Perceptions of Qualitative Versus Quantitative Monitoring for the Assessment of

Postoperative Residual Neuromuscular Blockade Among CRNAs: A Quality Improvement

Project

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Notes from the Author

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This project is a tangible representation of my journey through a rigorous program that I would like to dedicate to my wife Sabrina, my family, and all my classmates. Without your unconditional support, sacrifices, and assistance this would not have been possible.

Abstract

There are two categories of monitoring neuromuscular blockade: qualitative and quantitative. There is no defined method supported by the AANA, creating the potential for misdiagnosis and misinterpretation of residual neuromuscular blockade (rNMB) and potential patient outcomes. The purpose of this quality improvement project was to assess anesthesia providers' perceptions of the usefulness of and preference for qualitative peripheral-nerve-stimulator (PNS) versus quantitative acceleromyography (ACM) neuromuscular blockade reversal measurements in the perioperative setting of a level one trauma center located in the eastern United States. The intervention consisted of an educational video slideshow demonstrating how to operate and interpret quantitative assessment of neuromuscular blockade. Pre- and post-intervention surveys were used to gather data. A review of pre-intervention data showed that participants did not routinely utilize quantitative methodology despite having had a patient experience rNMB. Post-intervention data showed increased utilization and increased likelihood of future use of ACM. Standardizing monitoring of neuromuscular blockade monitoring with quantitative methodology has the potential to reduce incidence of residual neuromuscular blockade, which is linked to poor patient outcomes, prolonged hospitalization, and increased patient costs.

Keywords: CRNA, residual neuromuscular blockade, acceleromyography

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Section I. Introduction

Background

Through modern medical advancements, scientists have better grasped the physiology in neuromuscular blockade (NMB). In a normal neuromuscular transmission cycle, an action potential reaches the terminus of the motor-nerve and signals to release acetylcholine (ACh), a neurotransmitter, from the synaptic vesicles (Ortega et al., 2018). ACh then diffuses to the postsynaptic plate where nicotinic acetylcholine receptors are housed. Nicotinic acetylcholine receptors then convert the ACh chemical into an electrical impulse which depolarizes the postsynaptic membrane. Muscle contraction is the byproduct of depolarization. With time, ACh passively diffuses with assistance of acetylcholinesterase.

There are two distinctly different types of neuromuscular blockade agents (NMBAs), depolarizing and nondepolarizing (Ortega et al., 2018). The only depolarizing neuromuscular blocking agent (DNMBA) used in clinical practice is succinylcholine. Succinylcholine imitates ACh and produces a sustained depolarization. Nondepolarizing neuromuscular blocking agents (NDNMBA) competitively block ACh from the nicotinic ACh receptor to inhibit depolarization and skeletal muscle contraction.

There are two general methods of monitoring neuromuscular blockade, qualitative and quantitative assessments. Qualitative assessments may also be referred to as subjective, and quantitative may be referred to as objective. Certified Registered Nurse Anesthetists (CRNAs) use neuromuscular blockade monitoring methods to assess the degree of neuromuscular transmission in the perioperative setting. Monitoring is important in verifying full resolution of the neuromuscular blockade to increase patient safety and identify the return of normal neuromuscular transmission postoperatively. Routinely, this monitoring is done prior to patients

being extubated after a surgical procedure to ensure they can spontaneously ventilate without support.

Qualitative methods for assessment are derived from observing eye-opening, tongue protrusion, head lift, sustained hand grip for more than 5 seconds, and peripheral-nerve-stimulator (PNS) train of four (TOF) counts. A PNS TOF is used to assess neuromuscular transmission when neuromuscular blocking agents (NMBAs) are given to block musculoskeletal activity (Goyal et al., 2018). Despite the common use of qualitative observations for assessment, evidence from published studies and literature reviews more strongly supports the use of PNSs connected to quantitative monitors, particularly an acceleromyograph, as crucial in monitoring neuromuscular blockade depth. Residual neuromuscular blockade (rNMB) is a potential complication linked to varying poor outcomes and prolonged hospitalizations, yet it remains a prevalent issue (Ortega et al., 2018).

Utilization of NMBAs is an essential aspect of delivering a safe anesthetic and in performing many life-saving procedures. The neuromuscular blockade CRNAs provide is needed to relax the glottic structures and vocal cords for endotracheal intubation and inhibit involuntary skeletal muscle movement during various surgical procedures. NMB reversal is necessary for safe extubation, as the diaphragm needs to regain the ability to depolarize and repolarize prior to initiation of ventilation and oxygenation without mechanical assistance (Ortega et al., 2018).

Residual NMB reversal increases the risk of postoperative airway and respiratory complications. Based on data from The Joint Commission, 21 million patients underwent general anesthesia in the United States in 2004 (Brull et al., 2008). Suggesting that approximately two-thirds of these patients received a NDNBM, Brull et al. (2008) estimated 112,000 patients were at risk of rNMB per year. Problems associated with inadequate return of neuromuscular function

include increased risk of atelectasis, aspiration pneumonitis, and even death (Grabitz et al. 2019). In addition to increasing morbidity or even the risk of mortality, each event is economically detrimental as it may lengthen post anesthesia care unit (PACU) stay, lead to reintubation, and/or promote an unanticipated hospital admission.

Organizational Needs Statement

The American Association of Nurse Anesthesiology (AANA) states in Standard 9 of their standards of nurse anesthesia practice, "When neuromuscular blocking agents are administered, monitor neuromuscular response to assess depth of blockade and degree of recovery" (2019, para. 13). Standard 9 does not specify how, when, or where this monitoring is to be performed. A panel of international experts in NMB monitoring published a consensus statement that reiterates the AANA standard while adding that subjective NMB reversal is not adequately indicative of reversal to support determination of safe extubation (Naguib et al., 2018). The group agreed that subjective measures including use of head lift and hand squeeze to assess reversal are inadequate. They recommend that objective monitoring with the ability to assess a train-of-four (TOF) ratio ≥0.9 should be utilized to determine a patient is adequately reversed.

The partnering organization for this quality improvement pilot project is a Level 1 trauma center located in Eastern North Carolina. This organization has policies for routine monitoring of Intensive Care Unit (ICU) patients receiving neuromuscular blocking agents. However, policies do not specifically address anesthetic implications nor inclusion of surgical areas. According to the project chair, CRNAs at the identified hospital have experienced rNMB in their patients. Despite this, there is a lack of consensus on monitoring techniques and no department protocol exists to outline current recommendations (T. Chabo, personal communication, September 28,

2021). With the criticality of this monitoring to patient well-being, there is an existing need for an anesthesia policy on NMB monitoring specific to patients in the surgical areas.

Based on current literature findings and a lack of consensus, exploration of the anesthesia providers understanding of and preference for neuromuscular monitoring is needed. This may identify gaps in practice standards and help develop an updated protocol using quantitative ACM to identify potential rNMB.

