An Educational Initiative to Increase Anesthesia Providers Use of Quantitative Neuromuscular Monitoring

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Author Note

Disclosure of Conflict of Interest: None

This paper is based on data from the DNP Project completed as partial fulfilment of the Doctor of Nursing Practice degree with the guidance and supervision of the following:

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Abstract

Neuromuscular blocking medications are frequently administered to patients undergoing general anesthesia. Research suggests that residual muscular blockade is present in as many as 40% of the patient population arriving to the post anesthesia care unit after a surgical procedure. Residual muscular blockade is associated with muscular weakness and an increased risk for respiratory complications postoperatively (Todd et al., 2014). It is the responsibility of the anesthesia provider to ensure patient safety is maintained during surgery. Residual muscular blockade can be prevented when using quantitative neuromuscular monitoring to guide neuromuscular blocking medications, and reversal medication administration (Naguib et al., 2019). The definition of recovery from neuromuscular blockade is a return of a train of four ratio greater than 0.9 when using a quantitative peripheral nerve stimulator (Naglehout, 2014). There are varying levels of evidence that suggest many different factors that contribute to provider deviation from the use of quantitative neuromuscular monitoring. The majority of evidence suggests that the lack of use stems from a lack of provider education. The aim of this project is to increase provider knowledge and overall use of intraoperative quantitative neuromuscular monitoring through an evidence-based educational session and Quick Look Guide.

Keywords: residual muscular blockade, quantitative neuromuscular monitoring, nondepolarizing neuromuscular blockers, medications, anesthesia, anesthesia providers, train of four (TOF), peripheral nerve stimulator.

An Educational Initiative to Increase Anesthesia Providers Use of Quantitative Neuromuscular Monitors

The rate of surgical procedures continues to increase annually, and nondepolarizing neuromuscular blocking agents (NMBAs) are often used for patients receiving general anesthesia. Yearly, 30.8 million patients are administered NMBAs in the United States (Brull & Kopman, 2017). These agents are administered to facilitate endotracheal intubation and provide skeletal muscle relaxation improving patient safety and operating conditions (Naglehout, 2014). Residual neuromuscular blockade (rNMB) results from inadequate recovery from NMBAs and is a potential serious patient safety issue. Residual neuromuscular blockade can result in generalized weakness, respiratory depression, airway obstruction, increased risk of aspiration, dysphasia, pneumonia, and postoperative respiratory failure in the surgical patient (Bedsworth et al., 2019).

Chapter 1: Introduction and Overview of the Problem of Interest

Background and Significance

The first nerve stimulator, developed in 1958, had limited access to its availability leaving providers to rely on their clinical tests, and judgements to rule out rNMB. Providers relied on their assessment of head, arm, and leg lift, tongue protrusion, tidal volumes, and the knowledge of the pharmacokinetics of the NMBA to accurately assess their patient. Providers began to realize that they could compare the patient's ability to perform certain clinical tests as compared to objective electrophysiological measurements of neuromuscular blockade. For example, many patients were able to maintain a five second head lift with a train of four (TOF) of two out of four, and with this assessment, providers started to endorse the use of peripheral nerve stimulators (PNS) to monitor neuromuscular blockade (Nemes & Renew, 2020).

The most widely used neuromuscular stimulating device is the PNS, which is a qualitative monitoring tool that relies on the anesthesia provider's subjective visual or tactile assessment of the patient's muscle response to a stimulus to determine the presence or absence of fade by comparing the size of the fourth twitch to the size of the first twitch. However, research suggests that human observers are not able to reliably identify the degree of TOF ratio with the use of these monitors, and most examiners are unable to detect fade through subjective assessment when the TOF ratio reaches 0.4 (Brull & Kopman, 2017).

Expert consensus is that patients receiving NMBAs should receive neuromuscular monitoring with the use of a quantitative TOF monitor (Naguib et al., 2019). The Anesthesia Patient Safety Foundation (APSF) further acknowledges that rNMB is a patient safety hazard that requires quantitative monitoring along with traditional subjective observations (Stoelting, 2016).

Acceleromygraphy is a quantitative method of assessing neuromuscular blockade and is based on Newton's Second Law (Force = mass x acceleration) whereby the force of the muscle contraction is proportional to acceleration, as mass remains constant. Quantitative monitoring via an acceleromygraphy is accomplished by attaching a piezoelectric sensor at the thumb to measure the rate of angular acceleration in response to nerve stimulation (Naguib et al., 2019). The size of the acceleration output is quantified into a TOF ratio and used to guide the administration and reversal of NMBAs (Dilos & Eisenkraft, 2014). Sasaki et al. (2014) states that postoperative rNMB is defined as a TOF ratio less than 0.9 and has been associated with respiratory morbidity in previous studies. Despite an abundance of evidence that postoperative residual weakness is prevalent and exposes patients to significant risk, many anesthesia providers fail to employ adequate quantitative neuromuscular monitoring (QNM) when utilizing NMBAs.

Domenech et al. (2019), found that almost 10% of American anesthesiologists and 20% of European anesthesiologists never use any form of neuromuscular monitors in patients receiving NMBAs.

Varying levels of empirical evidence suggest that many different factors contribute to provider deviation from the use of QNM. Much of the evidence suggests that the lack of use stems from inadequate provider knowledge regarding mechanism of action and pharmacology of muscle relaxants, residual muscular blockade, signs of inadequate reversal and its negative effects, and the use of the quantitative neuromuscular monitoring technology (Todd et al., 2014). Research suggests that reasons for the low adoption rate of QNM are also multifactorial. Overconfidence in one's practice is likely to be only one cause of this reality. Other possible causes include over perception by practitioners of reasons why the quantitative technique might not be appropriate in a particular instance (Naguib et al., 2019). In addition, reluctance to use the monitors to guide management of neuromuscular blockade may be compounded by the relative paucity of easy-to-use, reliable subjective monitors. Many providers find the quantitative system difficult to use and/or are unconvinced as to its value (Todd et al., 2014). Clinicians who have never used QNM erroneously believe that clinically significant postoperative rNMBA is a rare event and that such adverse outcomes do not occur in their own practice (Naguib et al., 2019). Analogously, anesthesiologists might be reluctant to use objective monitoring due to their belief that the incidence of residual block is less than 1% (Naguib et al., 2019).

Purpose, Aim, and Objectives

Proper assessment of neuromuscular blockade is paramount for patient safety. The current problem is the lack of provider use of QNM despite the availability of the technology in the operating room. Currently at the level one Trauma Center, there are Philips IntelleVue

acceleromygraphy devices in each operating room for use in monitoring and reversal of NMBAs. The devices were purchased over three years ago and have been in use for the past 28 months. Although the devices are available, the Chief of Anesthesia reports that there is only about a 20% usage rate. Currently staff do not use the technology at all or choose to use a qualitative monitor device (i.e., PNS) in place of the newly purchased quantitative monitor.

