Neuromuscular Blockade Monitoring: Assessing Nurse Anesthetists' Perceptions of the Usefulness of and Preference for Qualitative versus Quantitative Measurements: A Quality Improvement Project

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Abstract

Anesthesia providers are responsible for administering neuromuscular blocking agents, monitoring the level of blockade, and ensuring adequate reversal of these medications prior to extubation of surgical patients. Despite guideline recommendations to have a train-of-four ratio ≥ 0.9 by quantitative monitoring prior to emergence, there continues to be inconsistency in applying this standard. 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. An educational PowerPoint with voiceover recording along with a short video were developed to educate nurse anesthetists on residual neuromuscular blockade and demonstrate usage of the acceleromyography device. Qualtrics software was utilized to survey participants prior to and after a two-week device implementation period. All participants reported using peripheral nerve stimulators and/or clinical assessment such as head tilt, spontaneous breathing, etc. as their usual method for assessment of neuromuscular blockade, as well as all having had an episode with a patient experiencing residual neuromuscular blockade. Half of participants reported likelihood of future device use as only somewhat likely. Availability and time were two of the major barriers identified to using acceleromyography devices. Although it took all participants less than four minutes to set up and use the device, it was more time consuming than their usual methods. Future research is needed to address providers' perceptions regarding the impact and implications of residual neuromuscular blockade on patients' recovery.

Keywords: neuromuscular blockade, residual neuromuscular blockade, acceleromyography, peripheral nerve stimulator

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Section I. Introduction

Background

Anesthesia providers routinely administer pharmacological neuromuscular blocking agents to produce muscle paralysis during tracheal intubation and surgical procedures (Saager et al., 2018). Saager et al. (2018) reported that inaccurate assessment of neuromuscular function during paralysis may result in residual neuromuscular blockade, which is the lingering impairment of neuromuscular function in the postoperative period after administration of neuromuscular blocking agents (Dunworth et al., 2018; Renew et al., 2020).

During general anesthesia, patients routinely have an endotracheal tube inserted into the trachea to protect their airway, assist and/or control their breathing, and maintain alveolar gas exchange. Upon completion of the surgical procedure, extubation, or removal of the endotracheal tube, occurs when the anesthesia provider deems it appropriate. Determining readiness to extubate includes assessing the patient's respiratory function to exclude residual neuromuscular blockade, ensuring the patient can breathe unassisted safely. A train-of-four ratio is the most common pattern of stimulation to measure depth of neuromuscular blockade (Yeung, 2021). Yeung (2021) explains neuromuscular blockade monitoring devices deliver electrical stimulation every 0.5 seconds along a nerve to assess muscular response to stimulus. The train-of-four ratio is the measured amplitude of the fourth muscular twitch in comparison to the first. A train-of-four ratio < 0.9 at the time of extubation may indicate residual neuromuscular blockade. (Dunworth et al., 2018; Renew et al., 2020).

Many complications arise from this residual impairment, but respiratory complications including pneumonia, hypoxia, reintubation, and perioperative mortality are the most concerning (Dunworth et al., 2018). Therefore, anesthesia providers must assess neuromuscular blockade

levels accurately with neuromuscular monitors both intraoperatively and postoperatively prior to extubation.

Two common methods of peripheral nerve stimulation for assessing neuromuscular blockade level are qualitative and quantitative assessments. Qualitative monitors deliver peripheral neurostimulation to a selected nerve and rely on a provider's subjective tactile or visual assessment of the neuromuscular effect of the stimulation (Dunworth et al., 2018). Quantitative monitors deliver stimulation, evaluate neuromuscular effect, and display numerical results for the train-of-four ratio (Brull & Murphy, 2010). There are several quantitative monitors but, according to Brull and Murphy, mechanomyography devices are the gold standard of quantitative monitors. Unfortunately, this type of stimulation is not widely used in healthcare because of their complicated setup and bulkiness. Acceleromyography devices are small and portable, making their use more appealing to anesthesia providers in the perioperative setting (Murphy et al., 2008). These devices are placed around the thumb and measure the movement of the thumb muscles, specifically the thenar adductors, in response to peripheral stimulation of the ulnar nerve (Brull & Murphy, 2010).

The American Association of Nurse Anesthesiology (AANA) sets standards of care for Certified Registered Nurse Anesthetists (CRNAs). For neuromuscular blockade monitoring, the AANA's standard allows the CRNA to use clinical judgement in measuring and determining the degree of neuromuscular blockade (AANA, 2019). It does not specify time intervals for monitoring neuromuscular blockade, only that it should be performed "routinely" when neuromuscular blocking agents are used. Standard 9 states, "When neuromuscular blocking agents are administered, monitor neuromuscular response to assess depth of blockade and degree

of recovery" (AANA, 2019, p. 3). This standard leaves room for the provider to interpret how to accurately assess neuromuscular blockade level and frequency of monitoring.

Organizational Needs Statement

At the participating organization, anesthesia providers have access to both qualitative and quantitative monitors to assess neuromuscular blockade. Placement of the monitor for assessment may vary from provider to provider. When anesthesia providers change in the middle of surgery, for a break, or at the end of shift, monitor placement variations may lead to inconsistent assessments and potentially improper dosing of neuromuscular blocking agents.

The participating institution has a nursing policy for neuromuscular blockade assessment for intensive care patients receiving neuromuscular blocking agents but not one specifically for anesthesia providers. The policy details how to perform, and the frequency of, assessment. However, it does not specify type of peripheral nerve stimulator to use and bases titration of neuromuscular blocking agents from a train-of-four assessment, not a train-of-four ratio, which is a better indicator of neuromuscular recovery.

Based on the findings in the literature, the participating organization may benefit from developing a standard practice guideline for neuromuscular blockade monitoring for their anesthesia providers. This may facilitate reducing the potential of inadequate neuromuscular blockade reversal and related complications after extubation. Before development and implementation of a new policy, investigation into current practices and preferences of anesthesia providers for monitoring neuromuscular blockade and effectiveness of reversing neuromuscular blockade needs to be performed. It is the intent of this quality improvement pilot project to gain insight regarding present practices at the participating organization and provide

education to anesthesia providers regarding current neuromuscular blockade monitoring techniques.

Problem Statement

Despite guideline recommendations in anesthesia literature to have a train-of-four ratio $\geq$ 0.9 by quantitative monitoring prior to emergence, there continues to be inconsistency in applying these guidelines and understanding providers' perceptions in preference of qualitative versus quantitative 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 (peripheral nerve stimulator, PNS) versus quantitative (acceleromyography) neuromuscular blockade reversal measurements in the perioperative setting.

Section II. Evidence

Description of Search Strategies

The purpose of this literature review was to examine current evidence addressing CRNAs' perceptions regarding up-to-date recommendations for quantitative neuromuscular blockade monitoring. 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 for neuromuscular blockade reversal in the operating room.

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 monitoring OR neuromuscular blockade monitoring) AND (anesthesia OR anesthetist OR anesthesiology OR anesthesiologist). The search strategy created by the primary researcher pulled the MeSH terms "neuromuscular monitoring," "anesthesia," "anesthetists," "anesthesiologists," and "anesthesiology." Search limits applied included publication in the most recent five years (2016-2021) and English language. The database CINAHL and search engine Google Scholar were searched using a combination of keywords and subject headings identified using the keywords utilized in the PubMed search. 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. Additional evidence and information were identified by reviewing related and referenced articles as well as websites and resources of anesthesia organizations.