Problem Statement

Despite national guideline recommendations for a TOF ratio > 0.9 prior to extubation using quantitative monitoring prior to emergence, no formal processes are noted nor consistently followed, leaving CRNAs at this institution to use clinical judgment and personal preference selecting methods for monitoring neuromuscular function. There is, additionally, a lack of understanding of CRNA 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 qualitative (PNS) versus quantitative (ACM) neuromuscular blockade reversal measurements in the perioperative setting.

Section II. Evidence

Description of Search Strategies

The purpose of this literature review was to identify and examine current evidence and recommendations addressing qualitative versus quantitative monitoring of neuromuscular blockade by anesthesia providers in the perioperative setting. The PICOT question used to guide the search was: In neuromuscular blockade monitoring, how does education on the use of quantitative measurement affect CRNAs' preferences and perceptions of measurement practices when assessing 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 (nurse anesthetist OR anesthesia) AND (neuromuscular blockade monitoring) AND (education). This search strategy pulled in the MeSH terms neuromuscular monitoring, nurse anesthetists, anesthesia, education, teaching, education [MeSH Subheading], and educational status. Limits applied included publication in the recent five years (2016-2021) and English language. CINAHL and Google Scholar were subsequently searched using a combination of the same keywords and subject headings identified and utilized in the PubMed query. See Appendix A for a list of keywords, MeSH terms, and subject terms utilized in searches. See Appendix B for search strategies and numbers of articles found and kept using structured searching. Additional sources of evidence and information were identified by reviewing related and referenced articles as well as the websites and resources of anesthesia organizations.

The PubMed search produced 26 articles of which eight were kept for a detailed review. CINAHL produced 47 articles of which 21 were screened for a detailed review. Google Scholar produced 5,030 articles in which 17 were kept after reviewing four pages of search results. Each of the 17 articles were then read in entirety. Melnyk and Fineout Overholt (2019) levels of evidence categories were used for evidence categorization. The seven levels of evidence range from the highest level, which is systematic reviews of randomized controlled trials (Level I) to the lowest level, which includes background information/expert opinion (Level VI). Upon full-text review, nine sources of evidence were identified as pertinent to this project, including one study containing both Level I and Level V evidence, four containing Level IV evidence, one with Level VI evidence, and three with Level VII evidence. For a detailed literature matrix, see Appendix C.

Selected Literature Synthesis

Further Background

PNSs are battery powered, handheld devices that generate up to 80 milliamps (mA) of electric current and can be applied to a nerve to evoke a muscle response which can be used to determine NMB status of surgical patients (Ortega et al., 2018). In the event direct stimulator to skin access is unavailable, electrical wiring connecting the stimulator to electrodes can be used. Stimulators offer different bursts of electrical current. The TOF offers four 2 Hz stimuli lasting 0.2 milliseconds each at 0.5 second intervals. Each stimulus causes a minor contraction in a nearby muscle group. Each contraction correlates with an unknown quantity of ACh available at the neuromuscular junction for transmission. The number and strength of each contraction gives the anesthesia provider an indication of the possible degree of paralysis. During qualitative monitoring, visual or tactile twitches are quantified to demonstrate the depth of NMB. If no

twitches are visible, user error, including connections and battery supply, should be assessed. If there are still no twitches, one can conclude that NMB has rendered the neuromuscular junction completely blocked by a NMBA. When four twitches are visible, the strength of twitches may be diminishing chronologically to a degree that is imperceptible to the human eye. This makes qualitative monitoring methods potentially inadequate. Additionally, it is possible that up to 70% of the receptors may still be occupied at the neuromuscular junction by the non-depolarizing agent. With quantitative monitoring, the TOF mode delivers four stimuli that can be measured using an acceleromyograph, or similar device with piezoelectric sensors. At baseline, this TOF method should indicate four equal twitches referred to as T1, T2, T3, and T4. The height of the fourth twitch is then divided by the height of the first twitch to get a measurable reading, also known as a TOF ratio (TOFR). Diminishment of twitches indicates a degree of NMB. A TOFR (T4:T1) of >0.9 has been shown to indicate safe recovery from NMBA (Lin et al., 2020).

The recommended site for both quantitative and qualitative NMB monitoring is the ulnar nerve, with objective findings deriving from contraction and measurement of the adductor pollicis muscle (Lin et al., 2020). The ulnar nerve has a high blockade threshold compared to the diaphragm. Therefore, once contraction of the adductor pollicis is visible, it is generally assumed that the diaphragm has recovered from NMB. Another commonly used site for qualitative NMB monitoring is the facial nerve located near the eyebrow. Despite this common monitoring site, Bouju et al. (2017) noted that in 996 qualitative TOF assessments on facial and ulnar nerves, results were significantly different. Facial site TOFs were twice as likely to show a subtherapeutic neuromuscular block. This means that no twitches may be present at the facial site, but the patient may not truly be pharmaceutically paralyzed, which demonstrates unreliability in subjective monitoring methodology. This study demonstrated that qualitative

monitoring can often result in confusion and can be considered inferior to quantitative

monitoring, which would be performed on the ulnar nerve and result in a more accurate

measurable ratio.

It has been suggested by Goyal et al. (2018) that additional medications, such as

acetylcholinesterase inhibitors, can be reduced with quantitative NMB monitoring methods.

These pharmaceutical agents come with potential adverse side effects. Neostigmine is a

quaternary amine inhibitor of acetylcholinesterase (AChE: Wolters Kluwer Clinical Drug

Information, Inc., 2021). Its function is to decrease AChE, which normally has the function of

decreasing ACh. Therefore, if an AChE inhibitor is given, AChE would be inhibited and ACh

would increase, leading to increased likelihood of neuromuscular transmission. If given

appropriately, it can give ACh the opportunity to competitively antagonize NDNMB. Side

effects of neostigmine are bradycardia, salivation, lacrimation, urination, defecation,

gastrointestinal motility, and miosis. Of these, bradycardia and salivation can cause serious

adverse events leading to pulmonary edema and aspiration. To combat these effects, an

anticholinergic is given. Based on findings from almost 200 limited (less than 2 hour) duration

cases, Goyal et al. reported that when quantitative methods were used to achieve a TOF>0.9 for

extubation, use of neostigmine could be completely avoided. With continuing education,

competent quantifiable techniques can indicate that extubation can be achieved safely without

aspiration and improve patient outcomes.

Understanding the benefits and risks of neuromuscular blockade management and

monitoring is necessary for anesthesia providers. Lin et al. (2020) set out to clarify provider

monitoring competency for Singapore anesthetists. From survey results of 150 anesthesia

providers, researchers identified that only 45.3% of anesthetists were able to define when a

patient is fully reversed from NMB. Additionally, 98.7% admitted to not routinely using PNS

following administration of NMB, demonstrating a lack of education and provider competency.

Monitoring Utilization

In a 2019 study of 653 Danish anesthesia providers (285 physicians and 368 CRNAs) by

Söderström et al., monitoring by quantitative TOFR was noted as "always utilized" by CRNAs

and physicians 68% and 47% of the time, respectively. Eighty six percent of participants claimed

to use quantitative monitoring devices at least 75% of the time. However, 75% of respondents

reported experiencing difficulties with the quantitative device in 25% of cases, and 20% reported

difficulties in more than every other case. Problems included fluctuating quantitative TOF ratio

values and monitor error messages. Four percent of the respondents claimed quantitative

monitors were not in use due to lack of availability. The lack of quantitative TOF assessment can

lead to higher incidence of adverse symptoms.