The purpose of this Doctoral of Nursing (DNP) project is to use current evidence-based information to develop an educational presentation to disseminate best practices about the use of intraoperative QNM. Specifically, education will be provided to current anesthesia providers about the use of the QNM device, troubleshooting methods, pharmacokinetics of depolarizing neuromuscular medications, and the current reversal protocol in place at the agency. Education will also be provided about patient safety concerns that can occur in the event the devices are not used or used incorrectly.

Todd et al. (2014) suggests that extensive education efforts with repeated feedback can sustain the use of QNM in practice. The aim of this project is to increase provider knowledge and overall use of intraoperative QNM through an evidence-based educational session and Quick Look Guide. The objectives of this project are to close the knowledge gap regarding the use of QNM that exists among providers within this facility that is contributing to the lack of use of the QNM. Short term goals for this project include providing an educational offering to anesthesia providers pertaining to the use of QNM; long term goals include increasing the use of QNM and improving patient safety.

PICO Question Guiding Inquiry

This DNP project will examine the following PICO question: In anesthesia providers, does an educational initiative regarding QNM improve the intraoperative use of this technology

over a six-week period following the presentation? This project will include providing an educational presentation to the anesthesia providers (certified registered nurse anesthetists (CRNAs) and anesthesiologists). The education will focus on three educational deficits identified in the research: 1) mechanism of action and pharmacology of muscle relaxants; 2) residual muscular blockade and signs of inadequate reversal and its negative effects; and 3) use of the quantitative neuromuscular monitoring technology.

Systems and Population Impact

The Agency for Health Care Research and Quality (AHRQ) Needs Assessment provides necessary information for closing gaps and solving problems. Currently at the Level one Trauma Center, there are acceleromygraphy devices in each operating room for use in monitoring neuromuscular blockade. To determine the current use of QNM, the Chief of Anesthesia observed 10 random operating rooms of patients undergoing surgery and receiving non depolarizing NMBAs. With this observation, it was determined that only two providers were using the technology. When the providers were asked why they were not using the technology, responses included “The monitors did not work.”, “The monitors failed calibration.”, “The patient’s arms were tucked and the monitor would not work for that reason.”, and “The time was not taken to calibrate the monitor during induction.”

Based on this observation, a comprehensive literature search was conducted to help identify the key factors contributing to the lack of use of QNM by anesthesia providers. Based on these findings, an educational initiative was developed and will be used to educate the anesthesia providers about the QNM devices and their applicable use, troubleshooting the devices, pharmacokinetics of depolarizing neuromuscular medications, and current reversal protocol. Education will also be provided about the negative patient safety issues that can occur in the

event the devices are not used or used incorrectly. This educational initiative can help close the knowledge gap that exists contributing to provider nonuse within this facility. Lastly, the health care facility is an indirect benefactor from the educational presentation through decreased costs associated with complications related to rNMB and increased efficiency.

Chapter 2: Review of Literature

Search Methodology

A literature search was conducted using the databases Cumulative Index of Nursing and Allied Health Literature, MEDLINE, Ebscohost, and Google Scholar. The keywords used included residual muscular blockade, quantitative neuromuscular monitoring, nondepolarizing neuromuscular blockers, medications, anesthesia, anesthesia providers, TOF, peripheral nerve stimulator. The inclusion criteria included performing an advanced search, and limiting the results to peer reviewed, evidence-based articles in the English language that were not older than six years. Eighty-nine results were found and further eliminated based on the exclusion criteria. Research articles that did not address the population or setting identified in the project were also excluded.

Findings and Limitations

Bedsworth et al. (2019) developed an initiative to improve anesthesia providers' knowledge of neuromuscular blockade pharmacology, physiology, monitoring, and management, to increase the use of neuromuscular monitoring devices. The sample consisted of 200 patients (100 before the educational demonstration and 100 after), in a large academic anesthesia department. Despite the availability of quantitative monitors, most providers reported use of the peripheral qualitative nerve stimulator as their primary assessment tool for neuromuscular blockade reversal. A series of presentations were held for anesthesia providers to review the literature and clinical outcomes of residual muscular blockade, physiology of neuromuscular blocking medications, pharmacology of these medications, proper lead placement for neuromuscular monitoring, and monitor troubleshooting. In addition, a hands-on demonstration was done. Data was collected for three months on 100 patients before the quantitative monitoring

educational initiative was implemented. Post initiative data was collected for three months from 100 random intraoperative records in the electronic chart system. The quantitative monitoring education initiative significantly increased the use of QNM (Bedsworth et al., 2019).

Naguib et al. (2019) explored anesthesia providers confidence in their knowledge of the core concepts in neuromuscular monitoring. The study consisted of a sample size of 1,629 anesthesiologists who were administered an Internet-based survey in 80 different countries. All questions related to anesthesia practice were in a true/false format. After each question, respondents were asked to indicate his/her level of confidence in the answer using a scale from 50% to 100% in 5% increments using a drop-down menu. The respondents correctly answered an average of 57.1% of the nine questions. The mean confidence assigned by the respondents was 83.5% which was greater than their accuracy of 57.1%. Of the total respondents, 1,496 (91.8%) were overconfident, 119 (7.3%) were underconfident, and 14 (0.9%) were perfectly confident. The results of the study helped confirm the hypothesis that the anesthesiologists sampled are overconfident regarding their knowledge of intraoperative NMB management and monitoring. The study discussed the reasons why anesthesiologists did not utilize perioperative neuromuscular monitoring, and one reason included that anesthesia providers who believe that they have high levels of expertise think they do not need such assistance (Naguib et al., 2019).

The research suggests that reasons for the low adoption rate of QNM are multifactorial. Overconfidence is likely to be only one cause of this reality. Other possible causes include over perception by practitioners of reasons why the quantitative technique might not be appropriate in a particular instance. In addition, reluctance to use monitors to guide management of neuromuscular blockade may be compounded by the relative paucity of easy-to-use, reliable objective monitors. Clinicians who have never used QNM (erroneously) believe that clinically

significant postoperative rNMB is a rare event and that such adverse outcomes do not occur in their own practice. Analogously, anesthesiologists might be reluctant to use objective monitoring due to their belief that the incidence of residual block is less than 1%. However, 15% of clinicians admit that they have seen a patient who had inadequately recovered from neuromuscular block in the PACU (Naguib et al., 2019).

Other factors contributing to the nonuse of neuromuscular monitoring might include the cost of providing monitors in every operating room, their maintenance, and practitioner resistance to change (Naguib et al., 2019). When clinicians are highly confident that they are knowledgeable about a procedure, they are less likely to modify their clinical practice or seek further guidance or knowledge (Naguib et al., 2019).

Domenech et al. (2019) aimed to estimate the incidence of rNMB in patients managed with or without suggamadex or neostigmine as antagonists and quantitative monitoring in the operating room. The sample consisted of 240 patients who had undergone elective surgical procedures requiring neuro-muscular blockade in a tertiary referral University hospital in Buenos Aires, Argentina. Residual neuromuscular blockade was present in 1.6% of patients who received intra-operative QNM and 32% of patients whose neuromuscular blockade was not monitored. The rate of quantitative neuromuscular blockade monitoring in the current study was 26%, which is very low considering the availability of monitoring equipment in every operating room. The study suggested, the low neuromuscular blockade monitoring rates could be related to a poor understanding of the pharmacology of nondepolarizing neuromuscular blockade drugs (Domenech et al., 2019).

