Perceptions Among CRNAs on Qualitative Versus Quantitative Monitoring for the Assessment of Residual Neuromuscular Blockade

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Abstract

Neuromuscular blockade medications are frequently administered during general anesthesia. Residual neuromuscular blockade is assessed with qualitative or quantitative devices to determine the amount of blockade remaining at the end of surgery. Despite guideline recommendations for a TOF ratio ≥ 0.9 by quantitative monitoring prior to emergence and extubation, there continues to be inconsistency in applying this guideline to clinical practice. The purpose of this quality improvement project was to assess anesthesia providers' perceptions of the usefulness of and preference for using qualitative (PNS) versus quantitative (acceleromyography) neuromuscular blockade reversal measurements in the perioperative setting. A single plan-do-study-act cycle was used to perform this project. Pre- and post- surveys were delivered to participants via email and included an educational video. Quantitative monitoring devices remained available during the implementation period for all participants within the organization. Four out of five CRNAs within the project setting participated in the quality improvement project. Survey questions addressed current use and perceptions of neuromuscular blockade monitoring. Most participants used a PNS to quantify neuromuscular blockade and viewed acceleromyography measurement as neutral. The acceleromyography device was used by 25-75% of CRNAs during the implementation period. Participants reported an increase in the use of the acceleromyography devices as well as increased likelihood of use after project completion, suggesting that implementation of a similar quality improvement project may impact practice thus benefitting patient safety and accuracy of residual neuromuscular blockade measurement.

Keywords: neuromuscular blockade, monitoring, anesthesia

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Section I. Introduction

Background

Neuromuscular blockade medications are frequently administered by Certified Registered Nurse Anesthetists (CRNAs) during general anesthesia to facilitate cessation of musculoskeletal movement during surgery. Intraoperatively, medications most often used to produce muscle paralysis are nondepolarizing muscle relaxants that compete with acetylcholine and bind to nicotinic receptor sites at the neuromuscular junction. To monitor the level of neuromuscular blockade and muscle paralysis, a peripheral nerve stimulator (PNS) is utilized to provide an electrical stimulus to a peripheral nerve site where a series of muscular twitches are produced. The most commonly used peripheral nerve stimulation pattern is the train of four count (TOF), which attempts to quantify the quality of depth and recovery of neuromuscular blockade. This measurement may be performed after the administration of neuromuscular blocking medications and, most importantly, at the conclusion of the procedure to assess the level of neuromuscular blockade that remains (Dunworth et al., 2018).

TOF monitoring utilizes a small device that is placed along the ulnar or facial nerve. An electrical impulse sends an elicited stimulus to one of these nerves to contract the corresponding muscle, respectively, the adductor pollicis and orbicularis oculi. Four separate stimuli are delivered over 2 seconds at 2 Hz, 0.5 seconds apart and represented by T1, T2, T3, and T4. The first and last twitch present are compared to one another and a ratio is calculated based on the subjectivity of the CRNA performing the assessment with the amplitude of the T4 twitch divided by T1 (Naguib et al., 2018). As neuromuscular blockade deepens or is reversed, the four twitches variably decrease or increase in amplitude in regard to the level desired and type of medication used. A calculated TOF ratio of ≥ 0.9 indicates the strength of T4 is greater than or equal to

90% of the strength of T1. A TOF ratio of $\leq$0.9 represents presence of or residual blockade while a TOF ratio of $\geq$0.9 represents recovery of neuromuscular blockade.

In comparison, acceleromyography monitoring devices use quantitative measurement to measure, analyze and provide a TOF ratio in real time. These devices are not new but are infrequently used compared to a PNS device. Acceleromyography removes the subjectivity of visual or tactile interpretation from PNS TOF ratio calculation through piezoelectric technology, based on the Newton law of motion. Movement produced by stimulation of the transducer on the thumb generates a voltage that is compared to clinical data and calculates the ratio of T1 to T4 on a scale of 0 to1 (Dunworth et al., 2018). Along with other subjective clinical assessments, however, such as patient's ability to follow commands, lift the head, and perform adequate forced vital capacity breaths, TOF count measurement using a PNS device remains the most widely utilized method of neuromuscular blockade monitoring (Wiatrowski et al., 2018).

The quantity and quality of TOF count is subjective but a generally accepted measurement strategy. The goal is for patients to have a TOF count between 0 and 2 out of 4 twitches via PNS monitoring for adequate neuromuscular blockade during a procedure. Differences in PNS monitoring interpretation, however, can lead clinicians to assess a subjective TOF count and ratio higher than actually present. This may lead to additional and unnecessary doses of neuromuscular blockade medication intraoperatively or inadequate dosing for neuromuscular blockade reversal agents. Furthermore, administration of additional neuromuscular blockade medications may lead to postoperative muscle impairment, with respiratory and pharyngeal muscles being the most affected.

Residual neuromuscular blockade can be problematic postoperatively in patients who have received a neuromuscular blocking medication. The most current recommendations are for

patients to have a TOF ratio ≥0.9 to be considered fully reversed and at adequate neuromuscular function upon emergence and extubation. Dunworth et al. (2018) reported from their study that 31% of patients arriving to the post anesthesia care unit (PACU) had an actual TOF ratio measurement of ≤0.9 when qualitative monitoring (PNS) was used. With objective measurement to identify complete reversal of neuromuscular blockade, complications from residual neuromuscular blockade, such as respiratory failure, reintubation, or intensive care admission, may be attenuated. This may lead to a reduced length of hospital stay for patients and reduced financial costs for the patient and institution.

Organizational Needs Statement

In July of 2018, a consensus statement on perioperative use of neuromuscular monitoring was published in *Anesthesia & Analgesia*. This statement aimed to set a standard for the use of quantitative versus qualitative neuromuscular blockade monitoring in the perioperative setting. The clinicians proposed that objective monitoring and documentation of TOF ratio be ≥ 0.90 was the only way to accurately assure adequate neuromuscular recovery has occurred (Naguib, M. et al., 2018). Likewise, the statement suggested that subjective evaluation of TOF ratio using PNS devices and clinical assessment of patient neuromuscular blockade status should be discontinued, unless it is the only method available in that institution.

The Anesthesia Patient Safety Foundation (APSF) published collaborative recommendations on neuromuscular blockade monitoring in 2018, stating that quantitative monitoring should be utilized when neuromuscular blockade medications are administered (Naguib, et al., 2018). These recommendations also included the need to establish practice standards and guidelines from professional organizations, detailing the management of

perioperative administration of neuromuscular blockade medications and use of adequate monitoring.

Standards for nurse anesthesia practice from the American Association of Nurse Anesthesiology (AANA) are currently aimed at quality improvement initiatives to increase the use and understanding of quantitative monitoring. Current guidelines do not specify neuromuscular blockade monitoring mode or frequency, only that neuromuscular response to blockade and reversal agents should be assessed (Wiatrowski, et al., 2018). Anesthesia providers at the partnering healthcare organization routinely use PNS to assess neuromuscular blockade, adequate reversal, and to calculate TOF ratio. To date, this organization has a number of handheld acceleromyography devices for CRNA providers to utilize perioperatively. However, despite this, there is no specific policy on the perioperative use of neuromuscular blockade monitoring devices for anesthesia providers, indicating the need to address perceptions regarding the use of quantitative verses qualitative monitoring techniques.

Problem Statement

Despite guideline recommendations to assess for a TOF ratio ≥ 0.9 by quantitative monitoring prior to emergence and extubation, there continues to be inconsistency in applying this guideline to clinical practice. Additionally, there is limited understanding of providers' perceptions and preferences for quantitative versus qualitative neuromuscular blockade reversal monitoring.

Purpose Statement

The purpose of this quality improvement project was to assess anesthesia providers' perceptions of the usefulness of and preference for using qualitative (PNS) versus quantitative (acceleromyography) neuromuscular blockade monitoring in the perioperative setting.

Section II. Evidence

Description of Search Strategies

The purpose of this literature review was to examine current evidence and recommendations addressing the preferences and utilization of different neuromuscular blockade monitoring techniques among anesthesia providers. The PICOT question used to guide the search strategy was: In neuromuscular blockade monitoring, how does education on the use of quantitative monitoring affect CRNAs' perception and use of monitoring within neuromuscular blockade reversal in surgical patients?

A search of current literature was conducted using the databases PubMed and Cumulative Index to Nursing and Allied Health Literature (CINAHL) as well as the search engine Google Scholar. Boolean operators were used to combine keywords and concepts. The search strategy used to query PubMed was ((neuromuscular blockade monitoring) AND (anesthesia OR anesthetist OR anesthesiologist OR anesthesiology)). This search strategy pulled in the MeSH terms neuromuscular monitoring, anesthesia, anesthetists, anesthesiology, and anesthesiologists. Limits applied included publication in the most recent five years (2016-2021) and English language. CINAHL was searched using a combination of keywords and subject headings identified in the PubMed search. Google Scholar was searched using the same search strategy as PubMed. See Appendix A for a list of keywords, MeSH terms, and subject terms utilized in searches. See Appendix B for search strategies and number of articles found and kept using structured searching. Evidence and information were also identified by reviewing related and referenced articles as well as the websites and resources of anesthesia organizations. Additionally, the search was expanded to include relevant and original articles related to the implementation of acceleromyography and peripheral nerve stimulation, as well as current

guidelines from anesthesia organizations, the partnering healthcare facility, and correspondence from anesthesia providers.