The previously cited survey of 150 Singapore anesthesia providers by Lin et al. (2020)

found 43.7% of participants reported not using PNS monitoring due to a lack of availability of

the required monitoring equipment. In a comparable survey by Teoh et al. (2016) completed by

over 100 anesthesia providers, despite 95.8% reporting availability of monitors, only 13.1%

responded that they would use them regularly.

Dunworth et al. (2018) set out to improve quantitative monitoring practice in a large

United States facility using a face-to-face educational approach. First, expert clinicians

emphasized the effects of rNMB. Then, monitors were made available in all 39 operating rooms

and quantitative monitoring vendor representatives completed educational sessions on how to

operate the devices. Weekly median utilization increased from 24% pre-intervention to 40%

post-intervention in surgical cases requiring NMBAs. The researchers noted that even with

availability and educational presentations, quantitative monitoring utilization only increased an additional 16%, supporting the idea that other barriers may exist.

Based on results of this literature review, there is a tendency for anesthesia providers to continue to rely on qualitative assessment when managing patients with NMB. There is a gap between existing best-practice evidence and implementation of recommendations into clinical practice. Understating the perceived and real barriers to consistently implementing quantitative measurement strategies in the perioperative setting is needed. Greater understanding may help to close this gap so that the safest and highest quality of care is provided to every/each patient.

Consequences of Neuromuscular Blockade Residual

While rNMB is a potential complication linked in current literature to varying poor outcomes and prolonged hospitalizations, it remains a prevalent issue. Evidence shows that return of diaphragm function alone does not guarantee complete reversal of NMB, as lingering effects in certain neuromuscular groups take longer to recover (Goyal et al., 2018). Comparing outcomes of objective neuromuscular monitoring to subjective neuromuscular monitoring, Goyal et al. found that patients extubated without objective TOF monitoring had an increased need for supplemental oxygen.

Saager et al. (2019) conducted a study in which 83% of a sample of 55 patients in a community hospital were transferred to the PACU with rNMB. The researchers observed that those with rNMB displayed an increase in both systolic and diastolic blood pressure post-operatively when compared to those with complete paralytic reversal. Following PACU discharge, respiratory therapy consultations were increased for those with rNMB. The researchers concluded that quantitative TOF monitoring of NMB is necessary to optimize positive patient outcomes and to reduce the risk of aspiration. Likewise, Lin et al., (2020) found

that 33.4% of 335 surgical patients had rNMB in the PACU, resulting in desaturations, dysphagia, dyspnea, weakness, or blurred/double vision.

In a study of 2,233 patients undergoing anesthesia, 457 demonstrated postoperative rNMB on PACU admission (Grabitz, 2019). The incidence of ICU admission was three times higher in patients with post-operative rNMB than that of patients who had complete reversal. Staying in the ICU is costly and puts patients at an even higher risk for a multitude of potential adverse events. Despite the availability of literature that points to these potential consequences, and monitoring devices that could easily prevent them from happening, inadequate neuromuscular blockade reversal is still a common occurrence. Saager et al. (2019) noted that 64.7% of the participant population extubated (255) had a later revealed TOF ratio <0.9, representing an incomplete reversal of NMBAs, which can contribute to adverse events. Thus, proper neuromuscular blockade monitoring using a quantitative approach provides an objective method to better identify inadequate reversal and neuromuscular function to increase patient safety, thus reducing postoperative complications cost to patients and hospital systems. After additional review of the literature, there appears a need for further exploration to identify barriers to why not all anesthesia providers are consistently using quantitative methods to ensure reversal of NMB before transfer to the PACU.

Conclusion

Lack of quantitative NMB monitoring may be a byproduct of multiple factors, including provider confidence, availability of equipment, and time. However, proper quantitative monitoring has been shown to improve patient outcomes and should be utilized when NMBAs are in use (AANA, 2019). Additionally, by using objective neuromuscular monitoring, use of reversal anticholinergics such as neostigmine and sugammadex can be reduced, rNMB

minimized, and patient outcomes improved (Goyal et al., 2018). Since there are no apparent

negative consequences of quantitative NMB monitoring, it is strongly supported in the literature

over qualitative methods. Greater understanding of barriers to and facilitators of correct and

consistent use of quantitative monitoring methods in patients with NMBA is needed.

Project Framework

The model for improvement using the plan, do, study, act (PDSA) cycle endorsed by the

Institute for Healthcare Improvement was used to develop and perform this project (Associates

in Process Improvement, 2021). The PDSA cycle is useful in identifying needed changes;

planning for who, what, when, and where a project will be implemented; analyzing findings and

comparing data to predicted outcomes; and carrying out the planned project. The PDSA model is

designed to be continually repeated to allow for maximal efficiency in processes and ultimately

improve patient outcomes.

In the plan phase of this project, the topic of neuromuscular blockade monitoring

methods was identified, and project team meetings were held to guide sharing of ideas and

creation of intervention tools. In the do phase, participants were given instructions and

participated in the project. In the study phase, results were analyzed. The act phase consisted of

sharing project findings so the process could be replicated and improved. A presentation was

held to share results and findings of the project, including ways to better improve practice in the

facility.

Ethical Considerations and Protection of Human Subjects

No specific ethical concerns or ethical violations were identified for this project. There

was no more than usual and minimal risk to the population from participation. No personal

health information was identified or collected. The quality improvement project was focused on

CRNA provider preferences and perceptions of qualitative versus quantitative NMB monitoring

methods. The primary researcher and all committee members completed Collaborative

Institutional Training Initiative (CITI) modules prior to initiation of the project

(https://about.citiprogram.org). The organizational approval processes included approval through

a quality improvement/quality assurance assessment process set up through an agreement

between the East Carolina University (ECU) College of Nursing (CON) and the ECU University

and Medical Center Institutional Review Board (UMCIRB). Additionally, the project was

approved through the participating facility in cooperation with the ECU UMCIRB. A signed

agreement to deliver the intervention and collect data was signed by a local site representative as

part of this process. See Appendix D.

Section III. Project Design

Project Setting

The partnering organization for this quality improvement pilot project, located in the southeastern United States, is a level one trauma center with approximately 1,000 licensed beds and approximately 33 operating suites. This facility supports both elective and emergent operative procedures. Organizational factors that helped facilitate this project included availability of needed equipment for utilization by staff without additional charges, the large volume of opportunities for utilizing monitoring, and access to facility educational resources. Potential site-related barriers to the project included a patient population with complex needs that did not always allow for set up time of NMB quantitative monitoring as well as a fast turnover culture.

Project Population

The project population consisted of CRNAs providing care to patients undergoing bariatric surgery. There are approximately 70 CRNAs on staff that rotate through varying operative suites at the partnering organization. Five CRNAs agreed to participate in this project. All of the participants are well versed in all patient populations but are primarily assigned to patients undergoing bariatric surgery. The primary project facilitator specific to the CRNA population was agreeability to participate in the project. Potential barriers specific to the population included short onboarding orientation to the facility as well as the potential for general reluctance to change and pre-existing negative perceptions of quantitative NMB monitoring.