After full text review, six articles were identified that contained pertinent evidence for this quality improvement project. Based on Melnyk and Fineout-Overholt's (2019) levels of

evidence hierarchy, evidence identified included two quality improvement projects (Level VI), two prospective observational studies (Level IV), one experimental observational study (Level VI), and one descriptive analysis study (Level VI). Studies in these articles were performed in a variety of academic institutions, healthcare systems and community hospitals in multiple countries. A breakdown of information from these articles can be found in Appendix C: Literature Matrix.

Selected Literature Synthesis

Current Practices

Although there is a consensus within the literature that objective quantitative monitoring is an evidence-based practice, Dunworth et al. (2018), Renew et al. (2020), and Saager et al. (2018) found that, in the United States (U.S.), common monitoring practices are frequently performed with qualitative monitors. Dunworth et al. and Renew et al. reported that qualitative monitoring is imprecise in identifying adequate recovery of neuromuscular function. In a study of 114 anesthesia providers at an academic teaching facility by Dunworth et al., providers using qualitative monitors assessed higher train-of-four ratios than objective quantitative monitors 96% of the time. Renew et al. studied a convenience sample of 20 CRNAs and found that even after five years of clinical experience, anesthesia providers inconsistently assessed train-of-four ratios > 0.4 when using qualitative monitors. Inaccurate assessments may lead to improper dosing of maintenance neuromuscular blocking agents intraoperatively, increased use of reversal agents, and increased risk of impaired respiratory function in the postoperative period (Dunworth et al., 2018; Goyal et al., 2018).

Issues

Thomsen et al. (2020) suggest use of acceleromyography monitoring as more appropriate intraoperatively to reduce residual neuromuscular blockade, despite not being the device of choice of anesthesia providers. In the U.S., provider use of agents to reverse the paralytic effects of neuromuscular blocking agents has become more common (Dunworth et al., 2018). Use of neuromuscular blockade antagonists alone, or in conjunction with qualitative assessment of neuromuscular function, may be ineffective in reducing the incidence of residual neuromuscular blockade. Multicenter studies by Saager et al. (2018), examined 255 patients undergoing elective abdominal surgeries and identified residual neuromuscular blockade in 64% of cases despite the use of reversal agents. Additionally, nearly two thirds of patients experienced residual blockade despite the use of qualitative monitoring in conjunction with reversal medications.

Quantitative monitors are beneficial to assess the need for administration and dosing of reversal agents. In a study by Thomsen et al. (2020) that looked at a sample of 96 anesthesia providers in Denmark and the U.S., Danish anesthetists administered reversal agents only when train-of-four ratios were < 0.9 with quantitative monitoring. Administration of reversal agents by Danish anesthetist was less often than that of U.S. anesthesia providers using qualitative monitoring. Some U.S. anesthesia residents even administered a “legal” dose of reversal agent to all patients. “Legal” dose is the administration of a small dose of reversal agent to all patients thought to be helpful to reverse any residual neuromuscular blocker remaining even when the assessment does not show the need for it. This may lead to unintentional risks and unnecessary costs to patients.

In contrast, Bedsworth et al. (2019) found, in a random sample of 200 patients undergoing surgery at a large academic facility, that quantitative monitoring did not significantly

impact the administration practices of maintenance doses of neuromuscular blockade or administration of reversal agents. Researchers also identified a gap in provider knowledge regarding the effects of dosing practices of neuromuscular blockade and reversal agents. Reversal agents, including neostigmine have potential adverse side effects when not administered judiciously (Goyal et al., 2018). Without accurate quantitative assessments of train-of-four ratios, a patient may receive unneeded doses of neuromuscular blockade reversal agents. This may increase the risk for cardiopulmonary complications seen with incorrect administration of reversal agents, including neostigmine (Bedsworth et al., 2019; Goyal et al., 2018).

Barriers

Dunworth et al. (2018) and Thomsen et al. (2020) found that, although anesthesia providers perceive residual neuromuscular blockade as clinically significant, monitoring practices have not changed. Dunworth et al., Renew et al. (2020), and Thomsen et al. reported that time-pressure and workflow delays are common negative perceptions providers associated with using quantitative monitors. In studies by Dunworth et al. and Renew et al. which provided quantitative monitoring educational programs, participants found application and utilization of monitors straightforward. Renew et al. found that despite longer times of quantitative monitor application (19-30 seconds) versus qualitative monitor application, the minimal additional time was worthwhile. Furthermore, application time should decrease as use and familiarity of devices improves. Dunworth et al. and Renew et al. identified disruption of workflow reported as a barrier prior to intervention, but participants did not report disruption in the workflow as a barrier after the educational intervention. Postoperatively, Goyal et al. (2018) reported no significant impact on mean times from the end of procedures to extubation when quantitative monitoring was compared to qualitative monitoring combined with the use of reversal agents.

Both education and increased exposure to quantitative monitors have been identified as helpful in reducing the negative perceptions of time-pressure and workflow delay among providers, but limited implementation of quantitative monitoring remains an issue in the U.S. (Dunworth et al., 2018, Renew et al., 2020, and Thomsen et al., 2020). Dunworth et al. (2018), Saager et al. (2018), and Thomsen et al. (2020) identified lack of adequate education and training as prominent barriers. Bedsworth et al. (2019) noted that a gap in provider knowledge regarding qualitative monitor's limitations in measuring neuromuscular recovery is part of the issue. After implementing educational programs to increase quantitative monitor use, Bedsworth et al. and Dunworth et al. reported an increase in both provider utilization and the number of patients who received quantitative monitoring. Participants also reported an increase in knowledge, skill, and confidence to monitor neuromuscular blockade levels effectively after the intervention (Dunworth et al., 2018)

Quantitative monitors are typically attached to a patient's wrist area. Dunworth et al. (2018), Renew et al. (2020), and Thomsen et al. (2020) identified patient positioning as a potential limitation for access to a patient's arms. For example, this occurs when the arms are tucked at the patient's sides under sheets, creating a physical barrier to their use. Dunworth et al. noted that arm sleds, if available, are beneficial for access and facilitate the use of these monitors. Patient positioning barriers point to an opportunity for device development for use on other areas of the body when monitor application to the arm is not feasible. Thomsen et al. reported a lack of consensus among attending physicians regarding neuromuscular monitoring practice creates a barrier for residents and student anesthesia providers in academic teaching facilities. Agreement among providers and a standardized protocol for neuromuscular monitoring would be of value in increasing utilization.

Project Framework

The project framework selected for this quality improvement project was the model for improvement utilizing the plan-do-study-act (PDSA) cycle (Institute for Healthcare Improvement, 2021). The PDSA cycle is a four-stage method created as a tool for accomplishing continuous improvement. The Institute for Healthcare Improvement (2021) notes the goal of the PDSA cycle model is to evaluate a change implemented to determine if there is an improvement. "Plan," the first of the four stages, is where the problem or situation is assessed along with planning of the change. "Do" is the stage where the change is implemented. In the "Study" stage, results are observed and evaluated. In the final stage, "Act," actions are taken based on what has been learned. This is typically done on a small scale and repeated cycles are performed to refine the change before system implementation.