After full text review, five inferential observational cohort studies (Level VI), one prospective observational study (Level IV), one retrospective cohort study (Level III), and one randomized controlled trial (Level II) were identified as pertinent to this project (Melnyk & Fineout-Overholt, 2019). These studies were thoroughly analyzed and arranged chronologically with the listed purpose, design and level of evidence, setting, sample size, intervention, and summary of results (Appendix C: Literature Matrix).

Selected Literature Synthesis

Throughout much of the published literature, authors agree, and information supports, that quantitative neuromuscular blockade monitoring is more useful to determine a TOF ratio $\geq$0.9 to decrease the risk of residual neuromuscular blockade postoperatively compared to qualitative monitoring assessment. Barriers to the use of quantitative monitoring, educational needs of anesthesia providers regarding the use of this method, and the identification of at-risk patients are also important factors in preventing perioperative complications. Specific barriers to the use of quantitative monitoring were assessed by Renew, et al. (2021) and Thomsen, et al. (2020), where ease of utilization and patterns were explored among anesthesia providers. The researchers noted that the participants most often used PNS to monitor neuromuscular blockade and previously felt that quantitative methods affected time management. This study utilized level VI experimental design with observational and inferential analysis among 20 experienced CRNAs in a United States healthcare facility. Participants were timed using qualitative and quantitative monitors in a real-time clinical setting and differences among devices used were noted. Researchers determined that time was a statistically significant barrier in the application of

quantitative monitoring among participants. Similarly, Thomsen, et al. (2020) reported that barriers to consistent use of quantitative methods of neuromuscular blockade monitoring among international providers included time-pressured learning, equipment use, misconceptions, and culture. In this study, 96 anesthesia providers throughout five academic medical centers in the United States and Denmark were sampled and interviewed through level VI descriptive study design. Perception of monitoring technique, equipment functionality, and the need for training were assessed. The authors concluded that anesthesia providers in Denmark generally apply objective neuromuscular blockade monitoring while providers in the United States utilize subjective neuromuscular blockade monitoring. Thomsen et al. (2020) outlined the presence of barriers in neuromuscular blockade monitoring among international providers with their results supported by similar findings published by Renew et al. (2021).

In addition to practice barriers for consistent use of objective neuromuscular blockade assessment, findings from current literature suggest differences in education are a determining factor in the methods anesthesia providers choose to monitor neuromuscular blockade. Anesthesia provider's knowledge and confidence levels were assessed in Naguib, et al. (2019) by an international randomized survey of 1629 anesthesiologists. Their level VI experimental design was performed through qualitative survey to assess each participant's confidence regarding the use of neuromuscular blockade medication and monitoring. In this study, 92% of anesthesia providers expressed overconfidence in using neuromuscular blockade medications with an actual usage accuracy of 57%. This led researchers to determine that confidence in current practice is a barrier to adopting new practices, such as limited use of quantitative neuromuscular blockade monitoring. Furthermore, Bedsworth et al. (2019) reported that study participants were unaware of the limitations of clinical assessment and PNS to indicate adequate recovery from

neuromuscular blockade. In their level VI experimental observational study, researchers examined the use of qualitative versus quantitative neuromuscular blockade monitoring after an educational initiative. Researchers found that although education improved the use of quantitative monitoring for neuromuscular blockade, it did not affect dosing practices of neuromuscular blockade medications. This suggested that additional education was necessary to reduce instances of residual neuromuscular blockade. Dunworth, et al. (2018) performed a similar level VI quality improvement study measuring the use of quantitative monitoring before and after participation in a blended-curriculum educational program. The 114 providers in this study agreed that residual neuromuscular blockade was a clinically important issue. There was an increase in utilization of quantitative monitoring after the educational program initiative, from 25% to 40%.

Lastly, quantitative TOF ratio monitoring using acceleromyography may lower the frequency of postoperative complications, as suggested by a randomized controlled trial comparing PNS and acceleromyography, as well as additional morbidity associated with these complications. Murphy et al. (2008) demonstrated the effectiveness of quantitative assessment using acceleromyography over qualitative monitoring using PNS in their clinical trial among 185 surgical patients. Researchers measured and compared hypoxemic events within the first thirty minutes of admission to the PACU and found that incidence, severity, and duration of hypoxemia and residual neuromuscular blockade were less in the acceleromyography group compared to the PNS group. Additionally, Saager et al. (2018) found that qualitative measures in clinical practice often fail to detect residual neuromuscular blockade. In their study, 64.7% of patients (n=225) who had received neuromuscular blocking medications had residual neuromuscular blockade postoperatively despite reversal agents and use of qualitative (PNS)

monitoring. This level IV multicenter study compared TOF ratio with qualitative (PNS) monitoring and quantitative monitoring (acceleromyography) throughout various abdominal procedures requiring neuromuscular blockade medications and at tracheal extubation. Researchers concluded that by routinely monitoring neuromuscular blockade with quantitative monitoring devices instead of qualitative monitoring and clinical judgment, clinical outcomes can be improved. Similarly, Rudolph et al. (2018) conducted a blinded observational study to compare the accuracy of the TOF count and computed ratio with postoperative experience, and to predict occurrence of residual neuromuscular blockade compared to the TOF count and ratio at the conclusion of a surgical case. They found 20.2%, (432 of 2144) of adult non-cardiac surgical patients showed clinical signs of residual neuromuscular blockade, including hypoxemia. From their findings, the researchers created a systematic patient assessment tool listing these identified, independent, patient-related predictors of residual neuromuscular blockade. When used, anesthesia providers may be able to recognize and prevent instances of inadequate neuromuscular blockade reversal earlier in the perioperative setting.

Project Framework

The framework used for execution of this project was the Institute for Healthcare Improvement (IHI) model using a single plan-do-study-act cycle (PDSA: Langley, et al., 2009). The PDSA cycle is a cost-effective approach to change using small-scale testing to identify which ideas are the most useful for improvement. The plan phase identifies the change that will be implemented for improvement to occur. Information from an improvement model and driver diagram assist in clarifying the aim and measure, persons responsible for change, a timeline of implementation, and how measurements will occur. The primary goal of the do phase is to ensure participants understand the data collection process while introducing the desired change.

During the study phase, observed information is analyzed and data is qualified and quantified, comparing predictions with actual results while modifying changes based on the results of the test of change. The final step, the act phase, involves deciding if the previously performed small-scale test aligns with the proposed change and determining whether adaptation or developing something new is needed altogether. This PDSA cycle may help provide accelerated improvement within a healthcare organization while respectively questioning its current practices. Three fundamental questions that ultimately guide improvement address what will be accomplished, recognition of the importance of improvement, and identifying change that will ensure improvement is successful (Langley, et al., 2009).

Ethical Considerations and Protection of Human Subjects

The protection of human subjects was addressed by gaining approval for the project through the organizational Institutional Review Board (IRB) as well as completion of Collaborative Institutional Training Initiative (CITI) program training in research, ethics, and compliance by each team member. The proposed intervention carried no greater than usual perceived risk or harm in its application to anyone within the target population. The CITI program training (https://about.citiprogram.org/) was completed online and included courses on biomedical responsible research and biomedical investigation. The organizational approval process was completed through a process established by the East Carolina University (ECU) College of Nursing in collaboration with the ECU University and Medical Center Institutional Review Board (UMCIRB) to determine if full IRB approval was required. The project was classified as quality improvement and not required to seek full approval. Facility approval was additionally obtained through the participating organization in conjunction with the ECU

UMCIRB. Local facility approval to collect data was obtained from a site contact person whose signature was included on the participating organization's approval form. See Appendix D.

Section III. Project Design

Project Setting

The setting for this project included several general surgery operating rooms within a large tertiary healthcare organization. This organization is designated as a level one trauma facility and serves a large population within the region. Within this facility, there are more than thirty operating rooms where adult general surgical procedures are performed daily. Facilitators of the project included frequent use of neuromuscular blocking agents, neuromuscular monitoring equipment availability, functionality of equipment, and the AANA practice standards of care concerning neuromuscular blockade monitoring. Potential barriers included fast paced operating room turnover, procedures not requiring neuromuscular blockade and reversal, and opportunities for monitoring during complex surgical cases where access to monitoring sites are limited.

Project Population

The project population included CRNAs delivering care to patients in several general surgery operating rooms. Within the partnering organization, a number of CRNAs provide anesthesia in these rooms with several general surgical procedures performed daily. Facilitators for participation included agreeability and willingness of the CRNAs to participate in quantitative neuromuscular blockade assessment using the acceleromyography device. Perceived barriers consisted of preexisting perceptions regarding the use of quantitative neuromuscular blockade monitoring, time constraints, satisfaction with current neuromuscular monitoring practice, and established practice patterns.

