulation. However, Naguib et al. (2018) point out a critical flaw in this approach: the human inability to reliably discern fade in muscle response, whether tactilely or visually, when the TOFR (Train-Of-Four Ratio) exceeds 0.40. This limitation underscores the inherent challenges in qualitative monitoring methods.

Quantitative monitoring techniques have emerged as a more reliable alternative to qualitative monitoring in the past two decades. These methods have revolutionized the assessment of NMB depth, addressing the issue of postoperative residual paralysis. These techniques, including electromyography (EMG), acceleromyography (AMG), and kinemyography (KMG), provide an objective quantification and recording of muscle responses to nerve stimulation. Despite being superior to qualitative assessment methods, each quantitative method has nuances and constraints. EMG-based devices, which measure compound muscle action potentials without the necessity of movement, offer versatility across various surgical

positions. In contrast, AMG devices, which utilize Newton's second law of motion to measure thumb acceleration in response to nerve stimulation, depend heavily on the unrestricted movement of the thumb. This dependency can pose challenges during surgeries that restrict access to the patient's arms and hands (Naguib & Johnson, 2017). Similarly, KMG devices, which measure the degree of bending of a piezoelectric sensor, face accuracy issues and are less valid than EMG, particularly when surgical positioning restricts access to the patient's arms and hands (Naguib et al., 2018).

Qualitative versus Quantitative Neuromuscular Monitoring.

Despite the susceptibilities to various interferences, the quantitative monitoring methods—EMG, AMG, and KMG—have consistently demonstrated superior accuracy in predicting and preventing residual NMB. A review of five studies comparing qualitative and quantitative neuromuscular monitoring showed that quantitative monitoring significantly reduces the incidence of postoperative residual neuromuscular blockade when compared to clinical evaluation or qualitative assessment using a peripheral nerve stimulator (Wardhana et al., 2019; Alenezi et al., 2021; Domenech et al., 2019; Todd et al., 2014; Carvalho et al., 2020). Further, emerging data suggest that quantitative monitoring decreases the risk of hypoxemic events, upper airway obstruction, and the need for postoperative reintubation (Adembesa et al., 2018; Weigel et al., 2022; Goyal et al., 2018; Wardhana et al., 2019; Kirmeier et al., 2019; Blobner et al., 2020).

The current literature and the American Society of Anesthesiologist's practice guidelines recommend that clinicians perform quantitative neuromuscular monitoring at the adductor pollicis and ensure a TOFR of 0.9 or higher before extubation (Thilen et al., 2023). In addition, clinicians should use the evidence presented in this literature review to develop departmental educational programs to increase clinician awareness of the incidence and clinical implications

of postoperative residual neuromuscular blockade and the limitations of using clinical tests and peripheral nerve stimulators to detect recovery from neuromuscular blockade. Successful implementation of such a program may increase local acceptance of quantitative monitors, thereby increasing patient safety and improving patient outcomes.

Project Methods

Purpose and Goals.

The primary purpose of this project was to initiate change in anesthesia providers' knowledge, attitudes, and practices related to neuromuscular monitoring and postoperative residual neuromuscular blockade at a tertiary care center in southern Illinois. The educational intervention aimed to enhance staff understanding and application of quantitative neuromuscular monitoring techniques, securing their engagement and supporting the integration of these techniques into daily practice. The learning objectives for the intervention were designed to empower providers to accurately identify and manage residual NMB, understand TOF monitoring, interpret TOFR values, and appreciate the advantages of quantitative monitoring methods over traditional qualitative assessments. These objectives aimed to close knowledge gaps and promote evidence-based practices to improve patient outcomes.

Project Setting.

The educational presentation occurred during a regularly scheduled staff meeting in a designated conference room at the host facility. This setting facilitated the use of a nonexperimental pretest-posttest design, which measured the impact of the educational intervention on enhancing participants' understanding of quantitative neuromuscular monitoring and its clinical significance. Anesthesia providers, including anesthesiologists and nurse anesthetists, participated voluntarily after being recruited through a convenience sampling

strategy. Completion of the pretest and post-test served as informed consent. Participants accessed the pretest and post-test electronically via a QR code linked to a Qualtrics survey.