Project Team

The project team consisted of Student Registered Nurse Anesthetists (SRNAs), faculty members, and a CRNA site contact in the unit where the project was performed. The primary investigator, an SRNA, was responsible for literature synthesis, project creation, Qualtrics (https://www.qualtrics.com/) data collection, compilation of data, result analysis, and synthesis of findings. The project was initially developed in collaboration with two additional SRNAs who assisted in creating the educational electronic presentation, Qualtrics survey questions, and tools utilized to perform the project. The project chair also served as the clinical faculty contact person who provided guidance and topical information, and assisted with identifying participants for the project. The site contact coordinator signed the letter of acknowledgement that data was to be collected on the unit. The nurse anesthesia program director guided the entire project and the course director provided crucial feedback and leadership to make this process possible.

Methods and Measurement

The purpose of this quality improvement pilot project was to assess anesthesia providers' perceptions of perioperative usefulness of qualitative and quantitative monitoring for perioperative rNMB. As previously mentioned, the PDSA cycle was utilized to guide the project.

After project approval was obtained and participants recruited, a pre-survey questionnaire followed by a video reviewing current guidelines of 0.9 train-of-four ratio with quantitative monitors for determining adequate neuromuscular reversal was made available to the participating CRNAs (Appendix E). Participants were then asked to use the objective measuring device in their practice and to record their assessment practices for two weeks (Appendix F). Upon completion of the two-week period, they were again asked to complete a questionnaire about their perceptions of the usefulness of the qualitative and quantitative neuromuscular

blockade methods (Appendix G). Qualtrics survey software was used to create and deliver the surveys used to gather participant perceptions of acceptability and adequacy of the qualitative and quantitative methods of assessing rNMB prior to and post implementation of the project. No patient information was recorded or maintained during this project.

In the plan phase, the program director assigned project chairs and in person meetings were held to facilitate sharing of ideas and the development of the intervention. This included survey questions, intervention processes, and collaboration to develop statements and ideas which guided the project. In the do phase, the CRNAs participating in the project were recruited by the clinical faculty contact person and were sent an email thanking them for their participation as well as instructions on the project. Links to the Qualtrics pre-survey questionnaire (Appendix G) and educational video (Appendix F) were disseminated to participating CRNAs. The CRNAs were asked to then utilize quantitative NMB monitors for two weeks. Participants had the option to decline or not continue to participate at any time during this period. In the study phase, data was collected through a Qualtrics post-intervention survey questionnaire sent to each participant via email (Appendix G). The levels of measurement of collected data included nominal, ordinal, interval, ratio, and free response. In the act phase, results were shared with the partnering organization and peers to further improve practice. The settings selected for the Qualtrics surveys did not force respondents to answer questions before moving forward, leading to several missing responses.

Section IV. Results and Findings
Results

After five CRNAs agreed to participate in this project, a pre-intervention survey was emailed to each of them. An educational video demonstrating the use of ACM was embedded at the end of the pre-survey. Participants were asked to keep track of their acceleromyograph usage

for a total of two weeks. Data was collected over a three week period, with a total of two weeks

per participant. Participants were asked to complete a post-intervention survey via Qualtrics at

the conclusion of their two-week intervention period. Perceptions, barriers, and usage were

collected via these Qualtrics surveys and data collected were analyzed using Excel.

Data Presentation

During the pre-intervention phase, participants were asked about their preferred method

for monitoring NMB as well as previous outcomes of monitoring NMB. All five participants

reported using PNS as at least one of their methods to monitor for rNMB. No matter the

monitoring methodology utilized, two respondents viewed monitoring as not difficult, two as

somewhat not difficult, and one as neutral in difficulty. Two reported they perceived no

hindrances, one respondent reported equipment education and comfort with use of monitor, one

noted availability, while another reported time as a limiting factor for perceived barriers. Prior to

the implementation period, four participants reported using an ACM device to monitor for

adequate reversal prior to extubation between 0% and 25%, while one reported using it 50% to

75% of the time. Of the five participants, two reported their perceptions of ACM accuracy as

neutral, one as accurate, and one as very accurate. One participant responded that they have

never had a patient with inadequate neuromusclar block reversal leading to residual weakness.

Every participant that reported experiencing having a patient with rNMB also reported using

PNS as at least one of their monitoring methods.

The post-survey had a total of 5 participants; however, some questions were only

answered by four of the CRNAs. During the implementation period, three CRNAs reported using

ACM 0-25% of the time, one used it 25-50% of the time, and one used it 75-100% of the time.

Only one of four respondents reported finding ACM difficult to use. The one respondent that

said that ACM was difficult to use reported it was due to comfort of use with the monitor, availability of a monitoring device, and time constraints of applying the monitor. Of the five CRNAs, one perceived that ACM was more accurate than their usual monitoring methods, two that it was slightly more accurate, one that they were neutral in their opinion of accuracy, and one that ACM was their primary monitoring technique. Among the four participants responding, half reported taking less than a minute to set up ACM monitoring while the other half reported taking between one and two minutes. See Figure 1.
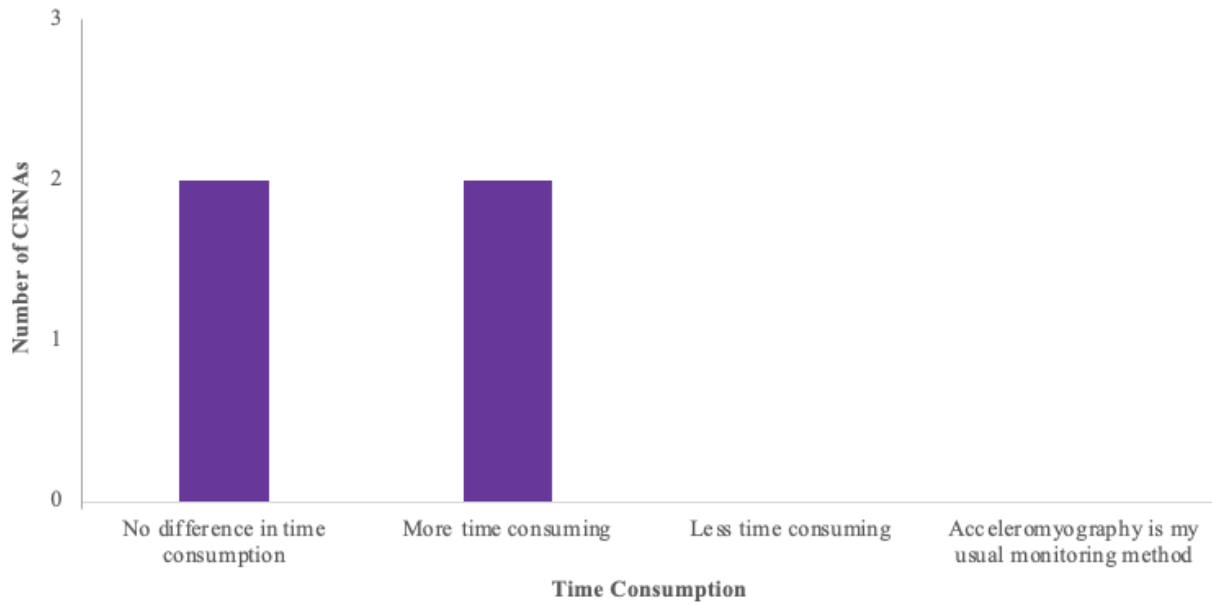
Figure 1