Project Team

The project team consisted of the team lead Student Registered Nurse Anesthetist, two student colleagues, the project chair, an organizational contact person, a clinical contact person, the program director, and the course director. The team lead worked cooperatively with two student colleagues to initially develop the project, including the educational video and the pre- and post-intervention questionnaires created using Qualtrics survey software. Sharing of the intervention and survey links along with collection and analysis of data for the specified population was accomplished solely by the team lead, with the support of the project chair.

A single CRNA program faculty member served as both project chair and clinical contact person and provided valuable guidance and clinical experience in project development, implementation, and analysis as well as assistance in recruiting participants. Timeliness, project orientation and facility information were directed by the project chair. Topic information and guidance of participants were also provided through the project chair. The CRNA program director provided organizational support and feedback and the course director provided feedback throughout the project process.

Methods and Measurement

The purpose of this quality improvement project was to assess anesthesia providers' perceptions of perioperative usefulness of qualitative (PNS) and quantitative (acceleromyography) monitoring for residual neuromuscular blockade monitoring intraoperatively and prior to extubation.

A single PDSA cycle was used to perform this project. The planning period consisted of team meetings with the project chair to facilitate the sharing of ideas, tools, processes, survey information and data collection processes. The purpose and problem statement were discussed with team members to guide project production. Furthermore, participating CRNAs were

identified by the project chair and clinical contact person and were communicated with through email. Approval project approval was obtained through the partnering organization during this planning period.

During the do period, an email consisting of a pre-intervention Qualtrics questionnaire regarding participants' perceptions and use of neuromuscular blockade monitoring and an educational video demonstrating the use of the quantitative acceleromyography device was provided (Appendix E). The provided video reviewed current guidelines, train-of-four ratio, and quantitative acceleromyography monitoring. Devices were given to participants to quantify neuromuscular blockade and reversal assessment (Appendix F). The acceleromyography neuromuscular monitoring devices were provided to participants in operating rooms within the general surgery area by the primary team lead to be utilized over a two-week time period. The participating CRNAs were asked to note the number of times acceleromyography was used, their perceptions of the technique, and outcomes of use using Qualtrics survey software (Appendix G). Upon completion of the two-week implementation period, they were asked to complete a post-questionnaire regarding their perceptions of the usefulness of the qualitative (PNS) and quantitative (acceleromyography) assessments as noted during the implementation period. Qualtrics survey software was used to deliver the intervention link and gather participant perceptions of acceptability and adequacy of the qualitative and quantitative methods of assessing residual neuromuscular blockade prior to and post implementation of the project (Appendix G).

Data collected through the pre- and post-intervention questions included nominal, ordinal, interval, ratio, and free response information types. After completion of the data collection period, the data was downloaded to Excel where it was analyzed. No patient

information was recorded or maintained during this project. Out of five recruited participants, all participants responded to the pre-survey, though one participant responded to only one question. The post-survey had four out of five participant responses with all questions answered. The implementation period was extended by one week, to a total of three weeks, as some participants were unavailable or were assigned to areas where neuromuscular blockade was not used during the implementation period. The original project method was carried out successfully, and surveys were delivered in Qualtrics with links sent via email. There were no other changes made to the project methods during data collection.

Section IV. Results and Findings Results

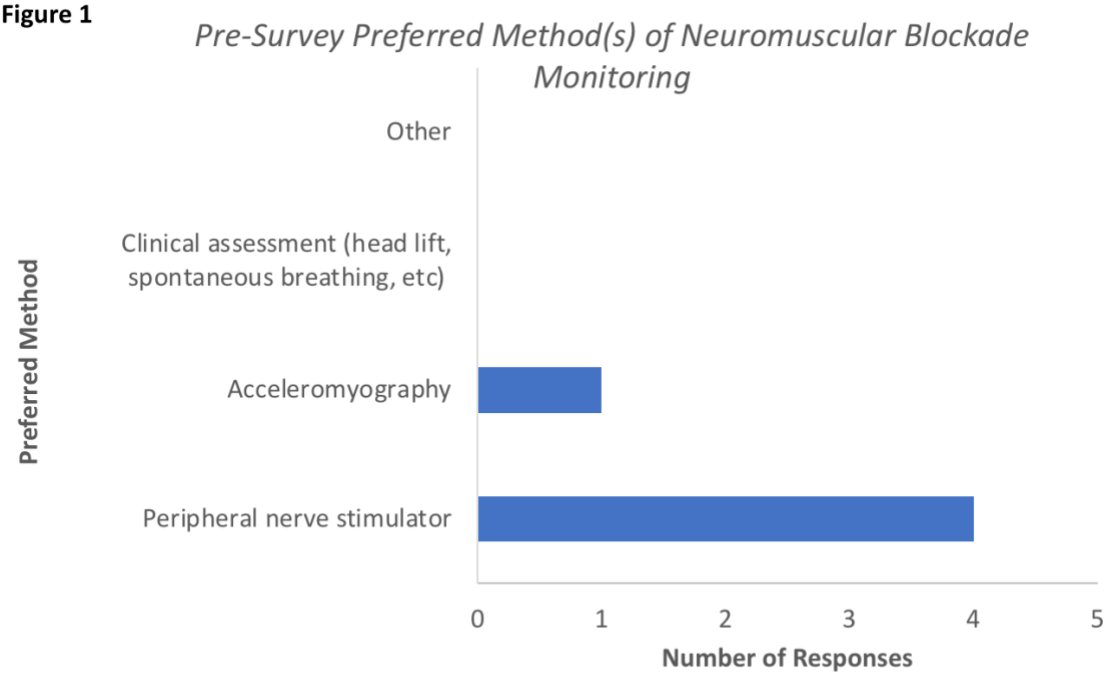
The purpose of this quality improvement project was to assess anesthesia providers' perceptions of the usefulness of and preference for using qualitative (PNS) versus quantitative (acceleromyography) neuromuscular blockade reversal measurements in the perioperative setting. At the participating institution, four out of five invited CRNAs participated in the data collection and use of the acceleromyography device. The CRNAs were asked to complete a pre-survey before and post-survey after the implementation period regarding their perceptions of use of qualitative versus quantitative neuromuscular blockade monitoring (Appendix G). To gather pre-survey data, participants were asked several questions regarding their current neuromuscular blockade monitoring practice, familiarity with the quantitative monitoring device (acceleromyography), hinderances to neuromuscular blockade monitoring, and any experiences of inadequate neuromuscular blockade reversal with a particular monitoring method. Similarly, post-survey data were gathered in regard to CRNAs' use of the acceleromyography device, perceived accuracy, amount of time required for set up, and likelihood they would use the device in the future. Qualtrics survey software was used to create and deliver the questionnaires and to gather data. The data obtained were then analyzed using Excel.

Data Presentation

In the pre-intervention survey, several questions were asked about CRNAs’ current neuromuscular blockade monitoring practices. Figure 1 depicts responses from the participating CRNAs. The perceived difficulty of using monitors to assess neuromuscular blockade for two of four participating CRNAs were recorded as not difficult while two CRNAs responded that monitor use was somewhat not difficult. Time and device availability were noted as being hinderances to the use of a neuromuscular blockade monitor by most of the participating

CRNAs. Two CRNAs responded that there were no hinderances to using a monitor to assess neuromuscular blockade and one CRNA responded that lack of comfort with the monitoring device was a hinderance. All four CRNAs responded that acceleromyography is used 0-25% of the time in their current practice. Two participants responded that their perceived accuracy of acceleromyography use was neutral, while one CRNA responded very accurate and one accurate. All of the four participating CRNAs have had a patient with inadequate neuromuscular blockade reversal in which qualitative neuromuscular blockade monitoring (PNS) was used to assess adequate neuromuscular blockade reversal.