This quality improvement project focuses on assessing perceptions of CRNA providers regarding neuromuscular blockade monitoring and implementing change for improvement. This falls in line with the elements of the PDSA cycle. The problem identified at the participating organization was the variability in assessment of neuromuscular blockade in the operating room. Variations in assessment may lead to negative side effects, including residual neuromuscular blockade, respiratory depression, and reintubation. Plans to improve this problem were developed in the "Plan" phase. In the "Do" phase, an instructional video was introduced which described a standard process for neuromuscular blockade assessment. In the "Study" phase, provider perceptions regarding preference for and usefulness of qualitative versus quantitative monitors was assessed. This cycle was a single PDSA cycle, with the "Act' phase involving passing on findings and suggestions to the participating organization to assist them in continuing cycles.

Ethical Considerations and Protection of Human Subjects

There were no ethical considerations for participants in this quality improvement pilot project beyond normal risks encountered in their daily activities. The intervention benefits applied equitably to everyone in the target population. There was no identified potential for harm to the target population (CRNAs) other than the potential for minor additional mental stress and time pressure associated with adding additional activities to their regular work routine. Training through the Collaborative Institutional Training Initiative (CITI; https://about.citiprogram.org/) Program was completed by the primary investigator prior to initiation of this project.

Approval for this quality improvement project was completed through the East Carolina University (ECU) College of Nursing in cooperation with the ECU University and Medical Center Institutional Research Board (UMCIRB) to evaluate the need for full Institutional Review Board approval. Facility approval was completed through the research office of the participating organization in conjunction with the ECU UMCIRB. Local facility approval to collect data was obtained from a facility IRB representative. See Appendices D and E.

Section III. Project Design

Project Setting

The participating organization, located in the eastern United States, is a level one trauma center and teaching facility with 37 operating rooms, including rooms designated for performing cardiovascular surgeries. This facility operates on both elective and emergent conditions. Organizational characteristics that facilitated this project included available equipment, frequent use of neuromuscular blockade agents, and hospital-approved online resources. Characteristics that served as barriers include a patient population with multiple comorbidities and complex needs that create time-constraints for monitor application and a fast-paced operating room environment.

Project Population

The target population for this project was Certified Registered Nurse Anesthetists (CRNAs) delivering care in the cardiovascular operating rooms. There are approximately 75 CRNAs in the participating organization who provide anesthesia care to patients. Facilitators included agreeability to participate in the project. Barriers included reluctance to change, negative perceptions regarding neuromuscular blockade monitoring, lack of orientation to the facility for new anesthesia providers, and no formal protocols for neuromuscular blockade monitoring for anesthesia staff. New providers to the facility do not receive a specific onboarding orientation process but are expected to practice at national standards. New CRNAs may reach out to the charge CRNA as a resource as they become acclimated to the environment.

Project Team

The project team was comprised of a student registered nurse anesthetist (SRNA) primary investigator, the project chair, a site contact person, a clinical contact person, a nurse anesthesia

program director, and a course director. The primary investigator was responsible for the literature search, result analysis, literature synthesis, Qualtrics survey set up, development of educational video, pre- and post-intervention survey delivery, data collection, analysis of data, and dissemination of results. Two student secondary investigators assisted with Qualtrics survey set up and development of the voiceover PowerPoint educaitonal video (See Appendix F). The project chair was also the clinical contact person and kept the project on track along with providing facility information. The site contact person was the liaison in the clinical setting and signed the letter of acknowledgment that data was to be collected on the unit. The program director guided the project, and the course director provided guidance for the development of this paper.

Methods and Measurement

The purpose of this quality improvement pilot project was to assess anesthesia providers' perceptions of the usefulness of and preference for using qualitative versus quantitative neuromuscular blockade reversal measurements in the perioperative setting. In the “Plan” phase, the program director scheduled bimonthly in-person meetings which were held to identify gaps in literature, clinical practice issues, and development of the intervention. This included collaboration to develop statements and opinions which guided the project, survey questions, and the intervention process. An educational PowerPoint with voiceover recording was developed by the primary investigator and two secondary student investigators. A short instructional video was then created to demonstrate the usage of the acceleromyography device.

In the “Do” phase, CRNAs participating in the project were identified by the clinical contact person. The primary investigator sent an email thanking them for their participation (See Appendix G). A link to Qualtrics pre-intervention survey questionnaire and instructional video

were disseminated to participating CRNAs through an email sent by the primary investigator. Qualtrics surveys included seven pre-intervention questions which survey participants answered regarding their perceptions of the adequacy of qualitative and quantitative methods of assessing perioperative residual neuromuscular blockade in the operating room setting (Appendix H). CRNAs were asked to utilize quantitative neuromuscular blockade monitors during the implementation phase for two weeks. The primary investigator introduced themselves to the participants at the beginning of the implementation period and made themselves available at the beginning of the day to answer participant questions regarding device use. Throughout the two weeks, the primary investigator ensured acceleromyography devices were available and functional in the operating rooms where participants would be working for the day. One need that arose from participants was the availability of the instructional video. After participants had completed the pre-intervention survey, which had the instructional video imbedded, they were unable to gain access to it. Adjustments were made and a direct instructional video link was delivered via email in the reminder email at the halfway mark through the implementation period (See Appendix G).

In the “Study” phase, providers were asked to record their preferred assessment practices (qualitative/quantitative) for two weeks. Upon completing the two weeks, they were asked to complete a post-survey. This Qualtrics survey included eight post-intervention questions to gather participant perceptions of acceptability and adequacy of the qualitative and quantitative methods of assessing residual neuromuscular blockade post-implementation of the project (Appendix H). Levels of measurement included nominal, ordinal, interval, ratio, and free response. No patient information was recorded or maintained.

The “Act” phase involved analysis of participant response data and creation of data visualizations using Excel. Suggestions and conclusions based on the findings were formulated and shared with nurse anesthesia faculty, students, and project participants through a poster presentation as well as this project paper.

Section IV. Results and Findings

Results

The purpose of this quality improvement pilot project was to assess anesthesia providers' perceptions of the usefulness of and preference for using qualitative versus quantitative neuromuscular blockade reversal measurements in the perioperative setting. Six participants were recruited at the beginning of the project and surveyed regarding their perceptions of the adequacy of qualitative and quantitative methods of assessing perioperative residual neuromuscular blockade in the operating room setting (See Appendix H). Acceleromyography devices were made available to all participants over the two-week implementation period and at the end of the implementation phase participants were asked to complete a post-survey regarding their perceptions of the usefulness of the qualitative and quantitative assessment methods (Appendix F). Data was collected from four respondents to the pre- intervention survey and four respondents to the post-intervention survey. Qualtrics survey software was used to collect pre- and post-intervention data over a four-week period and Excel was used for data analysis.