Todd et al. (2014) aimed to show that an ongoing program of education, monitoring, and repetitive provider feedback would reduce the incidence of inadequately reversed patients being

admitted to the PACU. The research study also aimed at identifying some of the reasons contributing to the difficult adoption of QNM methods. The sample consisted of 482 surgical patients. Quantitative neuromuscular monitoring was placed in 30 operating rooms within a health system. The implementation of the monitors was followed with an extensive educational program, including the circulation of multiple articles documenting the hazards of inadequate reversal. After six months of the monitors being in use, data was collected regarding the incidence of patients exhibiting signs of post-operative rNMB in the PACU. Review of a sample of anesthesia records indicated that the quantitative TOF monitoring system was being used in less than 50% of patients given nondepolarizing neuromuscular blockers. Staff were surveyed to identify opinions and attitudes regarding the lack of compliance with the use of quantitative monitoring of neuromuscular blockade. The survey indicated that many providers found the system difficult to use and/or were unconvinced as to its value. The study showed that providers had a very poor understanding of the pharmacology of the nondepolarizing relaxant most used. In addition, providers had a poor understanding of the clinical signs of adequate reversal or, more importantly, their limitations. Limitations to all the literature reviewed included that most research came from a single site which makes it difficult to generalize the applicability of the study results (Todd et al., 2014).

Conclusion

This comprehensive review of literature suggests that objective, QNM is a more accurate method of assuring satisfactory neuromuscular recovery in surgical patients, as compared to qualitative monitoring and clinical judgement, and should be used whenever NMBAs are administered for anesthesia (Stoelting, 2016). However, although the evidence and consensus statements recommend the use of QNM, this technology is not being used in clinical practice by

anesthesia providers (Domenech et al., 2019). Reasons cited in the literature for lack of provider use and compliance include lack of anesthesia provider knowledge, overconfidence of providers, a poor understanding of the clinical signs of adequate reversal, and the relative paucity of easy-to-use, reliable objective monitors (Todd et al., 2014). The intent of this DNP project is to disseminate the best evidence regarding the use of QNM to enhance education, create awareness, and influence anesthesia provider practice changes.

Chapter Three: Organizational Framework of Theory

The Theory of Planned Behavior was developed as an attempt to predict human behavior. The theory of planned behavior is comprised of six constructs that collectively represent a person's actual control over their behavior. The six constructs include attitudes, behavioral intention, subjective norms, social norms, perceived power, and perceived behavioral control. The population identified in this project may have existing attitudes about their current practice and may not perceive that there is a need to change their current practice (John Hopkins University, 2021). Prior to the implementation of the QNM at the level one Trauma Center, anesthesia providers used qualitative monitors and the use of subjective data and assessment to guide their practice and administration of neuromuscular reversal agents.

The evidence-based practice model used to operationalize this project is the RE-AIM Model. The goal of this Model is to encourage project planners to pay more attention to essential elements that can improve sustainable adoption, and implementation of effective evidence-based interventions. The five essential elements to translate research into action are reach, effectiveness, adoption, implementation, and maintenance (Ohio State University, 2021). To reach the right participants a meeting was held with the Chief of Anesthesia and Chief Nurse Anesthetist to talk about ideas for the project, making sure that support was granted from these key stakeholders. Collaboratively, a key patient safety issue was chosen as the topic of interest for the project. To reach the intended population, and create interest among staff, an email announcement will be sent by the Chief of Anesthesia to all anesthesia providers two weeks prior to the educational initiative.

Effectiveness and efficacy consider knowing if the intervention will be effective. Effectiveness will be monitored by completing a post educational initiative chart review to

determine if the use of QNM has increased. A post education survey will also be distributed to all staff to assess their willingness to use QNM. Buy in from key stakeholders will allow for organizational support to deliver the intervention as intended. Also, by engaging in continued monitoring, the DNP student will be able to promote adoption of the intervention. During this time, the DNP student can identify if there are any issues and adjust the plan if warranted.

To pursue maintenance, and sustained use, the DNP student will define critical long- and short-term policy strategies needed to assure sustainability. To pursue integration, implementation, and maintain sustainability, the DNP student will ensure the correct resources are available (things like human and financial resources) to ensure successful delivery of the educational initiative. Once the educational initiative is dispersed, the DNP student will be available to all staff for questions or concerns. Visual aids will be hung in the anesthesia library (high traffic area) for quick reference if needed to help ensure maintenance of the proposed project. In addition, a Quick Look Guide which includes the most pertinent points related to troubleshooting the Phillips IntelleVue QNM device will be laminated and placed in the operating rooms.

Chapter 4: Project Design

Institutional Review Board (IRB) Approval

The DNP student completed the online Collaborative Institutional Training Initiative (CITI) Program (Appendix A) and obtained Cedar Crest College (CCC) Internal Review Board (IRB) approval (Appendix B) prior to the initiation of the project on July 9, 2021. IRB approval was further obtained from the healthcare center on September 28, 2021 (Appendix C).

Implementation Plan

The DNP project will take place in the perioperative setting at a large level one Trauma Center in Reading, Pennsylvania. The level one Trauma Center performs more than 19,000 surgical procedures per year and serves Berks County and many surrounding areas. The perioperative setting has 24 operating rooms, and eight procedural suites. Twenty-three full time CRNA's and 20 full time anesthesiologists make up the population who have the opportunity to attend the DNP Project educational initiative. Support has been obtained from the Chief of Anesthesia (Appendix D) for development of the project, along with peer support and mentorship from Dr. Amy Colon, DNP, CRNA (Appendix E).

To determine the current use of QNM, the Chief of Anesthesia observed 10 random operating rooms of patients undergoing surgery and receiving non depolarizing NMBAs. With this observation, it was determined that only two providers were using the QNM technology. When the providers were asked why they were not using the technology, responses included "The monitors did not work.", "The monitors failed calibration.", "The patient's arms were tucked and the monitor would not work for that reason.", and "The time was not taken to calibrate the monitor during induction." Based on this observation, a comprehensive literature search was conducted to help identify the key factors contributing to the lack of use of QNM by

anesthesia providers. Based on these findings, an educational initiative was developed and will be used to educate the anesthesia providers on the benefits and use of QNM.

On behalf of the DNP student, a recruitment email (Appendix G), which includes the title of the project, project presenter, the location and time, informed consent to participate in the project, and an optional link to virtually attend the live educational initiative via Microsoft TEAMS, will be sent to anesthesia staff (i.e., Anesthesiologist, CRNA, SRNA) by the Chief of Anesthesia, two weeks prior to the implementation of the educational initiative; a follow-up reminder email will be sent four days prior to the educational presentation.