Figure 1



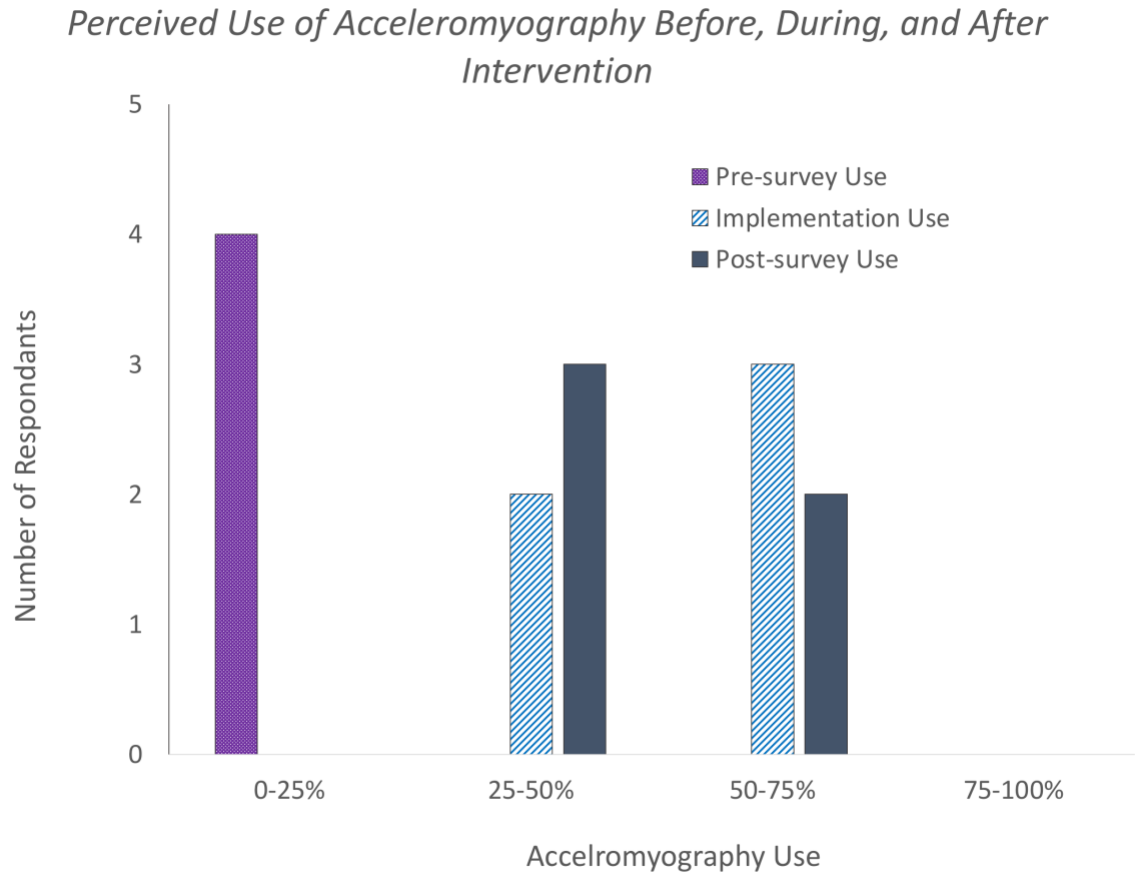
Note: n=4. Multiple selections allowed with a free text option under other methods.

The post-intervention survey inquired about participants' use of the acceleromyography device, accuracy, set up time, and future use of the device in their practice. Three participating CRNAs responded that the acceleromyography device was used 50-75% of the time with two respondents noting its use 25-50% of the time over the implementation period. No participants

found use of the acceleromyography device as difficult. Consequently, since participants did not find acceleromyography use difficult, there were no responses to the embedded question regarding types of difficulties experienced. Furthermore, four respondents stated that acceleromyography was slightly more accurate than their routine monitoring technique with one participant noting that it was more accurate. There were no responses suggesting that acceleromyography was part of the CRNAs' current technique. All participating CRNAs responded that, on average, set-up time of the acceleromyography device was less than 2 minutes, and more time consuming than their usual methods.

Participants were asked about current neuromuscular blockade monitoring practice, use during the implementation period, and future perceived use of acceleromyography. See figure 2. As depicted, participating CRNAs stated they currently used acceleromyography 0-25% of the time and stated they were either extremely likely, somewhat likely, and somewhat unlikely to use acceleromyography in the future. There was one response offered from participants in the final free text question area regarding the types of cases where using an objective neuromuscular blockade monitoring device would be paramount to reducing error in inadequate neuromuscular blockade reversal. This response suggested that it may be helpful in patients with preexisting neuromuscular conditions.

Figure 2



Note: Pre-survey n=4. Implementation n=5. Post-survey n=5

Analysis

Analysis of the pre-intervention survey responses showed that participating CRNAs most often utilize peripheral nerve stimulation as their preferred method to monitor neuromuscular blockade. Only one participant currently uses quantitative monitoring (acceleromyography) to monitor neuromuscular blockade. The perceived difficulty of using neuromuscular blockade monitors in the pre-survey was reported as not difficult and somewhat not difficult by most respondents. Similarly, participants responded that acceleromyography use remained not difficult in the post-survey after the implementation period. Hinderances to using a neuromuscular

blockade monitor included availability, time, comfort with use, and no hinderance. Availability of a functional acceleromyography device was the most prominent interference to neuromuscular blockade monitor use. Time constraints and comfort with the use of the acceleromyography device were also offered by participants as hinderances to neuromuscular blockade monitor use in the pre-survey.

All participants utilized acceleromyography 0-25% of the time to monitor the level of residual neuromuscular blockade in the pre-survey. During the implementation period, there was an increased use of acceleromyography by participants. After the intervention, there was a positive increase in the future utilization of acceleromyography to monitor for residual neuromuscular blockade prior to extubation among participants. See Figure 2.

Most participants' perceived accuracy of the acceleromyography device was neutral, though some participants responded it was accurate. There was one participant who currently utilizes acceleromyography as their current practice. These responses were overall unchanged after the implementation period as most respondents perceive the accuracy of the acceleromyography device as neutral. CRNAs were asked to note the time it took to set up the acceleromyography device during the implementation period with most respondents answering less than one minute. Compared to participants' current practice of neuromuscular blockade monitoring, most respondents felt use of the acceleromyography device was slightly more time consuming.

Section V. Implications

Financial and Nonfinancial Analysis

Financial analysis of the implementation of acceleromyography device use among CRNAs shows that it may be a cost-effective measure in reducing inadequate neuromuscular blockade reversal prior to extubation in the peri-operative setting. Device training, intraoperative set-up, and use by the CRNAs require no additional expense other than a slight increase in CRNA time and effort and do not require a major change of workflow. The major financial cost would be the purchase of additional acceleromyography devices to be available for each operating room. Furthermore, TOF ratio measurement by an acceleromyography device can be manually entered into the electronic health record for patient assessment and does not impede current practice.

Compared to the cost of one PNS device at $300, one acceleromyography monitoring device costs $1500. Although the acceleromyography device is more expensive, the long-term benefits are more cost efficient in terms of patient care and potential outcomes. Patient safety is the most important aspect of patient care and includes attempts to prevent negative perioperative outcomes. Postoperative residual neuromuscular blockade may facilitate the need for longer PACU stays, ICU admission, and increased cost to the patient and organization. On average, the cost for one day of Intensive Care Unit (ICU) admission is $5496, not including equipment, medications, physician services, or adjunct care (Cleveland Clinic, 2022). For patients unable to be extubated or those who require re-intubation in the post-operative period due to residual neuromuscular blockade, these expenses are significant and an unnecessary expense for the patient and partnering organization.

Barriers to successful outcomes of implementing a similar quality improvement project include the availability and functionality of acceleromyography devices and educational information for CRNAs. At present, there are fourteen acceleromyography devices located within the partnering organization. This number of devices falls short of the over thirty operating room areas where neuromuscular blockade may occur. If the partnering organization purchased fifteen more acceleromyography devices to be used in the general surgical operating room areas, it would require a cost of approximately $22,500 and be available in most operating rooms.

The financial return on investing in additional acceleromyography devices would be beneficial to the improvement in patient outcomes at the partnering organization and overall cost of associated complications from residual neuromuscular blockade. The purchase and utilization of acceleromyography monitoring devices among CRNAs may result in a significant decrease in the number of patients who have residual neuromuscular blockade and the need for ICU admission. The addition of one acceleromyography device could potentially prevent one patient from one day of ICU admission and save approximately $9,500. There would be no expected or unexpected negative outcomes to the implementation of acceleromyography devices into clinical practice and, if sponsored by the organization, would provide a great return on their investment.

Implications of Project

Implications of the quality improvement project align with the AANA standards of care for neuromuscular blockade monitoring as well as international recommendations for the TOF ratio to be ≥ 0.9 in determining the presence of adequate neuromuscular blockade reversal prior to extubation. Additionally, the project directly aligns with the recommendations from the APSF that quantitative neuromuscular blockade monitoring should be used when neuromuscular blockade medications are administered (Naguib, et al., 2018). Although there are published

recommendations suggesting the use of quantitative methods to accurately assess neuromuscular blockade, there is no current national guideline standard from the AANA regarding this practice.

Findings from analysis of survey response data tend to correlate with information in current literature as most CRNAs prefer a qualitative (PNS) device to monitor neuromuscular blockade and have had a patient with inadequate neuromuscular blockade reversal using this type of device. Specific barriers, such as time and education, were both noted in the pre- and post-survey findings as well as in the literature. Likewise, participating CRNAs responded that set-up time of the acceleromyography device during implementation took less than two minutes. These findings correlated directly to the Renew et al. (2021) research suggesting that it took nineteen additional seconds (less than one minute) to apply the acceleromyography device. The results reported from Bedsworth et al. (2019) and Dunworth et al. (2018) also suggested that providing education on acceleromyography neuromuscular blockade monitoring devices improved overall utilization. In support of literature findings and project result analysis, there was a positive improvement in acceleromyography utilization among CRNAs after education was provided and the implementation of the project initiated.

Outcomes of this project may have beneficial implications for patients, CRNAs, and the partnering organization as a whole. Patients may experience less complications when undergoing general anesthesia with neuromuscular blockade medications as recognition of inadequate neuromuscular blockade reversal may be objectively recognized and managed promptly. CRNAs may also benefit from these outcomes as their confidence of acceleromyography utilization and in identifying residual neuromuscular blockade reversal during general surgery cases may increase. Moreover, the PACU and partnering organization have potential benefit from

implementing acceleromyography as patient turnover time, length of hospital stay, and overall cost have the potential to be improved or reduced using this method.