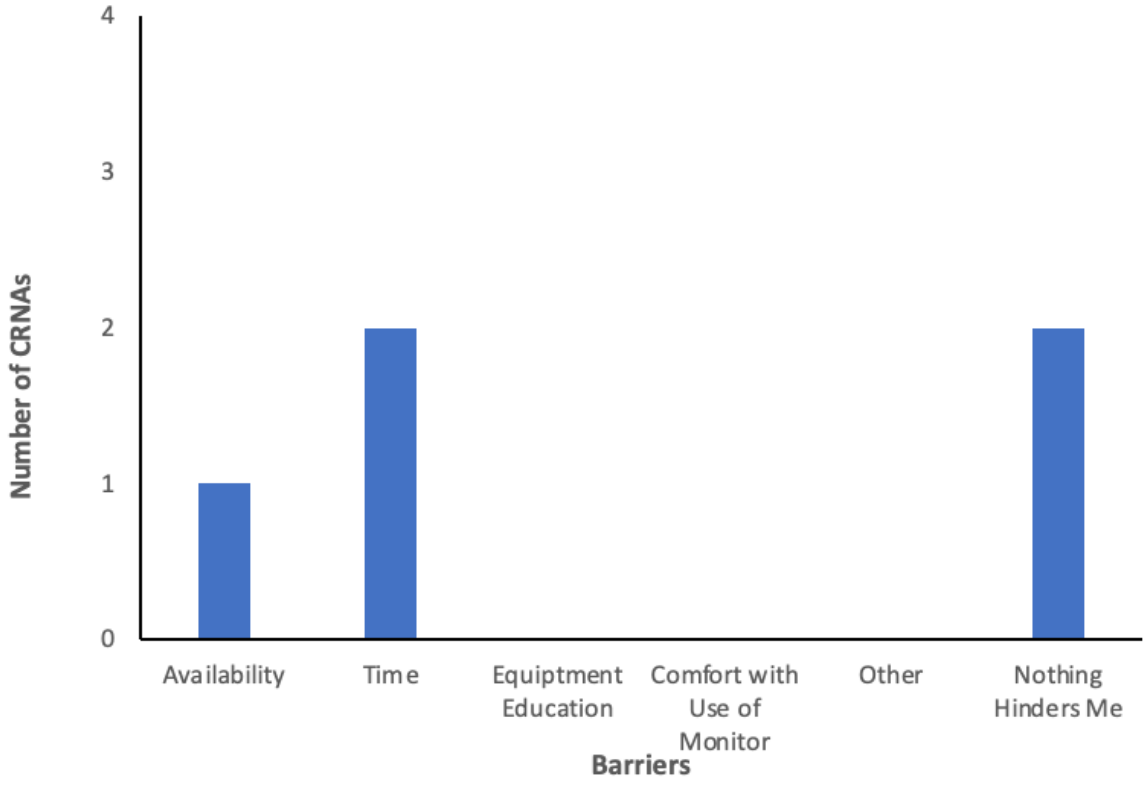
Data Presentation

Pre-intervention survey data was collected from four respondents. When surveyed about their current practice standards for assessing neuromuscular blockade, all participants reported using PNS and/or clinical assessment such as head tilt, spontaneous breathing, etc. All but one participant found using monitors to assess for neuromuscular blockade not difficult, while the remaining participant found it somewhat not difficult. When surveyed about barriers to use, as shown in Figure 1, participants reported device availability and time as two barriers to using acceleromyography devices for assessment of neuromuscular blockade. The use of acceleromyography devices pre-implementation was reported anywhere from 0-50%, with 0-

25% use among respondents being the majority of responses. All participants reported finding acceleromyography neuromuscular blockade monitors neutral when surveyed about their perceptions regarding the device's accuracy. Lastly, all participants reported caring for a patient experiencing inadequate neuromuscular reversal in the past, with all indicating using PNS and clinical assessment (head lift, spontaneous breathing, etc.) for assessment of neuromuscular blockade during those occurrences.

Figure 1

Barriers to Use of Neuromuscular Monitor Pre-intervention (n=4)



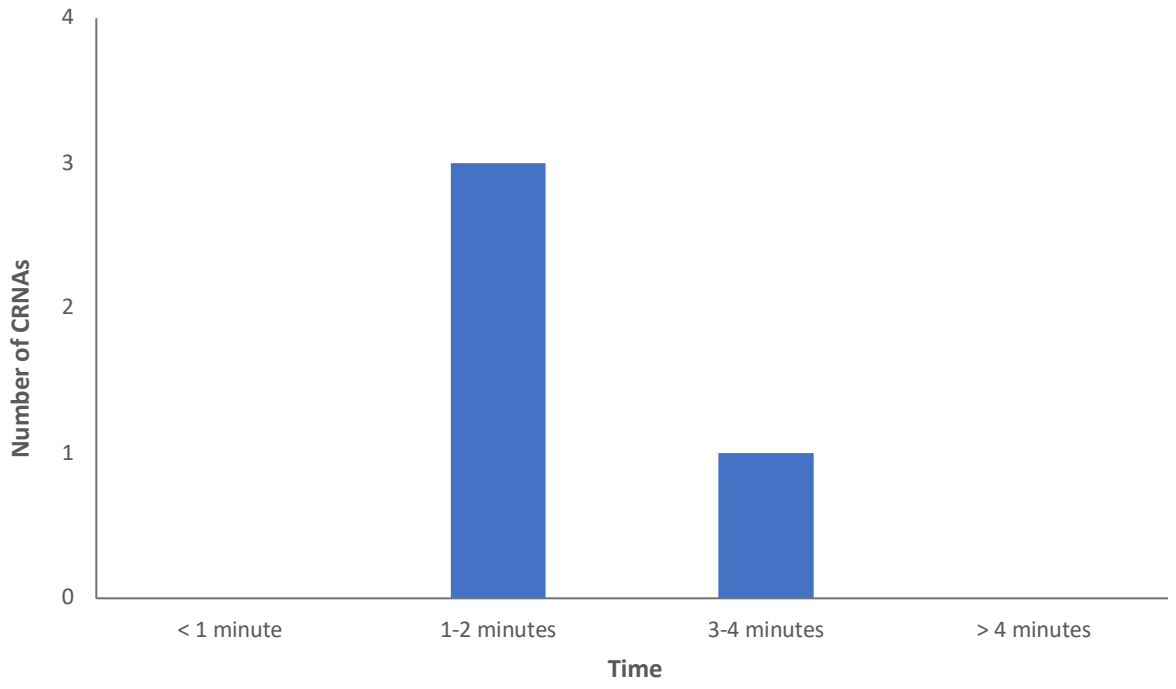
Note. Survey question was select all that apply for answer choice.

When surveyed regarding the difficulty of use of the acceleromyography device, all participants reported not finding the device difficult to use. Subsequently, there were no responses regarding what made the device difficult. After the implementation phase, one

participant found the acceleromyography device slightly more accurate while the other three participants reported finding its accuracy neutral in relation to their current practice. As shown in Figure 2, all participants identified it took less than 4 minutes to set up the acceleromyography device and reported this was more time consuming than their usual methods of monitoring.