A 30-minute PowerPoint presentation consisting of 26 slides (Appendix H) will be presented by the DNP student and will include education about the Philips IntelleVue QNM device and use, troubleshooting methods, pharmacokinetics of non-depolarizing neuromuscular medications, and the current NMB reversal protocol. A hard copy of the PowerPoint presentation will be available for review in the Anesthesia Department for reference following the educational presentation. In addition, a Quick Look Guide (Appendix I), which includes the most pertinent points related to troubleshooting the Phillips IntelleVue QNM device will be laminated and placed in the operating rooms. The Quick Look Guide will serve as a cognitive aid to standardize information and help to facilitate decision-making about common troubleshooting issues related to the QNM device. An Evaluation Survey (Appendix J) which contains two demographic and five 5-point Likert scale questions to assess the respondent's current use of QNM and willingness to change their practice following the educational initiative will be given to the participants at the completion of the presentation. The Survey will be collected in an envelope at the exit location.

To determine if the use of QNM by anesthesia providers improved, an electronic chart

review of the anesthesia record using the EPIC application Slicer Dicer will be conducted six weeks prior to and after the educational presentation, to determine the number of surgery cases that were performed using QNM in the presence of the administration of NMBAs. The inclusion criteria for the surgery cases will include any surgical procedure where general anesthesia was administered and QNM was applied in the presence of nondepolarizing muscle relaxation during the timeframe of September 23, 2021, through November 4, 2021, and November 5, 2021, through December 17, 2021. The exclusion criteria will include surgery cases of 1) patients under the age of 18; 2) patients who received depolarizing muscle relaxation; 3) patient procedures that were scheduled for moderate sedation and converted to general anesthesia; 4) patient procedures that were performed using neuromonitoring; 5) patients who are deceased; and 6) patients who were brought to the operating room intubated, with the expectation to remain intubated.

Data Collection and Analysis

Statistical analysis will be performed using the SPSS Statistics 26 version for Windows to determine if the educational initiative improves anesthesia provider use of QNM. Descriptive statistics will be used to describe the demographics of the sample population. To compare the use of QNM before and after the educational presentation, the number of surgery cases that were done using QNM in the presence of the administration of non-depolarizing neuromuscular blockade will be calculated. A Chi-square test will be used to determine if participation in the educational initiative resulted in a significant increase in the use of QNM.

Resources Needed

The resources required to complete this project will include personnel, technology, basic supplies, and facilities. Personnel for the project design will include the DNP student, mentors,

anesthesia stakeholders, and participants. The technology required for completion of the project will include a computer and PowerPoint software to complete the educational session, the Philips Intellevue Neuromuscular monitor, and the Slicer Dicer application that will be used for data analysis. The basic supplies required for completion of this project will include paper, printer, hole puncher and laminating device and supplies. The facilities required for completion of the project will include a conference room at the level one Trauma Center.

Budget Justification

Most of the resources needed for the completion of this project are available without cost through Cedar Crest College. Computers and Power Point software are available free of charge through Cedar Crest College's library facilities. The Slicer Dicer application is available to all Department Chairs within the level one Trauma Center and was offered for use by the Anesthesia Department Chair, under his guidance. The financial requirements of this project will include paper, printing, and laminating supplies. The lamination equipment was already owned by the DNP student and required purchasing of only the laminating paper. Paper and printing costs totaled $35.00, laminating paper costs totaled $5.00. There are no monetary benefits for the creation of this project or through participation in the project. Indirect benefits from this project included an increase in anesthesia professionals' knowledge in best practices in anesthesia patient safety. The health care facility is an indirect benefactor from the educational presentation through decreased costs associated with complications related to rNMB and increased efficiency.

Chapter 5: Implementation Procedures and Processes

A total of 43 anesthesia providers, currently working at the level one Trauma Center, were sent a recruitment email by the Chief of Anesthesia to attend the educational session. The implementation of this DNP project took place during an Anesthesia Department meeting on November 5, 2021. A 30-minute PowerPoint, which contained provider education regarding neuromuscular blocking medications, rNMB and its negative effects, and the use of the Philips IntelleVue neuromuscular monitoring technology, was presented face-to-face by the DNP student and was also streamed virtually via Microsoft Teams to anesthesia team members that could not be present. The participants were also introduced to the Quick Look Guide, and following the presentation, laminated copies were placed to serve as a reference in all operating rooms, with the exception of two cardiac surgery and one trauma operating room. The Quick Look Guide will remain in the operating rooms indefinitely.

Upon completion of the educational presentation, the participants were provided an Evaluation Survey and asked to complete it. While exiting the educational presentation, the Evaluation Surveys were collected in an envelope and then sealed. An envelope was placed in the Anesthesia Library for the collection of the Evaluation Surveys from all participants who attended the education remotely. Remote participants were given three weeks for completion and submission of Evaluation Surveys.

The Evaluation Survey data was entered into SPSS. Descriptive statistics were used to describe the characteristics of the sample. A Chi -square test was used to evaluate the relationship between the pre and post intervention data to determine if participation in the educational initiative resulted in a significant increase in the use of QNM.

Chapter 6: Evaluation and Outcomes

Evaluation

A total of 43 anesthesia providers, currently working at the Level one Trauma Center, were sent a recruitment email to attend the educational session. The overall participation rate was 48% (n = 21) and included 5 Anesthesiologists (23.8%), 12 CRNAs (57.1%) and 4 SRNAs (19%). The years of experience ranged from 0 to 21 years; 11 participants had an average of 0 to 5 years of experience (52.4%), 6 had 6 to 10 years of experience (28.6%), 1 had 11 to 15 years of experience (4.8%), and 3 had over 21 years of experience (14.3%) (Table 1).

Table 1

Demographics of Participants

Sample Characteristics	Class	n (Percent)
Anesthesia Role	Anesthesiologist	5 (23.8%)
	CRNA	12 (57.1%
	SRNA	4 (19%)
Years of Experience	0 - 5 years	11 (52.4%)
	6 - 10 years	6 (28.6%)
	11- 15 years	1 (4.8%)
	21+ years	3 (14.3%)

Following the educational offering, participants were asked to complete five questions using a 5-point Likert scale (rarely to always) to determine commonly encountered QNM troubleshooting issues, the participant's current practice, and their likelihood to change their practice after completion of the educational initiative.