Post-intervention Acceleromyography Set-up Time (n=4)
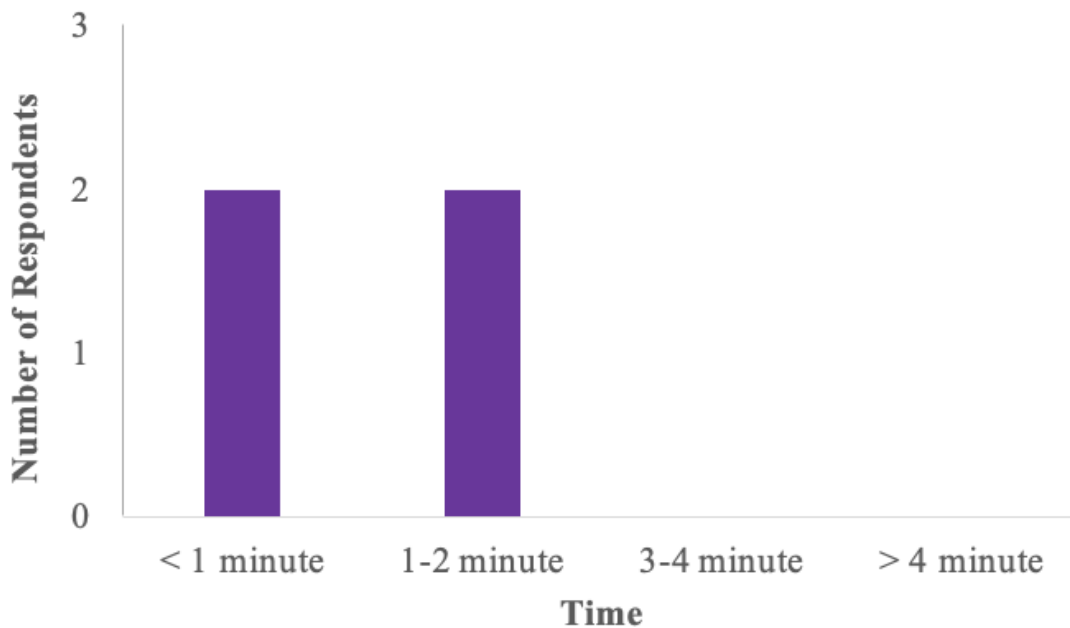
Half of the CRNAs said that there were no differences in set-up time of ACM compared to their usual monitoring methods while half said that it was more time consuming. See Figure 2.
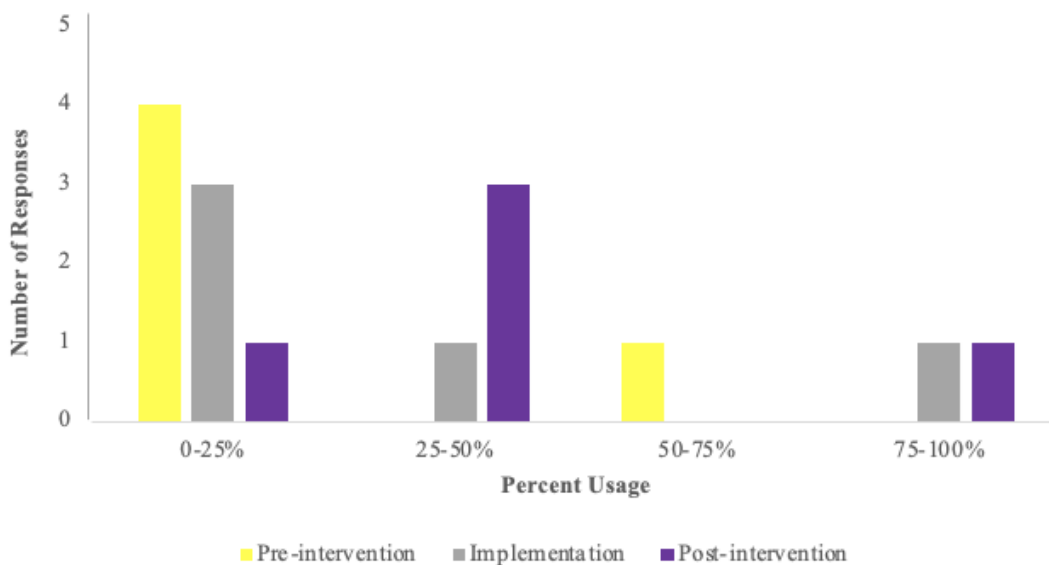
Figure 2

Post-intervention Qualitative Set-up Time Comparison (n=4)

Self-reported estimates of ACM use by participants pre-implementation, during the project implementation period, and in the future are shown in Figure 3.

Figure 3

Comparison of Pre-intervention, Implementation, and Post-Intervention Likelihood of Acceleromyography Usage (n=5)

Analysis

When analyzing the results of the survey data, it was noted that all participants with prior experience with rNMB (n=4) use PNS as at least one of their methods, though none had used ACM. This potentially demonstrates that, had ACM been utilized, rNMB may not have been encountered.

In the pre-survey, a Likert scale was used to better understand CRNA perceptions of difficulty regarding ACM usage. The CRNAs who expressed neutral opinions of difficulty may have encountered barriers that led them to that conclusion. Equipment education, comfort with use of the monitor, availability, and time were suggested as potential barriers to use of PNS monitors for assessing NMB. However, after completion of the intervention, only one out of four respondents reported that ACM was difficult to use. It is important to consider that every CRNA has a different educational and clinical background. Therefore, it is possible that some CRNAs had an assigned workload that was faster pace, the CRNA was new to the facility, they were unable to locate an acceleromyograph, and/or their education did not include quantitative monitoring methods. Though time was reported as a barrier on the pre-intervention survey, as displayed in Figure 1, half of the participants reported taking less than a minute, and half of the participants taking between one and two minutes, to set up ACM monitoring on the post-intervention survey. The operating room pace is indeed very swift; however, 1-2 minutes of safety precautions could prevent adverse events from rNMB. Only four CRNAs responded to the questions pertaining to set-up time. It is possible that this question was intentionally skipped by a participant who typically utilized ACM. On the other hand, it is also possible the missing participant did not use ACM and was therefore unable to comment on set-up time.

Figure 4 displays trending perceptions of ACM accuracy. It is noted that positivity is reflected in the post-intervention survey showing that overall discernments are for the better. The pre-survey results may be from inadequate training and or attention to detail as quantitative monitoring has been shown in the research to be superior in identifying rNMB. It is also possible that there is an underlying resistance to change which produced biased results due to participants not wanting to admit their true perceptions in the post survey.