Figure 2

Time To Set Up Acceleromyography Device Post-intervention (n=4)

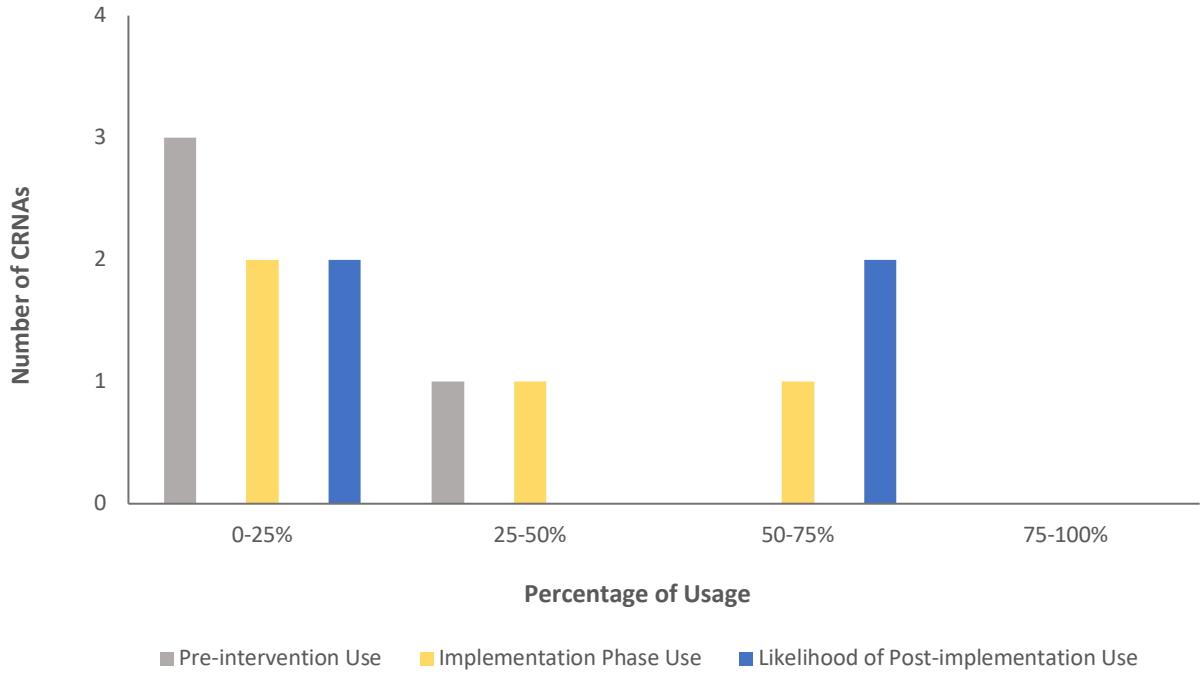


As shown in Figure 3, use of acceleromyography devices for the assessment of level of neuromuscular blockade pre-intervention was reported at less than 50% for all participants. Use of acceleromyography devices during the implementation period was reported in a range anywhere from 0-25% to 50-75% of the time. When participants were surveyed post-implementation, half of the participants reported they would use the device 50-75% of the time. When surveyed regarding likelihood of future use of acceleromyography, half of respondents reported likelihood of use 0-25%, while the other half reported likelihood of 50-75%. Finally,

participants were asked in what cases would they find using quantitative monitors useful in reducing the error of inadequate neuromuscular blockade reversal. There were no responses for this question.

Figure 3

Comparison of Acceleromyography Use (n=4)



Analysis

None of the respondents reported using acceleromyography devices in their current practice even though they reported not finding the device difficult to use. Availability of acceleromyography devices and time required for set up were two of the factors contributing to low use in the operating room. In the current literature, Dunworth et al. (2018), Renew et al. (2020), and Thomsen et al. (2020) all identified time consumption as one of the prominent barriers to implementation of the acceleromyography device. Therefore, participants were surveyed regarding time consumption to set up the device. As seen in Figure 2, all participants

identified it took less than 4 minutes to set-up the quantitative device and although most of them reported it took between 1-2 minutes, participants also reported that setting up the acceleromyography device was more time consuming than their usual methods of monitoring. An additional reported finding that may be a contributor to low use is the perceived accuracy level of the quantitative monitor versus the participants' usual methods. All participants responded that their perception of the accuracy of acceleromyography was neutral pre-implementation. Providers who do not find a new method or device any more accurate than their usual methods could contribute to barriers of its usage.

Although all participants reported having had a patient experience with inadequate neuromuscular blockade while using a PNS device and clinical assessment (head lift, spontaneous breathing, etc.) for assessment of level of neuromuscular blockade, they all reported using a combination of these two as their usual methods of assessment. This brings forward another potential barrier: Do providers see residual neuromuscular blockade as having a negative impact on patients' recovery? Post implementation, only one participant reported finding the acceleromyography device more accurate than usual methods. Thomsen et al. (2020) described in their findings that when providers can appreciate the benefit of a new device or change in practice, use is more likely to occur. This could be a contributing factor to the increase in likelihood of use of acceleromyography device post-implementation versus pre-implementation.

Section V. Implications

Financial and Nonfinancial Analysis

Implementation of this project hospital wide could be cost-effective for the organization. Currently, the operating rooms have a limited supply of acceleromyography devices for use by anesthesia providers. New devices could be purchased to increase the availability of devices in all operating rooms. Still, it would not be necessary to include acceleromyography devices in all operating rooms as not all surgical procedures require neuromuscular blockade. Educational materials incorporating modules and videos addressing device use could easily be distributed via email to all anesthesia providers. Educational videos on device use are available on the manufacturer's website. Links to the material could be sent via email to increase familiarity with device use. Review of educational materials by providers would take minimal time away from delivering anesthesia care. A Qualtrics survey link could be included in the email so providers could respond to a short survey after viewing the education link. The simplest survey would consist of a single question and be used only to keep track of the percentage of employees completing training.

Documentation of neuromuscular blockade assessment is currently a part of the patient record; no changes to the record-keeping software would need to be made. The cost without purchasing new devices would be two hours of work by the chief CRNA in creating the Qualtrics survey and email with links. This cost would approximately be $300. Adding in cost of purchasing 33 new devices to ensure availability in each operating room would be approximately $49,000, with each device costing $1,500.

Issues related to residual neuromuscular blockade can have negative financial impacts on a healthcare system. In a retrospective observational study conducted by Grabitz et al. (2019),

residual neuromuscular blockade was not associated with a statistically significant increase in total healthcare cost, however there was an increase in the average post-anesthesia care unit (PACU) length of stay. PACUs are high turnover, cost-intensive units in which nurse-to-patient ratios are very similar to those of intensive care units. With the increased length of PACU stays, one could assume that costs associated with residual neuromuscular blockade may be looked at more in-depth in situations where procedures were canceled or delayed due to a lack of staff availability (Grabitz et al., 2019). Patients with residual neuromuscular blockade in the Grabitz et al. study were also three times more likely to be admitted into the intensive care unit, a secondary event that had not been previously reported in this patient population. Unanticipated admission into an intensive care unit does come with unreimbursed increased cost. On average, a 1 day hospital stay in an intensive care unit costs approximately $5,500 (Cleveland Clinic, n.d.). Cost of x-rays, labs, and respiratory care would be an additional charge. If just seven patients are prevented from being admitted to the intensive care unit, that would cover the expenses incurred of project implementation involving placement of acceleromyography units in each operating room.