Sustainability

This pilot study can be used to guide the partnering organization in a larger quality improvement project on the implementation of acceleromyography use based on the perceptions of practicing CRNAs within the facility. The financial aspect of the quality improvement project can be attained through the purchase of additional acceleromyography devices and there is no cost in assessing CRNAs' perceptions of use. Further education on neuromuscular blockade monitoring and acceleromyography use may provide incentive to CRNAs' utilization of the device. Short-term factors negatively impacting sustainability include loss of, misplaced, or damaged units and the need for replacement, repair, and maintenance. There are no perceived long-term factors affecting sustainability as the need for neuromuscular blockade monitoring in patients undergoing general anesthesia persists in many general surgery cases and is supported by current guidelines.

Dissemination Plan

In addition to this project paper, a poster was developed by the project team lead for the dissemination of results. This poster was presented to nurse anesthesia program faculty and students with project participants also invited to join. Both in person and electronic format were utilized. The final version of this paper, as well as the project poster, have been posted in The Scholarship, the East Carolina University digital repository.

Section VI. Conclusion

Limitations

Limitations to the project included small sample size, limited survey capabilities, and method of delivery of information to participants. The sample size of five participants compared to the number of participants that provide anesthesia for the partnering organization is very small. Therefore, the results and analysis of data may not be representative of CRNAs' perceptions of acceleromyography use as a whole. Secondly, the surveys delivered through Qualtrics software were unable to distinguish CRNAs who already completed the survey, allowing participants to complete surveys more than once. This limitation could skew results as there was not a way to anonymously determine repeated surveys from CRNAs. Qualtrics survey software has the ability to distinguish between respondents but these functions were not used in this project in an effort to maintain anonymity. The delivery of surveys and the intervention tool via email may have limited participation of CRNAs if they did not check their email regularly. Likewise, participants may not have been able to access the intervention tool without revisiting the survey in Qualtrics or via the link embedded in the email, potentially altering participation.

Recommendations for Future Implementation and/or Additional Study

This pilot quality improvement project to assess perceptions among CRNAs on qualitative versus quantitative neuromuscular blockade monitoring for the assessment of postoperative residual neuromuscular blockade prior to extubation was performed as a simple project within a large healthcare organization. Recommendations for future planning, implementation, and evaluation of another project of this caliber include following similar guidance as this project team. The single plan-do-study-act cycle, which was performed successfully, identified concepts useful in the improvement of neuromuscular blockade

monitoring and outcomes in patients. Qualtrics survey software settings may be adjusted in future projects to address the issue of multiple surveys from the same participant.

Additional information of value for a future project includes the number of patients with prolonged admission to PACU and unexpected ICU admission from residual neuromuscular blockade at the partnering organization. Pre- and post- education and intervention data could be obtained to assess these outcomes and associated costs to the patient. Likewise, cost effectiveness of reversal medications and the potential for negative side effects may also be a factor in patient outcomes. Specific surgical considerations for the use of the acceleromyography device may also be investigated as patient factors, positioning, and expectations are variable with each case.

Based on the experience of this quality improvement project, further quality improvement and research is needed to address the inconsistencies in the application of recommended TOF ratio ≥ 0.9 using quantitative monitoring prior to emergence and extubation. Both the AANA (2019) and partnering organization do not currently have specific policies outlining neuromuscular blockade monitoring and the use of quantitative monitoring devices to assess for inadequate neuromuscular blockade prior to extubation. Through further research, standards of care for quantitative neuromuscular blockade monitoring during general anesthesia may be implemented and perioperative patient safety improved.

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Appendix A
Literature Concepts Table

	Concept 1: **Neuromuscular blockade monitoring**	Concept 2: **Anesthesia**	Concept 3: **Not used**
Keywords (these are the "normal" words you would use anywhere)	**Neuromuscular blockade monitoring**	**Anesthesia** **Anesthetist** **Anesthesiology** **Anesthesiologist**	**Not used**
PubMed MeSH (subject heading specific to PubMed)	"neuromuscular monitoring"[MeSH Terms]	"anesthesia"[MeSH Terms] "anesthetists"[MeSH Terms] "anesthesiology"[MeSH Terms] "anesthesiologists"[MeSH Terms]	Not Used
CINAHL Subject Terms (Subject headings specific to CINAHL)	((MH "Neuromuscular Blockade") AND "neuromuscular blockade") AND ((MH "Monitoring, Physiologic") AND "monitoring")	Additional concept not used for CINAHL search	Not Used
Google Scholar	(Neuromuscular monitoring OR Neuromuscular Blockade monitoring)	(anesthesia OR anesthetist OR anesthesiology OR anesthesiologist)	Not used

Appendix B
Literature Search Log

Search date	Database or search engine	Search strategy	Limits applied	Number of citations found/kept	Rationale for inclusion/exclusion of items
9/21/2021	**PubMed**	(neuromuscular monitoring or neuromuscular blockade monitoring) AND (anesthesia or anesthetist or anesthesiology or anesthesiologist) **PubMed Search Translation:** ((("neuromuscular monitoring"[MeSH Terms] OR ("neuromuscular"[All Fields] AND "monitoring"[All Fields]) OR "neuromuscular monitoring"[All Fields] OR ("neuromuscular"[All Fields] AND "blockade"[All Fields] AND "monitoring"[All Fields]) OR "neuromuscular blockade monitoring"[All Fields]) AND ("anaesthesia"[All Fields] OR "anesthesia"[MeSH Terms] OR "anesthesia"[All Fields] OR "anaesthesias"[All Fields] OR "anesthesias"[All Fields] OR ("anaesthetists"[All Fields] OR "anesthetist s"[All Fields] OR "anesthetists"[MeSH Terms] OR "anesthetists"[All Fields] OR "anaesthetist"[All Fields] OR "anaesthetists"[All Fields] OR "anesthetist"[All Fields]) OR ("anaesthesiology"[All Fields] OR "anesthesiology"[MeSH Terms] OR "anesthesiology"[All Fields] OR "anesthesiology s"[All Fields]) OR ("anaesthesiologist s"[All Fields] OR "anesthesiologist s"[All Fields] OR "anesthesiologists"[MeSH Terms] OR "anesthesiologists"[All Fields] OR	Last 5 years (2016-2021) English	423 results/33 kept	**Inclusion**: relevance to neuromuscular blockade monitoring in the perioperative setting; perceptions on the use of quantitative versus qualitative measurement; anesthesia; QI project on education **Exclusion**: neuromuscular blockade monitoring in the ICU, neuromuscular blockade and/or reversal medications; non-human subjects; incomplete; comparing other quantitative methods (not acceleromyography)

		"anaesthesiologist"[All Fields] OR "anaesthesiologists"[All Fields] OR "anesthesiologist"[All Fields])) AND ((y_5[Filter]) AND (english[Filter]))			
9/21/2021	**CINAHL**	((MH "Neuromuscular Blockade") AND ("neuromuscular blockade") AND ((MH "Monitoring, Physiologic") AND ("monitoring")	2016 - 2021 Peer reviewed English	68 results/16 kept	**Inclusion**: neuromuscular blockade monitoring; quantitative and qualitative monitoring; guidelines on monitor use; acceleromyography use perception **Exclusion**: overlap from PubMed articles; ICU monitoring; reversal-based medications; additional qualitative monitoring methods
9/21/2021	**Google Scholar**	(neuromuscular monitoring or neuromuscular blockade monitoring) AND (anesthesia or anesthetist or anesthesiology or anesthesiologist)	2016-2021	2880 results/5 pages viewed/18 kept	**Inclusion**: neuromuscular blockade monitoring; quantitative and qualitative monitoring; guidelines on monitor use; neuromuscular blockade monitoring use and education program **Exclusion**: medication-based reversal; incomplete results; ICU monitoring; non-human subjects;