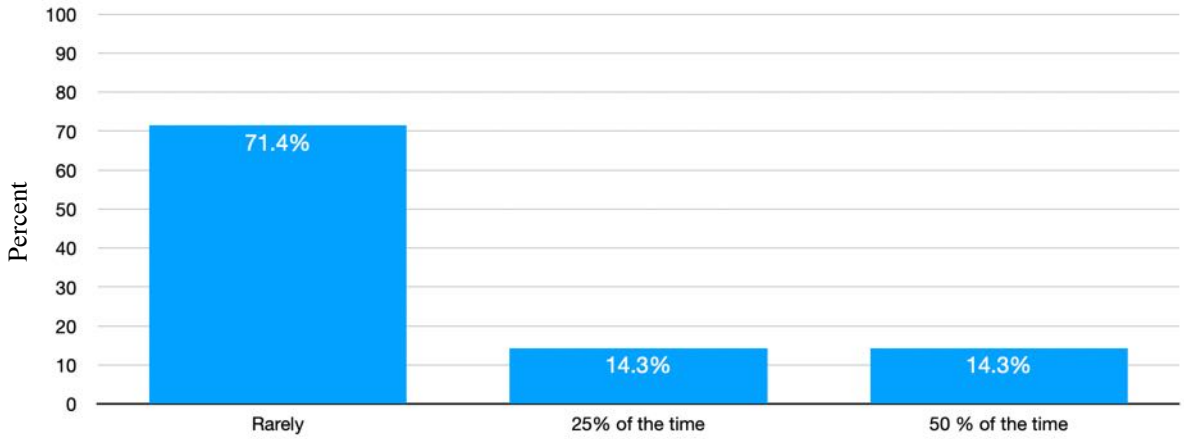
Project Question #1

To gather an understanding of the providers experience with witnessed rNMB, Question #1 included the question, *"How often have you witnessed negative side effects secondary to*

rNMB?" Of the 21 participants, 71.4% (n = 15) replied that they rarely witnessed negative side effects secondary to rNMB; 14.3% (n=3) reported 25% of the time, as well as 14.3% (n=3) reported 50 % of the time (Figure 1).

Figure 1

How Often Providers Witnessed Side Effects Secondary to rNMB

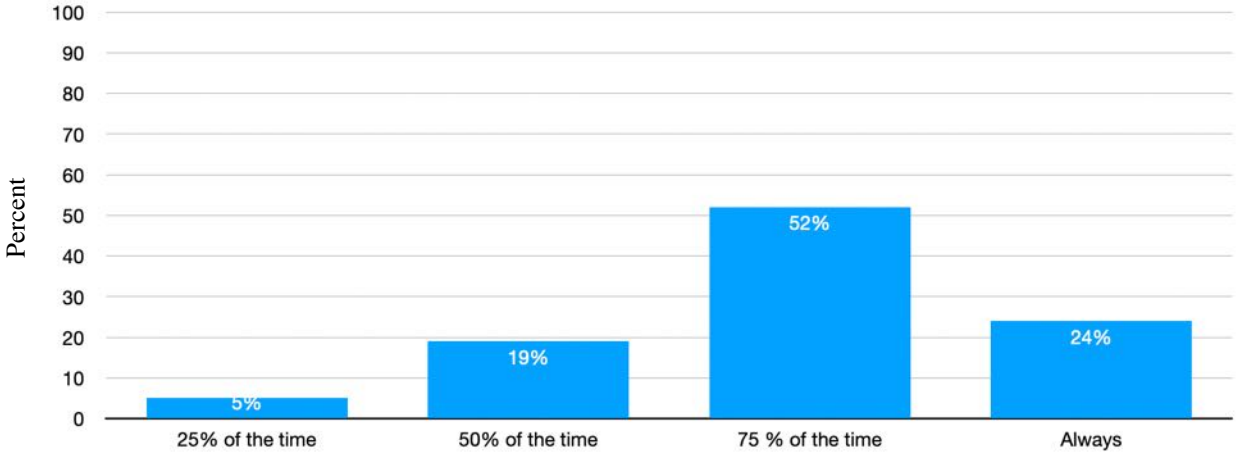


Project Question #2

To gather an understanding of the providers daily use of the QNM, Question #2 included the question, *"How often do you find yourself using a QNM in one day?"* Of the 21 participants, 5% (n = 1) replied that they use the QNM 25% of the time in one day; 19% (n=4) reported 50% of the time, 52% (n=11) reported 75% of the time, and 24% (n=5) reported they always use the QNM in one day (Figure 2).

Figure 2

Providers Daily Use of QNM

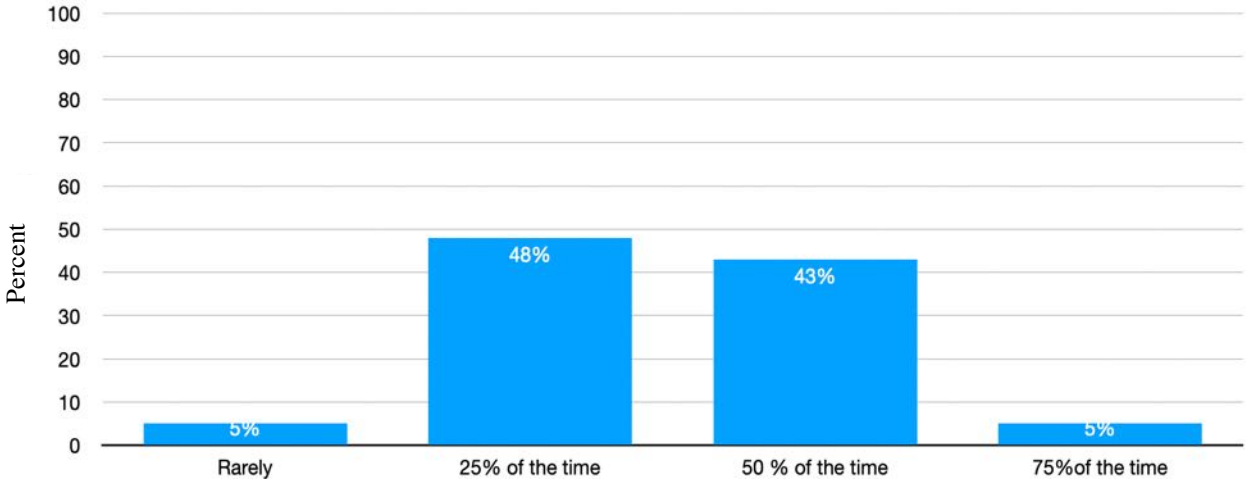


Project Question # 3

To gather an understanding of how often the providers encountered technological difficulties using the QNM, Question #3 included the question, *"How often do you encounter technological difficulties using the QNM in one day?"* Of the 21 participants, 5% (n = 1) replied that they rarely encounter difficulties in one day; 48% (n=10) reported 25% of the time, 43% (n=9) reported 50% of the time, and 5% (n=1) reported 75% of the time (Figure 3).