Implications of Project

With the implementation of this project, anesthesia providers would practice under the latest evidence-based practice recommendations. The healthcare organization would potentially decrease the incidence of residual neuromuscular blockade, a potential supported by published literature. One of the most prominent barriers to acceleromyography device use identified during this project was time. Regarding the length of time for device set-up, all participants perceived this as taking less than five minutes. Identification of the barrier of time to set up the device correlates with findings identified in the literature review.

These findings shed light on several reasons why providers at the organization are not using the acceleromyography device. Set-up time of less than 5 minutes will show providers that it is not as time-consuming as they originally perceived. Continued use will increase familiarity and comfort with using quantitative devices, leading to faster set-up times and increase overall device use. This would ensure anesthesia providers deliver patients to the intensive care unit with adequate reversal from neuromuscular blocking agents and in the best status to be extubated without delay once stable. Additionally, providers will be following best-practice guidelines from the literature for the care of their patients.

Implementation of this project has the potential to decrease hospital length of stay for patients and increase patient satisfaction. Lowering admissions into the intensive care unit, and unanticipated ventilator use, would also reduce the risk of hospital-associated infections. Hospital-associated infections are not reimbursed by insurance and can become expensive for a healthcare system. The healthcare system would benefit financially by decreasing overall costs, and clinical practice at the organization would improve with delivery of more evidence-based care.

Sustainability

With this pilot study, the organization could implement a larger quality improvement project to change practice and make the acceleromyography device use the standard of care. As described in the financial analysis section, the cost of implementation would be approximately $49,800. This would cover all new devices for each operating room and the dissemination of educational materials. Over three months, all anesthesia providers would be expected to complete training through educational materials, and device use could become policy. Participants' buy-in and practice change could be the most challenging aspect, but policy change

would ensure employees have an organizational standard under which to practice. To increase buy-in, educational sessions regarding the negative impacts of residual neuromuscular blockade could help increase motivation to change practice and sustain the change. People are more likely to change practice when they understand the reasoning behind the change and feel like the change will make a difference. Financially this would be sustainable because further money would only need to be spent on new devices if any malfunction or damage occurred.

Dissemination Plan

A poster was developed by the primary investigator for the dissemination of results. A poster presentation was delivered with CRNA program faculty, project participants, and all SRNAs in the program invited to join in person or virtually. The final version of this paper and poster have been submitted to The Scholarship, the East Carolina University digital repository.

Section VI. Conclusion

Limitations

A small sample size of six participants and self-reporting were limitations to the power and generalizability of the data. Participants were unfamiliar with the primary investigator, and some ignored the initial email until meeting the primary investigator in person. The lack of an initial introduction may have contributed to a delay in acceleromyography use during the implementation period.

Additionally, patients undergoing cardiovascular surgery are not extubated at the end of the case. They are transferred to the intensive care unit, stabilized, and extubated when appropriate. Time from arrival to the intensive care unit until extubation can take anywhere from a few hours to days, with the shortest time frame of about two hours. Neuromuscular blockade agents have a limited duration of action time and no longer lead to muscle paralysis after that time has passed. Providers may view the time from arrival to the intensive care unit to extubation as a sufficient time frame for the effects of neuromuscular blocking agents to wear off and may not be concerned with residual effects. This may have impacted participants' perception of the necessity of appropriate neuromuscular blockade reversal before leaving the operating room and limited device use to ensure reversal was appropriate.

Recommendations for Future Implementation and/or Additional Study

Recommendations for future projects during the planning phase include a larger sample size to obtain a better understanding of the need for and use of quantitative neuromuscular monitoring. If implemented, participation may be increased with the project team having a working relationship with participants before implementation. During implementation, efforts should be made to ensure disseminated educational links are continuously accessible through

multiple devices. Surveys can be done to assess for any known or potential issues and monitor outcomes

An additional study that could benefit the organization would be assessing a patients' level of neuromuscular blockade immediately after arrival at the PACU. This would help identify frequency and severity of residual neuromuscular blockade at the organization. This could potentially shed light on a preventable problem that leads to unplanned patient admission, reintubation, or respiratory compromise in the PACU. The information would be helpful for implementing a practice change in the organization if data shows patients are arriving to the PACU with residual neuromuscular blockade more frequently than national standards.

Two primary concepts that would be beneficial to investigate would be whether providers understand residual neuromuscular blockade, and what their perceptions are regarding the incidence and impact of residual neuromuscular blockade. Do anesthesia providers see this as an issue at all? Individuals are less likely to change practice if they do not personally recognize something as a problem. It is important to understand these views, especially if sustained change is the desired objective.

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Appendix A

Concept Table & Search Strategy Templates

PICOT: In neuromuscular blockade monitoring how does education on the use of quantitative monitoring affect CRNA's perception and use within neuromuscular blockade reversal in the operating room.
P: Neuromuscular blockade monitoring
I: CRNA education
C: --
O: neuromuscular blockade reversal
T: during anesthesia
S: operating room

	Concept 1: Neuromuscular blockade monitoring	Concept 2: Nurse anesthetist	Concept 3: N/A
Keywords	Neuromuscular blockade monitoring	Nurse anesthetist or anesthesia or anesthesiologist or anesthesiology	N/A
PubMed MeSH	"neuromuscular monitoring"[MeSH Terms]	"anesthesia"[MeSH Terms] "anesthetists"[MeSH Terms] "anesthesiologists"[MeSH Terms] "anesthesiology"[MeSH Terms]	N/A
CINAHL Subject Terms	"neuromuscular monitoring" OR (MH "Neuromuscular Blockade") OR (MH "Intraoperative Monitoring") OR (MH "Monitoring, Physiologic")	(MH "Anesthesiology") OR (MH "Nurse Anesthetists") OR (MH "Anesthetists") OR "anesthesia or anesthesiology or anesthetist or anesthesiology" OR (MH "Anesthesia Nursing") OR (MH "Anesthesia Recovery")	N/A

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
9/21/21	PubMed	(neuromuscular monitoring or neuromuscular blockade monitoring) AND (anesthesia or anesthetist or anesthesiology or anesthesiologist)	5 Years English	423/42	**Inclusion:** Guidelines for monitoring, reversal of NMB, provider perception focused, residual NMB focus **Exclusion:** Incorrect setting, neuromuscular diseases, incorrect monitoring, no NMB monitoring discussed, responses to articles
9/21/21	CINAHL	(“neuromuscular monitoring" OR (MH "Neuromuscular Blockade") OR (MH "Intraoperative Monitoring") OR (MH "Monitoring, Physiologic")) AND ((MH "Anesthesiology") OR (MH "Nurse Anesthetists") OR (MH "Anesthetists") OR "anesthesia or anesthesiology or anesthetist or anesthesiology" OR (MH "Anesthesia Nursing") OR (MH "Anesthesia Recovery"))	2016-2021 English Peer reviewed	162/21	**Inclusion:** Quantitative vs qualitative monitoring, evaluation of implementation of quantitative monitoring education, comparison of current practices **Exclusion:** Not in English, other physiologic monitors, chemical reversal specific
9/21/21	Google Scholar	(neuromuscular monitoring or neuromuscular blockade monitoring) AND (anesthesia or anesthetist or anesthesiology or anesthesiologist)	2016-2021	3410/22 (Reviewed 10 pages of results)	**Inclusion:** Perioperative focused, provider preferences, monitoring implementation