Appendix C

Literature Matrix

Year	Author, Title, Journal	Purpose & Conceptual Framework or Model	Design and Level of Evidence	Setting	Sample	Tool/s and/or Intervention/s	Results
2021	Renew, J. R., Hex, K., Johnson, P., Lovett, P., & Pence, R. (2020;2021;). Ease of application of various neuromuscular devices for routine monitoring. *Anesthesia and Analgesia*, *132*(5), 1421-1428. https://doi.org/10.1213/ANE.0000000000005213	No specific conceptual framework/model noted. Investigates how long experienced nurse anesthetists to apply various neuromuscular devices as well as their perception regarding the ease of application.	Level VI Experimental; observational study; inferential	1 US facility	20 Nurse anesthetists; survey; with at least 5 years of experience, 70% use routine PNS monitoring of NMB. Survey about ease of utilization of these devices.	Educational session to familiarize them with 3 devices (PNS, acceleromyography, and EMG) Participants timed while placing devices in a real-world setting. Participants timed when obtaining calibrated TOF ratios and connecting devices	It takes 19 seconds to apply a quantitative neuromuscular monitor than a PNS. This was statistically significant, however, this additional time represents a barrier to their application. Application of both types of monitoring devices were reported by nurse anesthetists as being straight forward.
2020	Thomsen, J. L. D., Marty, A. P., Wakatsuki, S., Macario, A., Tanaka, P., Gätke, M. R., & Ostergaard, D. (2020). Barriers and aids to routine neuromuscular monitoring and consistent reversal practice—A qualitative study. *Acta Anaesthesiologica Scandinavica*, *64*(8), 1089-1099. https://doi.org/10.1111/aas.13606	No specific conceptual framework/model noted. To explore barriers and aids to routine neuromuscular monitoring and consistent practice regarding reversal.	Level VI Descriptive study analysis; Coding of survey response themes; Qualitative	5 academic medical centers in Denmark and 3 academic medical centers in the US. Small and large anesthesia departments.	96; convenience sampling; surveys and focus group interviews among anesthesia providers.	Themes assessed: barriers, attitude, department, aids, need for training, NM after succinylcholine.	Danish anesthetists generally apply objective neuromuscular monitoring routinely while residents at a US institution often apply subjective neuromuscular monitoring. Barriers to consistent and correct use still exist, including unreliable equipment, time-pressure, training, misconceptions, culture, and lack of standards and guidelines.
2019	Bedsworth, M. B., Harris, E. M., Vacchiano, C. A., Thompson, J. A., Grant, S. A., & Goode, V. M. (2019). Evaluating a quality improvement initiative to increase anesthesia providers' use of and understanding of quantitative neuromuscular monitors. *AANA journal*, *87*(5), 357-363.	No specific conceptual framework/model noted. Purpose to develop a quality improvement initiative to enhance anesthesia providers' knowledge and management of NMB, including pharmacology,	Level VI Quality improvement Initiative; Pre and post initiative observational study; Inferential	Large, academic anesthesia department	200 patients (100 pre and 100 post initiative); random; Varied demographics	Pre-initiative observation of current practice using qualitative monitors for 3 months. Post initiative manual chart reviews of intraoperative records;	Quantitative neuromuscular monitoring initiative was successful in increasing the use of the QNM; however, it did not affect provider's overall dosing practices of NMBAs and neostigmine. Providers were unaware of the limitations of clinical

		physiology, and monitoring.					assessment tests and peripheral nerve stimulators as indicators for recovery from NMB Consistent education on these topics, along with the presence of cognitive aids in the OR, led to early increased use of the QNM. Clearly, additional education is needed to assess outcomes associated with residual NMB.
2019	Naguib, M., Brull, S. J., Hunter, J. M., Kopman, A. F., Fülesdi, B., Johnson, K. B., & Arkes, H. R. (2019;). Anesthesiologists' overconfidence in their perceived knowledge of neuromuscular monitoring and its relevance to all aspects of medical practice: An international survey. *Anesthesia and Analgesia*, *128*(6), 1118-1126. https://doi.org/10.1213/ANE.0000000000003714	No specific conceptual framework/model noted. To assess the hypothesis that non-utilization of neuromuscular monitoring was anesthesia provider's overconfidence in the knowledge and management of NMBD without monitoring	Level VI Single, descriptive qualitative study; Numerical representation of participant's confidence level	Online international survey; multi-lingual; randomized; anesthesiologists	1629 anesthesiologists completed the survey; randomized convenience sample.	Survey true/false questions related to use of NMBD's; rate accuracy of answers on a scale of 50% (pure guess) to 100% (certain)	92% of participants expressed overconfidence in using NMBD. Mean confidence exhibited 84% which was greater than the actual accuracy of 57%. This overconfidence may be partially responsible for the failure to adopt routine perioperative neuromuscular monitoring. Providers who are highly confident in their knowledge about a procedure, they are less likely to modify their clinical practice or seek further guidance on its use.
2018	Dunworth, B. A., Sandberg, W. S., Morrison, S., Lutz, C., Wanderer, J. P., & O'Donnell, J. M. (2018). Implementation of acceleromyography to increase use of quantitative neuromuscular blockade monitoring: A quality improvement project. *AANA Journal*, *86*(4), 269-277.	No specific conceptual framework/model noted. To improve knowledge and practice on neuromuscular monitoring by implementing a blended educational program, consisting of multiple learning modalities and clinical experts.	Level VI Quality Improvement project; pre- and post-intervention; experimental observational study; inferential/ quantitative	Academic Medical Center; Anesthesia Department	114; convenience sample; anesthesia providers providing care in 39 adult operating rooms; academic medical center;	Blended-curriculum educational program; use of neuromuscular blockade monitor; perceptions, knowledge of quantitative monitoring survey with 5-point Likert scale	Weekly provider utilization increased from a mean of 24% to 40% from baseline after the education period. The percentage of patients who received quantitative monitoring increased by 74% relative to baseline. Providers agreed that rNMB is a clinically important problem before and after educational program.

2018	Rudolph, M. I., Ng, P. Y., Deng, H., Scheffenbichler, F. T., Grabitz, S. D., Wanderer, J. P., Houle, T. T., & Eikermann, M. (2018). Comparison of a novel clinical score to estimate the risk of REsidual neuromuscular block prediction score and the last train-of-four count documented in the electronic anaesthesia record: A retrospective cohort study of electronic data on file. *European Journal of Anaesthesiology, 35*(11), 883-892. https://doi.org/10.1097/EJA.0000000000000861	No specific conceptual framework/model noted. Aim of the study was to develop a REsidual neuromuscular block prediction score (REPS) to predict rNMB and compare the accuracy with train-of-four count measurement at the end of a surgical case.	Level III Retrospective cohort study; observational; blinded.	Surgical cases performed under general anesthesia at Massachusetts General Hospital post anesthesia recovery unit.	2144 adult noncardiac surgical patients between October 2008 and March 2013. 18 years old, intermediate NMB agents used, and admitted to PACU post operatively.	Quantitative TOF ratio measurements obtained on admission to PACU in an observer blinded manner. Retrospective data from multiple patient data registries that compile data for research purposes.	Ten independent predictors for rNMB: hepatic failure, neurological disease, reversal, metastatic tumor, females, time period between NMB and extubation, agent type, BMI >35, CRNA presence, surgeon experience. rNMB occurred in 432 cases (20.2%). The REPS tool can be used to identify at risk patients, inform anesthetists better than TOF count, and tailor practices to specific patients to minimize rNMB.
2018	Saager, L., Maiese, E. M., Bash, L. D., Meyer, T. A., Minkowitz, H., Groudine, S., Philip, B. K., Tanaka, P., Gan, T. J., Rodriguez-Blanco, Y., Soto, R., & Heisel, O. (2019). Incidence, risk factors, and consequences of residual neuromuscular block in the united states: The prospective, observational, multicenter RECITE-US study. *Journal of Clinical Anesthesia, 55*, 33-41. https://doi.org/10.1016/j.jclinane.2018.12.042	No specific conceptual framework/model noted. To determine the incidence burden and risk factors associated with residual neuromuscular block during routine hospital care in the US.	Level IV Prospective; observational; blinded; multicenter cohort study; inferential	Operating and recovery rooms of 10 academic and community hospitals in the US	255 adults; convenience sample; patients undergoing elective abdominal surgery with general anesthesia requiring ≥1 dose of NMBD for endotracheal intubation or maintenance of NMB	Conventional qualitative monitoring of rNMB (PNS) Acceleromyography Recordings of various patient procedural characteristics and TOF ratio throughout procedure and at tracheal extubation	64.7% of patients had rNMB at the time of tracheal extubation, despite reversal agents and qualitative PNS used for. Qualitative neuromuscular monitoring and clinical judgement often fails to detect rNMB, causing potentially serious consequences to the patient. Clinical care could be improved by considering quantitative neuromuscular monitoring for routine care.
2008	Murphy, G., Szokol, J., Marymont, J., Greenberg, S., Avram, M., Vender, J., & Nisman, M. (2008). Intraoperative acceleromyographic monitoring reduces the risk of residual meeting abstracts and adverse respiratory events in the postanesthesia care unit. *Anesthesiology, 109*(3), 389-	No specific conceptual framework/model noted. To evaluate the effect of neuromuscular monitoring on the incidence of postoperative residual blockade compared to qualitative monitoring.	Level II Randomized controlled clinical trial; quantitative	Operating room and post-anesthesia care unit in a healthcare facility in Illinois. Anesthesiologists, nurse	185 patients; Randomized to intraoperative monitoring using acceleromyography or qualitative TOF.	Type of monitoring used. Incidence of postoperative residual neuromuscular blockade and hypoxemia. SPO2 monitoring and need for tactile stimulation	A lower frequency of neuromuscular blockade in the PACU was observed in the acceleromyography group compared to the conventional TOF group. The incidence, severity, and duration of hypoxemic events during the first 30 mins of PACU admission

	398. https://doi.org/10.1097/ALN.0b013e318182af3b	Examined the effect on intraoperative acceleromyography on hypoxia and airway obstruction in the PACU.		anesthetists, residents.			were less in the acceleromyography group.