Figure 3

How Often Providers Encountered Technological Difficulties with QNM in One Day

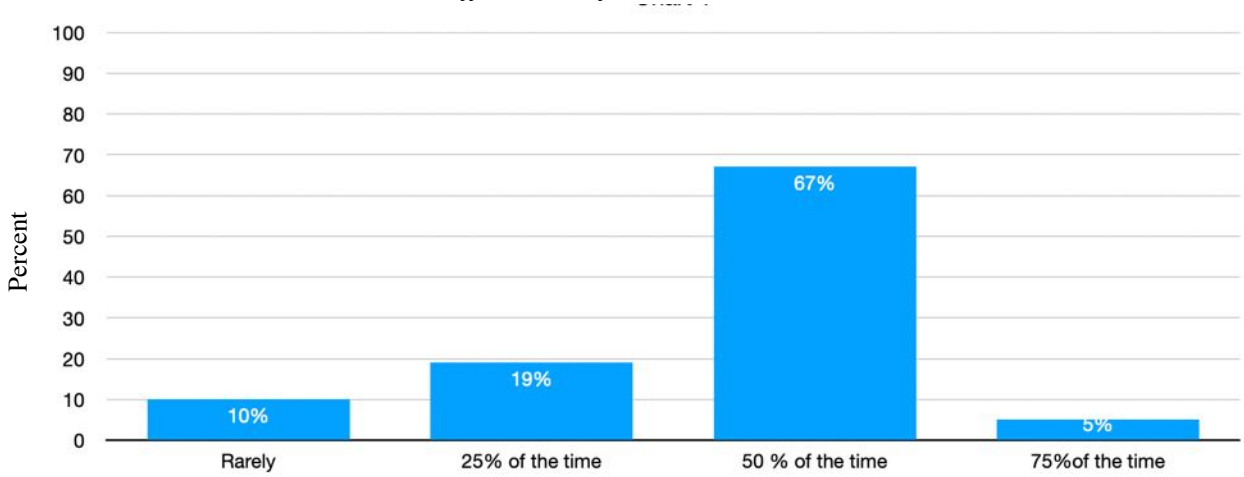


Project Question # 4

To gather an understanding of how often the provider experienced a failed calibration or technical difficulties using the QNM, Question #4 included the question, *"Upon calibration of the QNM, how often do you experience a failed calibration or technical difficulties?"* Of the 21 participants, 10% (n = 2) replied that they rarely encountered failed calibration; 19% (n=4) reported 25% of the time, 67% (n=14) reported 50% of the time, and 5% (n=1) reported 75% of the time (Figure 4).

Figure 4

Failed Calibration or Technical Difficulties After Calibration

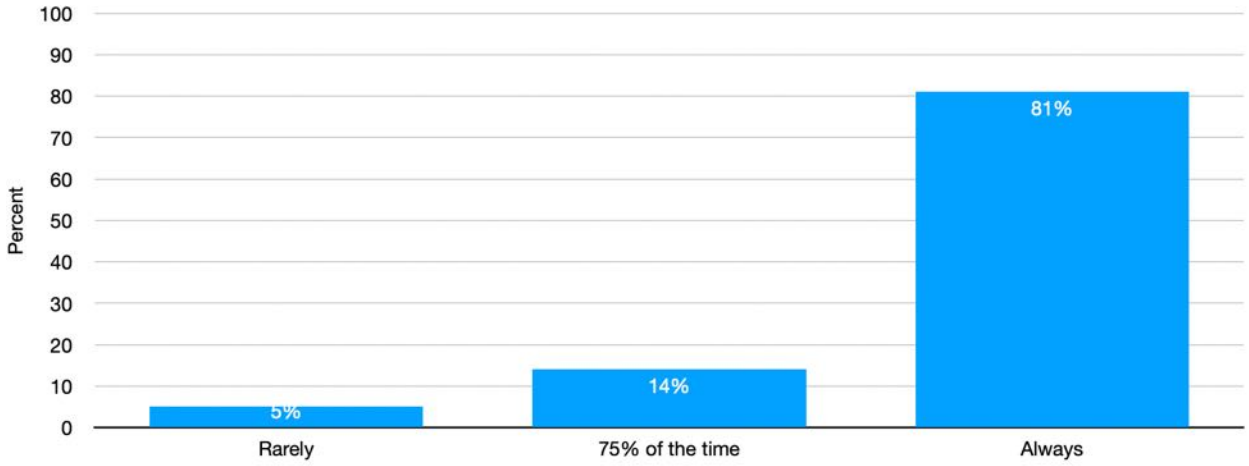


Project Question # 5

Finally, to gain insight of the provider's willingness to change their practice following participation in the educational initiative, Question #5 included the question, *"After participation in the education, how likely are you willing to change your practice and use the QNM device in your practice?"* Of the 21 participants, 5% (n = 1) replied that they would rarely change their practice; 14% (n=3) reported 75% of the time, and 81% (n=17) reported they would always change their practice (Figure 5).

Figure 5

Provider Willingness to Change Practice After Participation in the Educational Initiative



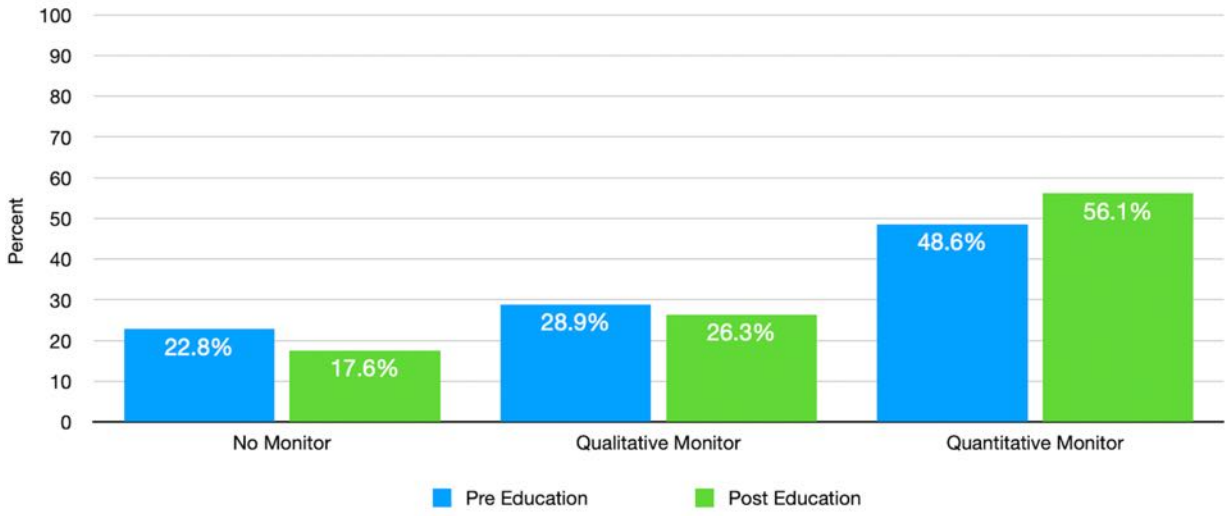
Even though most participants (n=20) responded that they were likely to change their practice and use the QNM, a chart review of the anesthesia record was conducted six weeks prior to and six weeks after the educational initiative to determine the number of surgical cases that took place, where QNM was used in the presence of general anesthesia and administration of neuromuscular blockade. Inclusion criteria included any surgical procedure where general anesthesia was administered and QNM was applied in the presence of nondepolarizing muscle relaxation. Cases were excluded if patients were 1) under the age of 18; 2) received depolarizing muscle relaxation; 3) were scheduled for moderate sedation; and converted to general anesthesia; 4) were performed using neuromonitoring; 5) who are deceased; and 6) who came to the operating room intubated with expectations to remain intubated.