Figure 4

Perceptions of Acceleromyography Accuracy (n=5)
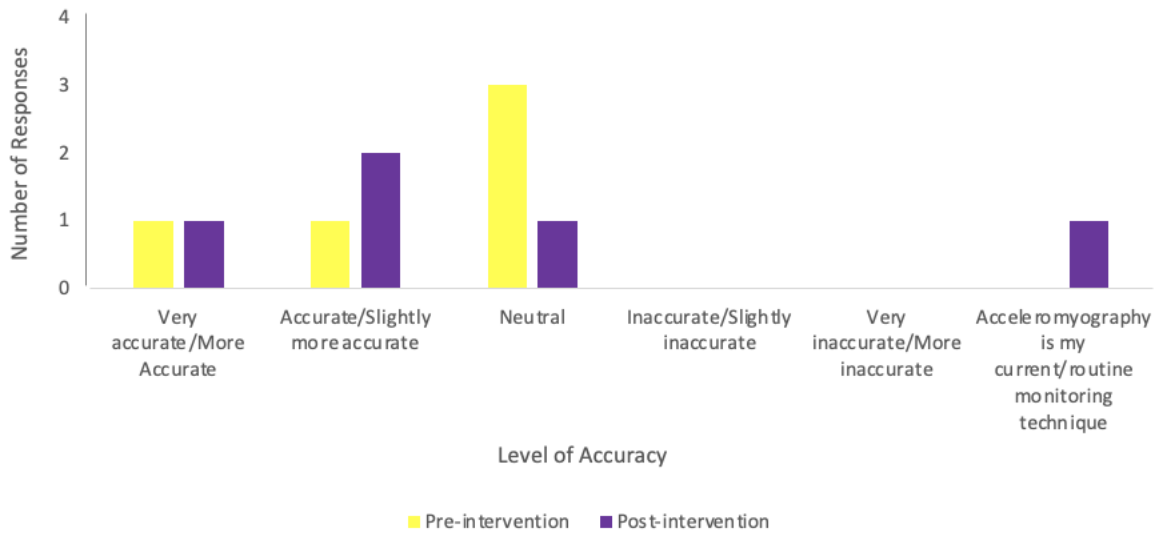
Of the participants who reported previous experience caring for a patient with rNMB, all reported using PNS as at least one of their monitoring and assessment methods, though none reported using ACM. The results illustrate that CRNA perceptions are positive towards ACM, despite most of the CRNAs not utilizing the device the majority of the time. Perhaps the most important take away from this project is that with education and proper training, utilization of ACM can be increased (Figure 3). With increasing utilization of ACM comes decreased risk of rNMB which, as discussed previously within the literature, has many negative consequences such as reintubation, pneumonia, and prolonged hospitalization.

Section V. Implications

Financial and Nonfinancial Analysis

If quantitative monitoring requirements were adopted by the anesthesia staff, it is possible that rNMB would be minimalized, potentially resulting in decreased reintubation, emergent reversal re-administration, as well as decreased unplanned hospitalization rates.

To better prepare the facility for utilizing ACM, more acceleromyograph devices would need to be purchased and readily available in each operative suite. Each device costs approximately $1600 (Bell Medical, n.d.). With 33 operating suites, and 14 already available ACM devices, an investment of approximately $30,400 would be required to purchase enough units to place one in each operative suite. Additional costs for maintenance and replacement of units over time would also be expected. These devices should never be removed from the operative suite as well. With a price of $1600 for each ACM device, it would be advisable to place tracking devices on each of them, to minimize displacement or loss. Unfortunately, the addition of tracking devices would also come with an added cost.

As a reminder, rNMB can lead to prolonged stays in the OR and PACU which slow up OR flow as well as increases in unexpected or extended ICU and hospital admission. It has been estimated that the first day of an ICU admission costs $10,794 with mechanical ventilation and $6,667 without mechanical ventilation (Dasta et al., 2005). With this knowledge, a reduction of three rNMB cases requiring ICU admission would cover the cost of purchasing the additional quantitative monitoring devices. These calculations do not include any savings that would be realized by preventing prolonged stays in the OR and PACU and from avoiding utilization of additional medications and respiratory therapy interventions. They also fail to address the nonfinancial burden of the extra time, discomfort, and risks to the patient experiencing rNMB.

Implications of Project

The purpose of this quality improvement project was to assess anesthesia providers' perceptions of the usefulness of, and preference for, qualitative (PNS) versus quantitative (ACM) NMB reversal measurements in the perioperative setting. As previously discussed, the AANA does not specify when, how often, and how to measure NMB when using NMAs. Specifics as to when, where, and how NMB monitoring is obtained need to be identified and implemented within the standard. Culture change within individual facilities is needed to adopt and follow a revised AANA guideline. This means that even if it may take extra time to use ACM, resulting in a slower operating room flow, it should be required as standard practice.

The findings identified in this project align with findings from the literature. The main association is that there are barriers that prevent the quantifiable measurement of NMB. One can assume that increasing availability and preventing misplacement of the units should eliminate the barrier of availability. However, lack of familiarity with the device may also limit its use, as might time to set up. With increased availability and more education, CRNAs may be encouraged to learn more about quantitative assessment while becoming more time efficient in set up, leading to increased utilization.

By overcoming these obstacles patient outcomes may be improved. If time is a barrier, one more minute to potentially eliminate the risk of rNMB postoperatively requiring intubation is well worth the wait. Production pressure by operating room staff may make this barrier difficult to overcome. Future education of non-anesthesia staff regarding implications and complications of rNMB may aid in this resolution.

Sustainability

To enhance sustainability, requirements of documentation of quantitative monitoring assessments could be implemented, then tracked and trended, with incentives for CRNAs utilizing the quantitative assessment method and completing proper documentation. With a large operative daily schedule, there are many opportunities for rNMB to occur. At the same time, this allows for more opportunities to prevent rNMB. With qualitative methods, it is difficult to identify true reversal, therefore, a monthly report of administration of reversal agents after extubation could allow for discussions during department meetings to facilitate adherence to utilizing ACM as an updated practice standard.

Dissemination Plan

The primary researcher created and presented a poster displaying project details and results to CRNA department members, program faculty, students of the nurse anesthesia program, as well as project participants using both in-person and virtual delivery. Additionally, this paper and poster have been posted in The Scholarship, the East Carolina University digital repository.

Section VI. Conclusion

Limitations

Limitations of this project include, but are not limited to, sample size, data collection tool, self-reported data, time limits, and unpredictability of CRNA assessment. A larger sample size across different institutions would allow for assessment of facility and practice barriers. Time limits were challenging due to some participants taking time away from work. The implementation period was extended due to some participant scheduling conflicts which could have allowed for more time for reflection about their current practice, altering their actual participation in the quality improvement project. When utilizing Qualtrics for data collection, the survey creator has many options that may or may not be utilized. In this project, respondents could continue to a question without answering the previous question, leading to an inconsistent number of responses. One way to potentially solve this issue is to set up the survey so that an answer is required before the next question is displayed.