					Exclusion: Studies with animals, chemical reversal only, single-small hospital studies, studies with monitoring and chemical reversal, ICU monitoring

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
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.	Improve neuromuscular monitoring knowledge and practice by implementing a blended-curriculum education program (face-to-face education, online materials, and trained clinical experts) No specific conceptual framework/model noted	Quality improvement project: pre-intervention and post-intervention; experimental observational study/ Inferential/ Quantitative Level VI	Anesthesia department at one academic medical center	114 Convenience sample; Anesthesia providers providing care in 39 adult operating rooms at an academic medical center	IV: blended-curriculum education program DV: use of quantitative neuromuscular block monitor, and perceptions and knowledge of quantitative monitors Survey with 5-point Likert scale for each item Acceleromyography	Education alone increases objective monitor use by 40%. Further interventions are needed to increase utilization. Inclusions of surgeons to educational programs to reduced real- or perceived-time pressure. **Strength:** Formal face-to-face presentations which were recorded as well
2018	Goyal, S., Kothari, N., Chaudhary, D., Verma, S., Bihani, P., & Rodha, M. S. (2018). Reversal agents: do we need to administer with	Evaluate the effectiveness of objective neuromuscular monitoring in	3-year prospective observational cohort study/	Operating rooms in an Indian healthcare institution	155 Convenience sample; Abdominal surgery	IV: use of objective quantitative monitor DV: time	Mean time required from the end of surgery to extubation at TOF ratio of 0.9 in

	neuromuscular monitoring - an observational study. *Indian Journal of Anaesthesia*, *62*(3), 219–224. https://doi.org/10.4103/ija.IJA_652_17	assessing adequate muscle relaxation for intubation, maintenance of intra-operative relaxation and recovery NMBA without using reversal agent No specific conceptual framework/model noted	Inferential/ Quantitative Level IV		patients, <2hrs surgical duration under general anesthesia 89 exposed group; 66 control group; ASA PS I, 48% male; 52% female, 18-45 yrs. old. Exclusion criteria: history of diabetes, myasthenia gravis, hepatorenal impairment, any neuromuscular disorders or surgery at the site where electrodes were to be applied and emergency surgeries.	required from end of surgery to extubation at TOF >/= 0.9 AMG, Graph Pad InStat 6.0 programme	exposed group was 14.48 ± 1.138 min and in the non-exposed group, it was 12.14 ± 1.067 min (P = 0.139) 4 patients in exposed group and 5 in control group experienced episodes of oxygen desaturation in PACU and required low flow supplemental oxygen in. No patients reintubated. PACU and hospital length of stay comparable in both groups; most patients discharged on post-operative day two and followed up for next 30 days. No incidence of respiratory complications observed in either group.

							Limitations: only evaluated patients in ASA physical status I and surgical duration <2hrs. Patients with comorbidities and undergoing prolonged surgical procedures not evaluated. Large scale randomized trials are needed to establish objective neuromuscular monitoring as the standard tool
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. (2018). Incidence, risk factors, and consequences of residual neuromuscular block in the United States: The prospective, observational, multicenter RECITE-US study. *Journal of Clinical*	Determine incidence burden and associated risk factors of residual neuromuscular block during routine US hospital care No specific conceptual framework/model noted	Prospective observational blinded multicenter cohort study/ Inferential/ Level IV	Operating and recovery rooms of 2 community and 8 academic US hospitals	255 convenience sample of patients undergoing elective abdominal surgery; <4hrs Adults 20-100 yrs. (mean 51yrs.); 75% female; 25%	IV: conventional qualitative monitoring DV: rNMB Acceleromyography	65% of patients had rNMB at the time of extubation despite neostigmine and qualitative monitoring

	Anesthesia, 55, 33-41. https://doi.org/10.1016/j.jclinane.2018.12.042				male; ASA PS 1-3 (89% ASA PS 2-3); 86% non-smokers; 79% in academic hospital; 21% in community hospital; 67.1% reversal and PNS; 31.8% reversal only; 0.8% PNS only		
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.	Improve anesthesia providers' knowledge of neuromuscular blockade pharmacology, physiology, monitoring, and management. No specific conceptual framework/model noted	Quality improvement initiative: pre- and post-intervention observational study/ Inferential/ Level VI	Large, academic anesthesia department	200 Random sampling Non-cardiac and non-thoracic surgical procedures, Pts >18yrs of age, ASA PS 1-4; Excluded pts who received sugammadex and pts undergoing ophthalmologic, endoscopic, and	IV: Educational session DV: NMB and reversal dosing practices, use of quantitative monitors	Quantitative 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 assessment tests and peripheral nerve stimulators as

					electrophysiologic procedures		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.
2020	Renew, J. R., Hex, K., Johnson, P., Lovett, P., & Pence, R. (2020). Ease of application of various neuromuscular devices for routine monitoring. *Anesthesia and Analgesia.* https://doi.org/10.1213/ANE.0000000000005213	Primary: Explore whether the application of quantitative monitors requires more time than application of PNS Secondary: Assess anesthesia provider perceptions regarding the ease of application and utilization of various NMMS No specific conceptual	Experimental observational study/ Inferential/ Level VI	1 US facility	20 Convenience sample CRNAs with at least 5 yrs. of experience; mean age 49 +/- 10, yrs. of practice mean 17 +/- 9 yrs.; 70% routinely use PNS	IV: Educational session DV: application timing and perceptions regarding use of quantitative monitors PNS AMG, EMG; Survey numerical scale 0-10: difficulty of application and calibration of monitor	Average difference of 19–30 seconds longer to apply quantitative vs qualitative monitors. Nurse anesthetists described little difficulty in applying quantitative monitors after receiving a 1-hor educational session on proper use of the quantitative monitors

		framework/model noted					
2020	Thomsen, J. L. D., Marty, A. P., Wakatsuki, S., Macario, A., Tanaka, P., Gätke, M. R., & Østergaard, 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	Explore barriers and aids to routine neuromuscular monitoring and consistent reversal practice. No specific conceptual framework/model noted	Descriptive study/analysis and coding of survey response themes/ Qualitative Level VI	3 US anesthesiology programs and 5 Danish teaching hospitals	96 Convenience sampling; Interviewed and surveyed anesthesia providers CRNAs, SRNAs, anesthesiology attendings, anesthesiology residents	Focus group interviews and online surveys. Findings reported according to the Consolidated Criteria for Reporting Qualitative Research (COREQ) and Coding was performed in nVivo 11 for Mac (QSR international).	Danish providers routinely apply quantitative neuromuscular blockade monitors while U.S. providers apply qualitative monitors. Barriers to application of quantitative monitors: unreliable equipment, time pressure, need for training, misconceptions about NMB agents pharmacokinetics and residual block, lack of standards and guidelines, and department culture.