A total of 370 cases were reviewed prior to the educational intervention and the findings revealed that 22.8% (n=83) of the time no neuromuscular monitoring device was used, 28.9% (n=107) of the time a qualitative monitor was used, and 48.6% (n=180) of the time a quantitative monitor was used. Six-weeks following the educational intervention, 346 cases were reviewed, and the findings were that 17.6% (n=61) of the time no neuromuscular monitoring device was

used, 26.3% (n=91) of the time a qualitative monitor was used, and 56.1% (n=194) of the time a quantitative monitor was used. Following the educational initiative QNM use increased from 48.6% to 56.1% (Figure 6).

Figure 6

Monitor Use Between Pre-Education and Post-Education Groups



To determine if the increase in use of the QNM was significant following the educational session, a Chi-square test (X^2) was performed (Table 2).

Table 2

Chi Square Test of QNM Usage

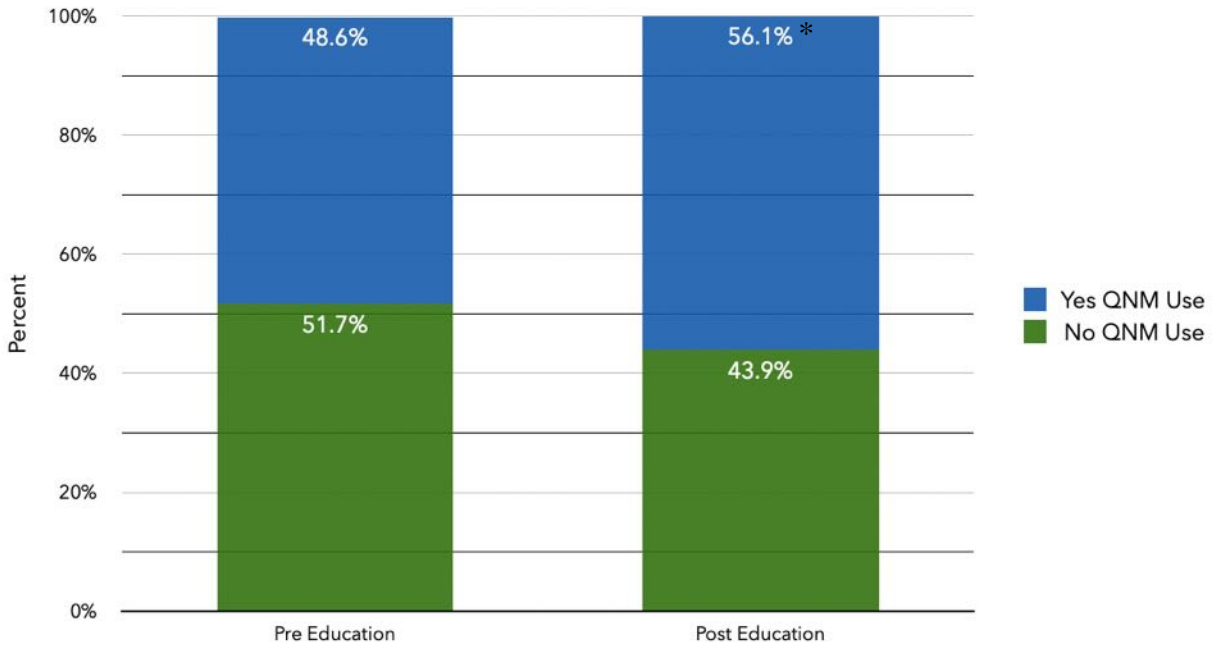
Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.139[a]	4	.025
Likelihood Ratio	11.053	4	.026
Linear-by-Linear Association	1.821	1	.177
N of Valid Cases	716		

A *p* value of less than .05 was considered statistically significant. The results revealed that there was a significant increase in QNM usage following the educational session, X^2 (4, N = 716) = 11.14, p = .025 (Figure 7).

Figure 7

Comparison of QNM Usage Between Pre/Post Education



*p=.025

Discussion

The education provided to the anesthesia staff was well received. Anesthesia staff were eager to ask questions regarding the technology and showed great interest in obtaining troubleshooting tips. The Quick Look Guide, that was placed in all operating rooms containing troubleshooting tips for the technology, was reported to be, “A nice resource that helped troubleshooting”.

It is interesting, although rNMB has been shown to cause serious perioperative morbidity, 71.4% of the anesthesia providers surveyed, responded that they rarely witnessed negative side effects secondary to the use of NMBs. For two decades, experts have suggested that patients receiving NMBAs should receive neuromuscular monitoring with the use of the quantitative TOF monitor (Nemes & Renew, 2020) however, the survey results revealed that providers only

reported a 24% usage rate of QNM 100% of the time and importantly, 67% of providers reported that they encounter technological difficulties /failed calibrations 50% of the time when using the technology. This is very concerning as well as eye opening as it may be a significant reason for reluctance to use the technology. Finally, it appears that the educational initiative was effective as 81% of the providers reported they would change their monitoring practices; the chart review confirmed this as the utilization of QNM increased by 7.5% among clinicians and analysis showed that the increase was statistically significant ($p = .025$). The implementation of the Quick Look Guide will hopefully sustain the increase in QNM usage.

Chapter Seven: Implications for Nursing Practice

Implications for Practice

The purpose of this project was to use evidence-based information to educate anesthesia professionals about the three educational deficits identified in the research: 1) mechanism of action and pharmacology of muscle relaxants; 2) residual muscular blockade and signs of inadequate reversal and its negative effects; and 3) use of the QNM technology to be used in their current practice to improve patient safety outcomes (Todd et al., 2014). Anesthesia professionals utilizing evidence-based findings in their clinical decision making will provide a safe clinical environment for patients in their care (Lehane et al., 2019). Todd et al. (2014) suggests that extensive education efforts with repeated feedback can sustain the use of QNM in practice; a cognitive aid, such as the Quick Look Guide can also help to sustain that use. With that being said, implications for future practice would be to continue yearly education on rNMB and the use of QNM to ensure continued patient safety outcomes.

Strengths of the Project

Strengths of this DNP project was the opportunity to provide education to a diverse group of anesthesia professionals (Anesthesiologists, CRNAs, SRNAs) with varying years of experience (0-21 years). Additional strengths of the project included the ability for the anesthesia providers to be able to attend the educational presentation virtually and the placement of the Quick Look Guide to serve as a cognitive aid and ongoing resource guide in the operating rooms to help standardize information and facilitate decision-making about common troubleshooting issues related to the QNM.

Limitations of the Project

There are several limitations to this project. Due to the nature of the project convenience sampling was used to gain participation from providers and only a small sample of providers (n = 21) participated. This sample size does not allow for the generalization of data to a larger population of anesthesia professionals. Additionally, the time constraints (one hour, one day, on a Friday) existing with the educational presentation may have impacted some anesthesia provider's ability to participate in the educational presentation.