Recommendations for Future Implementation and/or Additional Study

In future investigations, a larger participant sample size as well as a different primary focus of investigation should be considered. These emphases should focus on CRNA knowledge of receptor occupation and criteria of acceptable reversal. Without using ACM, one cannot confidently confirm receptor occupation by NMB which potentially leads to rNMB. Using a single PDSA cycle, this QI project identified perceived and real barriers to CRNA assessment of rNMB using ACM. Findings support the need for increased adherence to accepted guidelines, further investigation into current practices and outcomes, and implementation of policies that promote practice change at the participating institution.

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Appendix A

Literature Concept Table

	Concept 1: Neuromuscular blockade monitoring	Concept 2: Anesthesia	Concept 3: Education
Keywords (these are the "normal" words you would use anywhere)	Neuromuscular blockade monitoring	Nurse Anesthetist OR Anesthesia	Education
PubMed MeSH (subject heading specific to PubMed) (No filters)	"neuromuscular monitoring"[MeSH Terms]	"nurse anesthetists"[MeSH Terms] "anesthesia"[MeSH Terms]	"education"[MeSH Terms] "teaching"[MeSH Terms "education"[MeSH Subheading] "educational status"[MeSH Terms]
CINAHL Subject Terms (Subject headings specific to CINAHL) (2016-2021, Peer Review)	((MH "Neuromuscular Blockade") AND (MH "Monitoring, Physiologic")	((MH "Education, Nurse Anesthesia") OR (MH "Anesthesia") OR (MH "Anesthesia Equipment and Supplies") OR (MH "Anesthesia Recovery") OR (MH "Anesthesia, General"))	Not Used

Search Queries by Database/Search Engine

PubMed: nurse anesthetist OR anesthesia AND neuromuscular blockade monitoring AND education **Filters used:** in the last 5 years, English

PubMed Translation: (("nurse anaesthetist"[All Fields] OR "nurse anesthetists"[MeSH Terms] OR ("nurse"[All Fields] AND "anesthetists"[All Fields]) OR "nurse anesthetists"[All Fields] OR ("nurse"[All Fields] AND "anesthetist"[All Fields]) OR "nurse anesthetist"[All Fields] OR ("anaesthesia"[All Fields] OR "anesthesia"[MeSH Terms] OR "anesthesia"[All Fields] OR "anaesthesias"[All Fields] OR "anesthesias"[All Fields])) AND ("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 ("educability"[All Fields] OR "educable"[All Fields] OR "educates"[All Fields] OR "education"[MeSH Subheading] OR "education"[All Fields] OR "educational status"[MeSH Terms] OR ("educational"[All Fields] AND "status"[All Fields]) OR "educational status"[All Fields] OR "education"[MeSH Terms] OR "education s"[All Fields] OR "educational"[All Fields] OR "educative"[All Fields] OR "educator"[All Fields] OR "educator s"[All Fields] OR "educators"[All Fields] OR "teaching"[MeSH Terms] OR "teaching"[All Fields] OR "educate"[All Fields] OR "educated"[All Fields] OR "educating"[All Fields] OR "educations"[All Fields])) AND ((y_5[Filter]) AND (english[Filter]))

CINAHL: ("Neuromuscular blockade monitoring" OR (MH "Neuromuscular Blockade") AND (MH "Monitoring, Physiologic") AND ((MH "Education, Nurse Anesthesia") OR (MH "Anesthesia") OR (MH "Anesthesia Equipment and Supplies") OR (MH "Anesthesia Recovery") OR (MH "Anesthesia, General"))

Limited by 2016-2021, Peer-Review, English

Google Scholar: (nurse anesthetist OR anesthesia) AND (neuromuscular blockade monitoring) AND education

Limited by 2016-2021

Appendix B

Literature Search Strategy

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	(Nurse anesthetist OR anesthesia) AND (neuromuscular blockade monitoring) AND education	5 years (2016-2021), English	26 Found/8 Kept	Intraoperative and/or outcome focus. Excluded articles related to specific drug reports
9/21/2021	CINAHL	("Neuromuscular blockade monitoring" OR (MH "Neuromuscular Blockade") AND (MH "Monitoring, Physiologic") AND ((MH "Education, Nurse Anesthesia") OR (MH "Anesthesia") OR (MH "Anesthesia Equipment and Supplies") OR (MH "Anesthesia Recovery") OR (MH "Anesthesia, General"))	2016-2021, Peer-Reviewed, English	47 Found/21 Kept	Intraoperative and/or outcome focus. Excluded articles related to specific drug reports
9/21/2021	Google Scholar	(Nurse anesthetist OR anesthesia) AND (neuromuscular blockade monitoring) AND education	2016-2021	5,030 Found/ 17 Kept Reviewed 4 pages	Intraoperative and/or outcome focus. Excluded articles related to specific drug reports

Appendix C

Literature Matrix

Citation	Purpose & Conceptual Framework or Model and/or Theme	Design and Level of Evidence	Setting	Sample/ Method	Tool/s and/or Intervention/s	Results/Comments/Critique
Bouju, P., Tadié, J., Barbarot, N., Letheulle, J., Uhel, F., Fillatre, P.. Grillet, G., Goepp, A., Le Tulzo, Y., & Gacouin, A. (2017). Clinical assessment and train-of-four measurements in critically ill patients treated with recommended doses of cisatracurium or atracurium for neuromuscular blockade: A prospective descriptive study. *Annals of Intensive Care, 7*(1), 1-10. http://dx.doi.org/10.1186/s13613-017-0234-0	Themes: Gaps in monitoring methodology in terms of site location	IV	ICU	119 Observational non-experimental in two ICUs 119 patients, 94 with ARDS, who required a neuromuscular blockade for more than 24 hours.	IV: Clinical Assessment. DV: Ulnar and Facial TOF. Classification by very-paralyzed, well-paralyzed, and under-paralyzed.	Difference in TOF Scores and clinical judgement. Evaluation of blockade studies may be affected by the depth of sedation. Study completed on ICU patients but demonstrates location of TOF.
Goyal, S., Kothari, N., Chaudhary, D., Verma, S., Bihani, P., & Rodha, M. S. (2018). Reversal agents: Do we need to administer with neuromuscular monitoring - an observational study.	Themes: Monitoring methodology and consequences of residual	Level IV	OR	155 Observational Cohort on patients undergoing surgery of <2 h duration.	IV: Study vs placebo group. DV: Monitoring NMB.	Studies excluded surgery duration >2. Recovery from NMBA observation not assessed in prolonged/complicated cases. Evidence shows that return of diaphragm function alone does not guarantee complete reversal of NMBA, as lingering effects in certain

Reference	Concept	Level	Setting	Sample	Variables	Findings
Indian Journal of Anaesthesia, 62(3), 219–224. https://doi.org/10.4103/ija.IJA_652_17	neuromuscular blockade					neuromuscular groups take longer to recover. found that those extubated without TOF monitoring had an increased need for supplemental oxygen. By using objective neuromuscular monitoring, reversal anticholinergics such as neostigmine can be reduced, rNMB minimized, and patient outcomes improved.
Grabitz, S. D., Rajaratnam, N., Chhagani, K., Thevathasan, T. C., Teja, B., Deng, H., Eikermann, M., Kelly, & Barry J. (2019). The effects of postoperative residual neuromuscular blockade on hospital costs and intensive care unit admission: A population-based cohort study. *Anesthesia & Analgesia, 128*(6),1129-1136. http://dx.doi.org/10.1213/ANE.0000000000004028	Consequences of Neuromuscular Blockade Residual	Level IV	Hospital	2233 Prespecified secondary analysis on adult patients undergoing surgery under general anesthesia.	IV: rNMB. DV: side effects of rNMB. "Train-of-four measurements in the PACU, age, sex, body mass index, postoperative intensive care unit admission, hospital length of stay, as well as principal surgical procedures were recorded" (Grabitz et al. 2019).	Looks into many factors- cost of admission, % of population in PACU with rNMB. Suggests that decreased rNMB may decrease ICU admission.