Note. AMG: acceleromyography, CRNA: certified registered nurse anesthetist, DV: dependent variable, EMG: electromyography, IV: independent variable, NMB: neuromuscular block, NMMS: neuromuscular monitors, PACU: post anesthesia care unit, PNS: peripheral nerve stimulator, rNMB: residual neuromuscular block, SRNA: student registered nurse anesthetist TOF: train-of-four. 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.

Appendix D

Research Department Letter

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 CRG.Quality@v[redacted]. 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 [redacted]

For more guidance about whether the activity meets the definition of Human Subjects Research see https://rede.ecu.edu/umcirb/irb-faqs/definitions/ or https://www.hhs.gov/ohrp/regulations-and-policy/decision-charts-2018/index.html#c1

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: Jenn Romagnoli/	☐ Ed.D. ☐ J.D. ☐ M.D. ☐ Ph.D. ☐ Pharm.D. ■ R.N. ☐ Other(specify):	
Job Title	**Phone:**	**Email:**
	Primary Contact (If different from Project Leader): Student	
	Phone:	**Email:**

Key Personnel/ Project Team members:

Name and Degree:	Department:	Email:
Jenn Romagnoli, SRNA		

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.**

   The purpose of this quality improvement project is to assess anesthesia providers' perceptions of perioperative usefulness of qualitative (PNS) and quantitative (acceleromyography) for postoperative residual neuromuscular blockade. Anesthesia providers [redacted] will be asked several questions (through Qualtrics) about their perceptions of adequacy of currently used qualitative and quantitative methods of assessing postoperative 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 and quantitative assessments. An email will be delivered with the intervention link and gather participant perceptions of acceptability and adequacy of the qualitative and quantitative methods for assessing residual neuromuscular blockade prior to and post implementation of the project through Qualtrics software. 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]: [redacted] CRNA

   ☐ **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 [redacted] 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 [redacted] 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 [redacted] 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 [redacted] at CRG.Quality[redacted] the following will be completed and returned to you for your records.

NHSR vs. HSR Determination:

☒ **Not Human Subject Research:** The [ ] 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 [ ] 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:** _____

[ ] **CRG Reviewer:** _____ **Date:** _____

UMCIRB Office Staff Reviewer: _____ **Date:** _____

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 [ ] can disclose PHI to another CE (i.e. BSOM) 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

[ ] 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.

Jen Knight
Project Leader Signature

02/17/22
Date

Appendix E

IRB Response Summary

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 crg.quality[redacted] to obtain site support from [redacted]

Name of Project Leader:

Jenn Romagnoli

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 postoperative residual neuromuscular blockade. Anesthesia providers at [redacted] Center will be asked several questions (through qualtrics) about their perceptions of adequacy of currently used qualitative and quantitative methods of assessing postoperative 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 and quantitative 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 for 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?

- ● 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

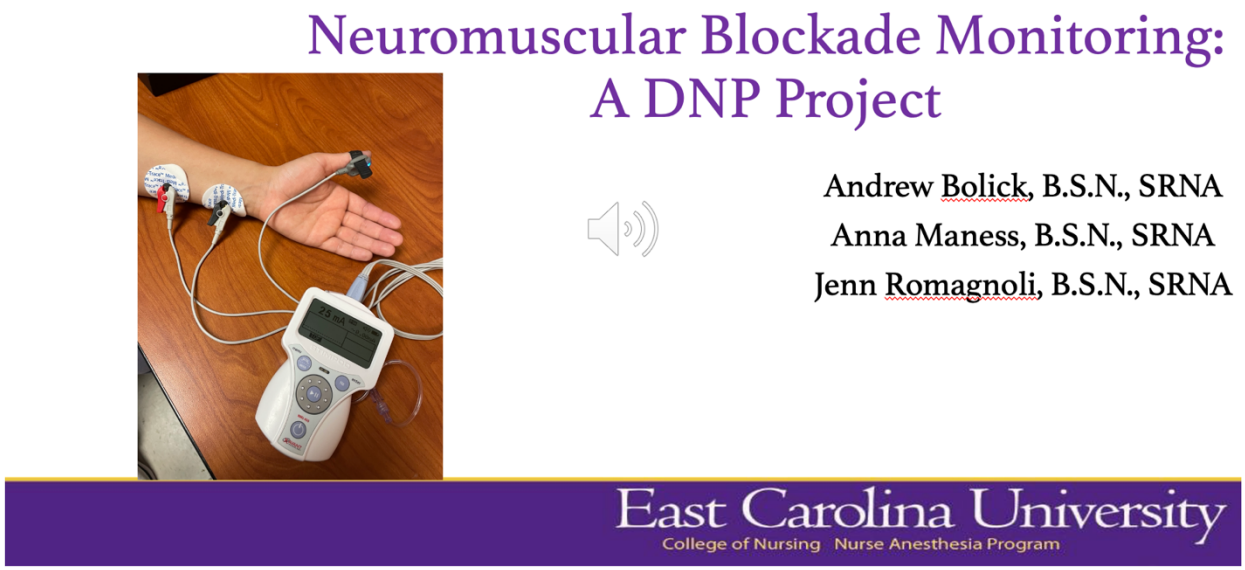
Based on your responses, the project appears to constitute QI and/or Program Evaluation and IRB review is not required because, in accordance with federal regulations, your project does not constitute research as defined under 45 CFR 46.102(d). If the project results are disseminated, they should be 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

Powered by Qualtrics

Appendix F

Tool/Guide/Intervention

https://www.youtube.com/watch?v=6YzMU5F9brs



Appendix G

Emails to Participants

Initial Pre-Survey and Video Email to Participants

Dear 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:
https://ecu.az1.qualtrics.com/jfe/form/SV_2tonmrXbWWg9xFY
Followed by viewing the PowerPoint video at the end of the survey.
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 Heart Center 4/4/2022 – 4/15/2022 if you have any questions but you may also reach out to me or Travis Chabo by email.

Sincerely,

Jenn Romagnoli, SRNA. Romagnolij20@students.ecu.edu
Travis Chabo, PhD, CRNA, Project Chair. Chabot14@ecu.edu

Pre-Survey and Video Reminder Email to Participants

Hello 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 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 with video: https://ecu.az1.qualtrics.com/jfe/form/SV_2tonmrXbWWg9xFY
If you have already done the pre-survey and would like to view the video again:
https://www.youtube.com/watch?v=6YzMU5F9brs

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

Sincerely,
Jenn Romagnoli, SRNA
ECU Nurse Anesthesia Program
Class of 2023

Post-Survey Email to Participants

Dear 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 survey is here: https://ecu.az1.qualtrics.com/jfe/form/SV_2tonmrXbWWg9xFY and the video is included at the end of the survey. 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: https://ecu.az1.qualtrics.com/jfe/form/SV_8bGj8E0drV8OV94. 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,
Jenn Romagnoli, SRNA
ECU Nurse Anesthesia Program
Class of 2023

Final Thank You Email to Participants

Dear 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 workroom.

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

Take care,
Jenn Romagnoli, SRNA
ECU Nurse Anesthesia Program
Class of 2023

Appendix H

Pre- and Post-Intervention Questionnaires

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)