Note: Key to Levels of Evidence: I: Systematic review/meta-analysis of randomized controlled trials (RCTs); II: RCTs; III: Nonrandomized controlled trials; IV: Controlled cohort studies; V: Uncontrolled cohort studies; VI: Descriptive or qualitative study, case studies, EBP implementation and QI ; VII: Expert opinion from individuals or groups. Adapted from *Evidence-based practice in nursing and healthcare: A guide to best practice* (4th ed.), by B. M. Melnyk and E. Fineout-Overholt, 2019, p. 131. Copyright 2019 by Wolters Kluwer.

Note: Key to abbreviations: blood oxygen saturation (SPO2), Certified Registered Nurse Anesthetist (CRNA), neuromuscular blockade (NMB), neuromuscular blocking drugs (NMBD), operating room (OR), peripheral nerve stimulator (PNS), post-anesthesia recovery unit (PACU), quantitative neuromuscular monitor (QNM), residual neuromuscular blockade (RNMB), train of four (TOF).

Appendix D

CON Approval Form

Click "download PDF" to save a copy of this page for your records.
Note: The IRB Office does not maintain copies of your responses.

Below is a summary of your responses

Download PDF

Quality Improvement/Program Evaluation Self-Certification Tool

Purpose:
Projects that do not meet the federal definition of human research pursuant to 45 CFR 46 do not require IRB review. This tool was developed to assist in the determination of when a project falls outside of the IRB's purview.

Instructions:
Please complete the requested project information, as this document may be used for documentation that IRB review is not required. Select the appropriate answers to each question in the order they appear below. Additional questions may appear based on your answers. If you do not receive a STOP HERE message, the form may be printed as certification that the project is "not research", and does not require IRB review. The IRB will not review your responses as part of the self-certification process. For projects being done at [redacted] site support will be required. Please email [redacted]com to obtain site support fro[redacted]

Name of Project Leader:

Anna Maness

Project Title:

Assessing anesthesia providers' perceptions of adequacy of qualitative versus quantitative monitoring for the assessment of postoperative residual neuromuscular blockade prior to extubation

Brief description of Project/Goals:

The purpose of this quality improvement project is to assess anesthesia providers' perceptions of perioperative usefulness of qualitative (PNS) and quantitative (acceleromyography) for perioperative residual neuromuscular blockade. Anesthesia providers at [redacted] will be asked several questions (through qualtrics) about their perceptions of adequacy of currently used qualitative (PNS) and quantitative (acceleromyography) methods of assessing perioperative residual neuromuscular blockade in the operating room setting. A video reviewing current guidelines of 0.9 train-of-four ratio with quantitative monitors for determining adequate neuromuscular reversal will then be made available. Providers will be asked to record their preferred (qualitative/quantitative) assessment practice for two weeks. Upon completion of the two-week period they will be asked to complete a questionnaire about their perceptions of the usefulness of the qualitative (PNS) and quantitative (acceleromyography) assessments. Qualtrics survey software will be used to deliver the intervention link and gather participant perceptions of acceptability and adequacy of the qualitative and quantitative methods of assessing residual neuromuscular blockade prior to and post implementation of the project. No patient information will be recorded or maintained during this project.

Will the project involve testing an experimental drug, device (including medical software or assays), or biologic?

- ○ Yes
- ● No

Has the project received funding (e.g. federal, industry) to be conducted as a human subject research study?

- ○ Yes
- ● No

Is this a multi-site project (e.g. there is a coordinating or lead center, more than one site participating, and/or a study-wide protocol)?

- ○ Yes
- ● No

Is this a systematic investigation designed with the intent to contribute to generalizable knowledge (e.g. testing a hypothesis; randomization of subjects; comparison of case vs. control; observational research; comparative effectiveness research; or comparable criteria in alternative research paradigms)?

- ○ Yes
- ● No

Will the results of the project be published, presented or disseminated outside of the institution or program conducting it?

- [x] Yes
- [ ] No

Would the project occur regardless of whether individuals conducting it may benefit professionally from it?

- [x] Yes
- [ ] No

Does the project involve "no more than minimal risk" procedures (meaning the probability and magnitude of harm or discomfort anticipated are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests)?

- [x] Yes
- [ ] No

Is the project intended to improve or evaluate the practice or process within a particular institution or a specific program, and falls under well-accepted care practices/guidelines?

- [x] Yes
- [ ] No

Based on your responses, the project appears to constitute QI and/or Program Evaluation and IRB review is not required because, in accordance with federal regulations, your project does not constitute research as defined under 45 CFR 46.102(d). If the project results are disseminated, they should be characterized as QI and/or Program Evaluation findings. Finally, if the project changes in any way that might affect the intent or design, please complete this self-certification again to ensure that IRB review is still not required. Click the button below to view a printable version of this form to save with your files, as it serves as documentation that IRB review is not required for this project. 11/10/2021

Appendix E

IRB Approval Form

Center for Research & Grants

Quality Assurance/Quality Improvement Project vs. Human Research Study (Requiring IRB approval) Determination Form

This worksheet is a guide to help the submitter to determine if a project or study is a quality assurance/quality improvement (QA/QI) project or research study and is involving human subjects or their individually identifiable information and requires IRB approval as defined by the Health and Human Services (HHS) or Food and Drug Administration (FDA). Once completed, please email the form to the for Research and Grants (I CRG) A CRG team member will contact you with the results of their review and may request additional information to assist with their determination. The determination will be made in conjunction with the UMCIRB office.

Please contact the with any questions a'

For more guidance about whether the activity meets the definition of Human Subjects Research see

Project Title: Perceptions Among CRNAs on Qualitative Versus Quantitative Monitoring for the Assessment of Postoperative Residual Neuromuscular Blockade Prior to Extubation		
Funding Source: None		
Project Leader Name: Anna Maness	☐ Ed.D. ☐ J.D. ☐ M.D. ☐ Ph.D. ☐ Pharm.D. ■ R.N. ☐ Other(specify):	
Job Title: ECU SRNA/	**Phone:**	**Email:**
	Primary Contact (If different from Project Leader): student	
	Phone: 336-953-8627	**Email:** manessa20@students.ecu.edu

Key Personnel/ Project Team members:

Name and Degree:	Department: (Affiliation if other than Vidant)	Email:
Anna Maness, SRNA	ECU Nurse Anesthesia Program	manessa20@students.ecu.edu

QI/QA Assessment Checklist:

Consideration	Question	Yes	No
PURPOSE	Is the PRIMARY purpose of the project/study to: • IMPROVE care right now for the next patient? OR • IMPROVE operations outcomes, efficiency, cost, patient/staff satisfaction, etc.?	✔	
RATIONALE 1	The project/study falls under well-accepted care practices/guidelines or is there sufficient evidence for this mode or approach to support implementing this activity or to create practice change, based on: • literature • consensus statements, or consensus among clinician team	✔	
RATIONALE 2	The project/study would be carried out even if there was no possibility of publication in a journal or presentation at an academic meeting. (**Please note that answering "Yes" to this statement does not preclude publication of a quality activity.)	✔	
METHODS 1	Are the proposed methods flexible and customizable, and do they incorporate rapid evaluation, feedback and incremental changes?	✔	
METHODS 2	Are patients/subjects randomized into different intervention groups in order to enhance confidence in differences that might be obscured by nonrandom selection? (Control group, Randomization, Fixed protocol Methods)		✔
METHODS 3	Will there be delayed or ineffective feedback of data from monitoring the implementation of changes? (For example to avoid biasing the interpretation of data)		✔
METHODS 4	Is the Protocol fixed with fixed goal, methodology, population, and time period?		✔
RISK	The project/study involves no more than minimal risk procedures meaning the probability and magnitude of harm or discomfort anticipated are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.	✔	
PARTICIPANTS	Will the project/study only involve patients/subjects who are ordinarily seen, cared for, or work in the setting where the activity will take place?	✔	
FUNDING	Is the project/study funded by any of the following? • An outside organization with an interest in the results • A manufacturer with an interest in the outcome of the project relevant to its products • A non-profit foundation that typically funds research, or by internal research accounts		✔

If all of the check marks are inside the shaded gray boxes, then the project/study is very likely QI and not human subject research. Projects that are not human subject research do not need review by the IRB.

In order to assess whether your project meets the definition of human subject research requiring IRB review or may qualify as a quality improvement/assurance activity, please provide the following information:

1. **Project Summary: In the space provided below, please provide a summary of the purpose and procedures.**
   Include approved summary here

The purpose of this quality improvement project is to assess anesthesia providers' perceptions of perioperative usefulness of qualitative (PNS) and quantitative (acceleromyography) for perioperative residual neuromuscular blockade. Anesthesia providers at will be asked several questions (through Qualtrics) about their perceptions of adequacy of currently used qualitative (PNS) and quantitative (acceleromyography) methods of assessing perioperative residual neuromuscular blockade in the operating room setting. A video reviewing current guidelines of 0.9 train-of-four ratio with quantitative monitors for determining adequate neuromuscular reversal will then be made available. Providers will be asked to record their preferred (qualitative/quantitative) assessment practice for two weeks. Upon completion of the two-week period they will be asked to complete a questionnaire about their perceptions of the usefulness of the qualitative (PNS) and quantitative (acceleromyography) assessments. Qualtrics survey software will be used to deliver the intervention link and gather participant perceptions of acceptability and adequacy of the qualitative and quantitative methods of assessing residual neuromuscular blockade prior to and post implementation of the project. No patient information will be recorded or maintained during this project.