IRB Information.

The Institutional Review Board (IRB) at Southern Illinois University Edwardsville reviewed the project. It issued a Not Human Subjects Research (NHSR) determination on July 3, 2023, ensuring compliance with ethical standards for quality improvement initiatives.

Evaluation

Tools and Measures.

The project employed a pretest-posttest design to evaluate the outcomes of an educational intervention, focusing on knowledge enhancement in neuromuscular monitoring. The tests, comprising multiple-choice and Likert scale questions, covered various topics such as the prevalence of postoperative residual neuromuscular blockade, monitoring techniques, and implications of residual paralysis. The post-test included additional questions to evaluate the presentation itself and the presenter. Participants used personal codes to anonymously link their responses, allowing detailed analysis while maintaining anonymity. Descriptive statistics and paired Wilcoxon signed-rank tests compared the scores from before and after the intervention, quantifying the changes in knowledge, attitudes, and practices among anesthesia providers. This methodological approach aimed to evaluate the impact and effectiveness of the educational intervention rigorously.

Results.

The intervention targeted anesthesia providers of diverse ages, predominantly in the 40-49 range, including two physician anesthesiologists and six nurse anesthetists with varying experience levels. Participants demonstrated significant improvements in their knowledge of

quantitative neuromuscular monitoring, particularly in the incidence of residual NMB and the calculation and clinical relevance of the TOFR. However, no significant change was observed in responses about subjective assessment methods and factors affecting the accuracy of quantitative monitoring, suggesting these areas require further educational focus.

The pretest responses varied widely on the necessity of quantitative neuromuscular monitoring, but post-test results shifted towards a more substantial consensus on its importance. Notably, all respondents in the post-test recognized the value of incorporating quantitative monitoring into practice, reflecting a significant positive attitude shift due to the intervention. Post-test feedback was overwhelmingly positive, unanimously agreeing on the presentation's clarity, knowledge conveyance, and overall quality. Participants acknowledged the initial cost and the challenge of provider buy-in as barriers to the adoption of quantitative monitoring. Responses highlighted the need for cost-effective, user-friendly equipment and reinforced the essential role of ongoing education in successfully implementing new monitoring practices.

Limitations.

The study's primary limitations involve its small sample size and the potential for selection bias, as only those participants who completed both the pretest and post-test surveys impacted the final analysis. These factors may limit the generalizability of findings to a broader population. Additionally, as with any educational intervention, changes in knowledge and attitudes may not necessarily translate into changes in clinical practice. Nonetheless, these outcomes underscore the necessity of continuous support and the provision of resources to overcome implementation barriers. Future studies should focus on long-term effects and include objective measures of practice change to enhance the robustness of the findings. Further, ongoing

training sessions, specifically with more interactive or hands-on training, may improve the effectiveness of future educational interventions.

Impact on Practice

The immediate response to the educational session was overwhelmingly positive, with participants expressing heightened appreciation for quantitative monitoring's role in anesthesia care. Feedback suggested that the presentation effectively enhanced understanding and generated interest in integrating new monitoring techniques. In the short term, this may lead to more informed discussions and decisions around neuromuscular blockade management at the clinical site. In the long-term, the project has the potential to shift standard practice towards quantitative monitoring, contingent upon continued education and addressing barriers such as cost and equipment usability.

Conclusion

The project underscored the value of targeted educational interventions in improving understanding and potentially shifting clinical practices in anesthesia. The knowledge gains in neuromuscular blockade monitoring signify that broader implementation of such educational strategies could significantly impact anesthesia safety and patient outcomes. Future efforts should integrate these educational components into ongoing clinical training, tackle identified economic and technical challenges, and encourage a collective approach to practice change to reinforce the project's benefits.

Author Contact Information

Caleb Culbreath, BSN, SRNA

cculbre@siue.edu

618-534-9452