Citation	Theme	Level	Setting	Sample	IV/DV	Findings
Lin, X. F., Kuen Yong, C. Y., Sam Mok, M. U., Ruban, P., & Wong, P. (2020). Survey of neuromuscular monitoring and assessment of postoperative residual neuromuscular block in a postoperative anaesthetic care unit. *Singapore Medical Journal, 61*(11), 591-597. http://dx.doi.org/10.11622/smedj.2019118	Theme: Monitoring methodology, monitoring utilization, and consequences of rNMB	Level I & Level V	PACU	150 Surveys of anesthesia provider knowledge as well 335 patients assessed for rNMB in PACU.	IV: TOF monitoring methods with use of NMBAs as well as use of reversal agents DV: prevalence of rNMB.	Gold standard of monitoring is mechanomyography as suggested by one of Lin et al sources. This study uses acceleromyography uncalibrated TOF ratio using 50 mA currents. This study was confined to the PACU so long-term effects of rNMB were not investigated.
Ortega, R., Brull, S. J., Prielipp, R., Gutierrez, A., De La Cruz, R., & Conley, C. M. (2018). Monitoring neuromuscular function. *The New England Journal of Medicine, 378*(6). http://dx.doi.org/10.1056/NEJMvcm1603741	Physiology	Level VII	N/A	N/A	No IV/DV.	Basic background/knowledge of neuromuscular blockade monitoring.
Saager, L., Maiese, E. M., Bash, L. D., Meyer, T. A., Minkowitz, H., Groudine, A., 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	Consequences of Neuromuscular Blockade Residual	Level IV	OR/PACU	255. "Elective abdominal surgery with general anesthesia and ≥1 dose of non-depolarizing neuromuscular blocking agent (NMBA) for	IV: TOF measurements using acceleromyography. DV: presence of rNMB.	Interesting findings are "residual block at tracheal extubation was more common in males, in patients with greater BMI, and those classified as ASA PS 3" and "rNMB on extubation was significantly associated with male gender, incremental increase in BMI, surgery performed in a community hospital, and shorter time from tracheal intubation to extubation such that the odds of rNMB were reduced

				endotracheal intubation and/or maintenance of NMB" in a blinded cohort study" (Sager et al. 2019).		by 37% for every hour of anesthetic duration" (Saager et al. 2019, para. 30).
Söderström, C. M., Eskildsen, K. Z., Gätke, M. R., & Staehr-Rye, A.K. (2017). Objective neuromuscular monitoring of neuromuscular blockade in Denmark: an online-based survey of current practice. *Acta Anaesthesiologica Scandinavica, 61*(6) 619-626. https://doi.org/10.1111/aas.12907	Monitoring utilization	Level VI	Anesthesia Department Denmark	65. Survey on anaesthetists.	15–17 short questions regarding the use of objective NMM.	In a 2019 study of 653 Danish anesthetists (285 MDs and 368 CRNAs) by Söderström et al., monitoring by quantitative TOF ratio was always utilized by CRNAs 68% of the time and 47% of the time for MDs. Eighty six percent of the of participants claimed to use quantitative monitoring devices at least 75% of the time. Interestingly though, 75% of the respondents reported experiencing difficulties in 25% of the cases and 20% of the anesthetists reported difficulties in more than every other case. Problems included fluctuating quantitative TOF ratio values and monitor error messages. Four percent of the sample claimed quantitative monitors were not in use due to lack of availability. (Söderström et al. 2017). This study took place in Denmark which may have different availability of monitoring devices than in the US.

Teoh, W. H., Ledowski, T., Tseng, P. S. (2016). Current trends in neuromuscular blockade, management, and monitoring amongst Singaporean anaesthetists. *Anesthesiology Research and Practice*, 2016. https://doi.org/10.1155/2016/7284146	NMB use, monitoring, and management	Level VII	Singaporean anaesthetists	137. Survey	45 question survey taking approximately 10-15 minutes.	Interestingly, 95.8% reported availability of monitors, but only 13.1% responded that they would use them regularly

Note. NMM=Neuromuscular Monitoring, TOF=Train of Four, rNMB=Residual Neuromuscular Blockade, NMBA=Neuromuscular Blockade Agents,

BMI=Body Mass Index, ICU=Intensive Care Unit, PACU=Post-Anesthesia Care Unit, ObjNMM=Objective Neuromuscular Monitoring. 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

Facility Research Department Letter

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 _____ CRG.Quality@_____. 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 ___ CRG with any questions at ___ or CRG.Quality@___

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 of Qualitative Versus Quantitative Monitoring for the Assessment of Postoperative Residual Neuromuscular Blockade Among CRNAs				
Funding Source:	None				
Project Leader Name:	Andrew M. Bolick	☐ 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: (Affiliation if other than	Email:

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 perioperative residual neuromuscular blockade. Anesthesia providers a████████████████ will be asked several questions (through Qualtrics) about their perceptions of adequacy of currently used qualitative and quantitative 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 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 of assessing residual neuromuscular blockade prior to and post implementation of the project. No patient information will be recorded or maintained.

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   CRG 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 CRG.Quality@   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: _____

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 (i.e.   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

Vidant 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   healthcare data has been utilized.

_____   2/17/2022
Project Leader Signature   Date

Appendix E

Intervention Tool

https://youtu.be/6YzMU5F9brs

Appendix F

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 _____.

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 here. Followed by viewing the PowerPoint video. Acceleromyography devices are available in the anesthesia workroom. Again, thank you for your participation in our quality improvement project. I will be at _____ during this time if you have any questions, but you may also reach out to me or Travis Chabo by email.

Sincerely,

Andrew Bolick, SRNA. Bolicka20@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,
Andrew Bolick, 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, and you can follow it up by watching the video 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 _____ soon.

Sincerely,
Andrew Bolick, 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 am in the process of receiving post-survey results. If you have not completed the post-survey, it can be found here. Once I have collected all the data, I will 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. 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,
Andrew Bolick, SRNA
ECU Nurse Anesthesia Program
Class of 2023

Appendix G

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, 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 often did you

   use the acceleromyography device over the last two weeks?

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

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)