2. **If the Primary purpose of your project/study is for QA/QI, have you obtained approval from the operational leader within your department or health system** [Please specify here whom and obtain their signature in the signature section below]:

   ☑ **Yes**

   No [Contact the appropriate operational leader for approval.]

Please note:

- By submitting your proposed project/study for QA/QI determination you are certifying that if the project/ study is established to qualify as QA/QI project, you and your Department would be comfortable with the following statement in any publications regarding this project: "This project was reviewed and determined to qualify as quality improvement by the ' for Research and Grants."
- If you are submitting a Poster to Media Services for printing, you will need to also submit this Quality Improvement Worksheet or proof of your IRB Application and IRB Approval.
- If the . CRG determines the activity is not human subject research, then any presentation, publication, etc. should not refer to the activity as "human subject research," "exempt research," or "expedited research."
- If you would like the to verify that a project/study is not human subject research, please provide this form completed with the summary of your activity and any additional information to the CRG at and the following will be completed and returned to you for your records.

NHSR vs. HSR Determination:

☒ **Not Human Subject Research:** The] CRG has determined that based on the description of the project/study, approval by the IRB is not necessary. Any changes or modifications to this project may be discussed with the . CRG at that time to ensure those changes do not elevate the project to human research that would need IRB approval.
☐ **Human Subject Research:** This project/study requires review by the IRB prior to initiation. An application in the electronic IRB submission system should be submitted.

Approval Signatures:

Operational Mgr/Leader: **Date:** 3-7-2022

CRG Reviewer: **Date:** 3/14/22

UMCIRB Office Staff Reviewer: **Date:** 3/15/22

Attestation of Understanding

My signature below indicates that I fully understand that HIPAA Privacy standards as they apply to Quality Projects involving Protected Health Information and patient medical records as outlined below.

Under HIPAA's minimum necessary provisions, must make reasonable efforts to limit PHI to the minimum necessary to accomplish the purpose of the use, disclosure or request.

Under HIPAA, a Covered Entity (i.e. can disclose PHI to another CE (i.e.) for the following subset of health care operations activities of the recipient CE without needing patient consent:

- Conducting quality assessment and improvement activities
- Developing clinical guidelines
- Conducting patient safety activities as defined in applicable regulations
- Conducting population-based activities relating to improving health or reducing health care cost

healthcare data utilized in this project should not be shared outside of the CE without a fully executed data use/sharing agreement. leadership reserves the opportunity to review all articles for dissemination/ publication for which data has been utilized.

Project Leader Signature

2/10/2022
Date

Appendix F

Emails to Participants

Initial Pre-Survey and Video Email to Participants

Dear _ Medical Center CRNAs,

Thank you for considering participating in a quality improvement project titled "Neuromuscular Blockade Monitoring". The purpose of this project is to assess anesthesia providers' perceptions of the usefulness of and preference for using qualitative (PNS) versus quantitative (acceleromyography) neuromuscular blockade monitoring at _ Medical Center.

Participation is voluntary and will involve completing a short pre-intervention questionnaire, viewing a brief video, utilizing acceleromyography in your CRNA practice for two weeks at your discretion, and completing a short post-intervention questionnaire when the two-week implementation period is over.

Each questionnaire and the video should take less than 2-4 minutes to complete. The questionnaires were created and are completed using Qualtrics® survey software. The use of acceleromyography falls within currently accepted practice in your work area. Your participation is voluntary and confidential. We will share the results of this QI study with you upon completion.

First, complete the pre-intervention questionnaire and view the PowerPoint and video here. Acceleromyography devices are available in the anesthesia workroom.

Again, thank you for your participation in our quality improvement project. I will be at _ Medical Center June 20-30, Monday through Thursday if you have any questions but you may also reach out to me or Travis Chabo by email.

Sincerely,

Anna Maness, SRNA manessa20@students.ecu.edu
Travis Chabo, PhD, CRNA, Project Chair chabot14@ecu.edu

Pre-Survey and Video Reminder Email to Participants

Hello _ Medical Center CRNAs,

I just wanted to send a quick reminder about the ongoing DNP Project on Neuromuscular Blockade Monitoring (original email below). If you've already filled out the pre-survey and viewed the video, thank you! If you haven't had a chance to yet, it's not too late and would be very helpful and much appreciated. There are still acceleromyography devices in the anesthesia workroom if you haven't already received one - you may use these at your discretion. After the end of next week, I will begin sending out the post-surveys.

Links:
Pre-survey
Video

Please let me know if you have any questions and thank you again for your participation.

Sincerely,

Anna Maness, SRNA manessa20@students.ecu.edu
ECU Nurse Anesthesia Program
Class of 2023

Post-Survey Email to Participants
Dear _ Medical Center CRNAs,

Thank you to everyone who has already completed my pre-survey and viewed the video! It's now time to complete the brief post-survey (link below).

If you have not filled out a pre-survey, I would really and truly appreciate your participation (it's just surveys and a video!). The link to the pre-survey and video is here. Acceleromyography devices are available for your use if you would like them, but their use is not mandatory for participation in this project.

If you've already completed the first survey, here is the link to the post-survey. It should take less than 2 minutes.

If anyone has questions or issues with the links, please let me know. Again, thank you to everyone for your help and for being excellent preceptors. I look forward to coming back to _ Medical Center soon.

Sincerely,

Anna Maness, SRNA manessa20@students.ecu.edu
ECU Nurse Anesthesia Program
Class of 2023

Final Thank You Email to Participants
Dear _ Medical Center CRNAs,

I just wanted to say thank you so much to everyone for helping me out with my DNP Project! I have collected all the data that I need to proceed with data analysis and will then be finishing my paper. Once it's complete you all will be able to read it if you'd like. And if you liked using acceleromyography and found it useful, you can locate them in the anesthesia supply room.

Thank you again! I hope to work with you more in the future.

Take care,

Anna Maness, SRNA manessa20@students.ecu.edu
ECU Nurse Anesthesia Program
Class of 2023

Appendix G

Intervention

https://youtu.be/6YzMU5F9brs

Appendix H

Pre and Post Intervention Questionnaire

Pre-Intervention Survey Questionnaire

1. In your current practice, which method(s) do you prefer for assessing neuromuscular blockade? *(Select all that apply)*

   Peripheral Nerve Stimulator, Acceleromyography, Clinical Assessment (head lift, spontaneous breathing, etc.), Other_____(Free response)

2. How difficult do you find using monitors to assess neuromuscular blockade? (Select one)

   Not difficult, Somewhat not difficult, Neutral, Somewhat difficult, Very difficult

3. What hinders you from using a neuromuscular blockade monitor? (Select all that apply)

   Availability, Time, Equipment education, Comfort with use of monitor, Other_____ (Free response), Nothing hinders me

4. At your institution, how often do you use an acceleromyography device to monitor for adequate reversal prior to extubation? (Select one)

   0-25%, 25-50%, 50-75%, 75-100%

5. In relation to your current practice, how accurate do you find acceleromyography neuromuscular blockade monitors? (Select one)

   Very Accurate, Accurate, Neutral, Inaccurate, Very Inaccurate, Acceleromyography is my current practice

6. Have you ever had a patient with inadequate neuromuscular blockade reversal? (Select one)

   Yes, No

7. If “yes”, what monitoring method was used? (Select all that apply)

Peripheral nerve stimulator, Acceleromyography, Clinical assessment (head lift, spontaneous breathing, etc), Other _____(Free response)

Post-Intervention Survey Questionnaire

1. While participating in this quality improvement project, approximately how many times did you use the acceleromyography device over the last two weeks? *(Free response)*
2. Did you find using the acceleromyography device difficult (Select one)

   Yes, No
3. *If Yes Selected* If difficult: what made it more difficult? (Select all that apply)

   Availability, Time, Equipment education, Comfort with use of monitor, Other _____ (Free response)
4. Since using acceleromyography, how accurate do you find this method compared to your routine monitoring technique? (Select one)

   More accurate, Slightly more accurate, Neutral, Slightly inaccurate, More inaccurate, Acceleromyography is my routine monitoring technique
5. On average, how long did it take to set up acceleromyography? (Select one)

   < 1 minute, 1-2 minutes, 3-4 minutes, >4 minutes
6. How does this compare to your usual monitoring methods? (Select one)

   No difference in time consumption, More time consuming, Less time consuming, Acceleromyography is my usual monitoring method
7. In the future, how likely are you to use acceleromyography? (Select one)

   Extremely unlikely (0-25%), Somewhat unlikely (25-50%), Somewhat likely (50-75%), Extremely likely (75-100%)

8. In what cases would you see using an objective measuring device as critical to reducing the error of inadequate neuromuscular blockade reversal? *(Free response)*