Linkage to DNP Essentials

The Essentials of Doctoral Education for Advanced Nursing Practice that have been met with this project and include Essentials I, II, III, IV, V, VI, VII, and VIII. Essential I is the application of scientific underpinnings for practice (American Association of Colleges of Nursing, 2006). This essential was met by identifying evidence-based research and applying it to practice by educating anesthesia professionals with an educational presentation. The RE-AIM Model and the Theory of Planned Behavior were scientific underpinnings utilized throughout this project to focus on essential elements that can improve sustainable adoption, and implementation of effective evidence-based interventions.

Essential II is the application of organizational and systems leadership for quality improvement and systems thinking (America Association of Colleges of Nursing, 2006). This Essential was met through collaboration with stakeholders in the Anesthesia Department to identify quality improvement needs. Essential III is the application of clinical scholarship and analytical methods for evidence-based practice (American Association of Colleges of Nursing, 2006). This Essential was met through the development of a DNP proposal, IRB submission, and creation of an educational module that addressed evidence-based anesthesia patient safety topics. Implementation of the project, data collection, and data analysis also served to meet Essential III.

Dissemination of the project results will take place with a poster presentation at Cedar Crest College, along with a poster presentation at the 2022 Pennsylvania Association of Nurse Anesthetist (PANA) Spring Symposium and is an additional element that fulfills Essential III.

Essential IV is the application of information systems/technology and patient care technology for the improvement and transformation of health care (American Association of Colleges of Nursing, 2006). This Essential was met using the virtual platform (TEAMS) as an added way for participants to participate. Electronic communication was used to distribute the invitation and consent to participate. Information systems/technology via the use of the Slicer Dicer application was used for the collection of data, and with SPSS software was used for the analysis of the data. Participation in the educational session for the Philips QNM device is another example of how Essential IV was met during this project.

Essential V is the application of health care policy for advocacy in health care (American Association of Colleges of Nursing, 2006). This Essential was met through delivery of an educational module developed upon the evidence-based guidelines suggested by the Anesthesia Patient Safety Foundation that rNMB in the postoperative period is a patient safety hazard that requires the use of QNM (Stoelting, 2016).

Essential VI is the application of interprofessional collaboration for improving patient and population health outcomes (American Association of Colleges of Nursing, 2006). The target audience for this project included the interprofessional anesthesia team, including Anesthesiologists, CRNAs, and SRNAs. This Essential was met through various meetings with stakeholders and interprofessional collaboration with Anesthesia Department leadership, DNP mentors, and DNP chairs. This Essential was also met with the various communications and collaboration with the health professional representative for the Phillips Intellevue QNM device.

Essential VII is the application of clinical prevention and population health for improving the nation's health (American Association of Colleges of Nursing, 2006). This essential was met through a needs assessment of hospital quality improvement needs and the development of a DNP Project to educate anesthesia professionals on the benefits of QNM for rNMB in surgical patients. Essential VIII is the application of advanced nursing practice (American Association of Colleges of Nursing, 2006). This Essential was met by identifying patient safety concerns in current anesthesia practice and the clinical setting, and then disseminating evidence-based education regarding best practice recommendations.

Chapter Eight: Summary of Project

Summary and Conclusions

Residual neuromuscular blockade results from inadequate recovery from NMBAs and is a potential serious patient safety issue. According to McLean et al. (2015), rNMB can result in generalized postoperative respiratory complications that contribute a significant burden to the patient and health system. This patient safety issue can be prevented when using QNM to guide administration of neuromuscular blocking medications, and reversal medication administration (Naguib et al., 2019). The findings of this project were consistent with the current literature that suggests even though QNM is superior to qualitative monitoring and clinical judgement, providers stray from using the technology.

The purpose of this Doctoral of Nursing (DNP) project was to use current evidence-based information to develop an educational presentation to disseminate best practices about the use of intraoperative QNM. Specifically, Anesthesia providers attended a 30-minute presentation focusing on the use of the QNM device and 1) mechanism of action and pharmacology of muscle relaxants; 2) residual muscular blockade and signs of inadequate reversal and its negative effects; and 3) use of the quantitative neuromuscular monitoring technology. Education was also provided about patient safety concerns that can occur in the event the devices are not used or used incorrectly. A Quick Look Guide was also distributed to the providers as well as posted in the operating rooms regarding the use of the QNM. The objectives of this project were met by demonstrating an increase in the providers willingness to change their practice and an increase in the use of QNM following the educational initiative.

Dissemination Plans

This project will be disseminated via poster (Appendix K) presentation on April 11, 2022, to students and faculty at Cedar Crest College. The project will also be presented at the PANA 2022 Spring Symposium.

Future Ideas

In clinical sites that have QNM, future projects should aim to identify and address barriers to implementing the use of QNM in current practice. Continued education in the form of a yearly competency review can help to address the educational issues pertaining to the use of QNM. New staff may be unfamiliar with the technology and providing a yearly review can help to reach newly hired staff within an organization. For clinical sites that do not have QNM in place, future projects can be aimed at implementing the monitors into practice and providing a Quick Look Guide to serve as a resource for review of the new technology. Future research could be aimed at addressing why providers deviate from using QNM although it is best practice.

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Appendix A

CITI Training

CITI PROGRAM

Completion Date 21-Oct-2019
Expiration Date 20-Oct-2022
Record ID 33867519

This is to certify that:

Rebecca Satterfield

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

Social & Behavioral Research - Basic/Refresher
(Curriculum Group)
Social & Behavioral Research - Basic/Refresher
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Lehigh Valley Association of Independent Colleges

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?w7c41d93d-5efd-40a7-8dc6-01b5ea90d412-33867519

Appendix B

Cedar Crest College IRB Approval

From: DocuWare Notification <noreply@docuware.cloud>
Sent: Friday, July 9, 2021 9:08 AM
To: Nancy Roberts <Nroberts@cedarcrest.edu>
Cc: DocuWare Service Account <DocuWare@cedarcrest.edu>
Subject: APPROVED - An Educational Initiative to Increase Anesthesia Provider Use of Quantitative Neuromuscular Monitors - IRB Request Number 356

Your IRB Request has been Approved by the Project Advisor/Supervisor and is passing on to be reviewed by the Committee Chair.

Attached you'll find the IRB Request Form for this request, including any notes added by the Project Advisor/Supervisor.

If additional files were submitted the request form and additional files will be delivered together in a zipped file.

Notes:

IRB Request Number: 356

Title of Research: An Educational Initiative to Increase Anesthesia Provider Use of Quantitative Neuromuscular Monitors

Type of Review: LIMITED REVIEW

Lead Researcher: Rebecca Satterfield

Project Advisor/Supervisor: Dr. Nancy Crane-Roberts and Dr. Mae Ann Pasquale

Date Submitted: 7/3/2021

Appendix C

Tower Health IRB Approval

TOWER HEALTH
Advancing Health. Transforming Lives.

September 28, 2021

Dear Ms. Satterfield,

On behalf of the Reading Hospital's DNP Review Committee, it is a pleasure to inform you that your project "An Education Initiative to Increase Anesthesia Provider use of Quantitative Neuromuscular Monitors" has been approved. The project was deemed a quality improvement effort by the Director, Human Subjects Protection.

Sincerely,

Deborah Swavely

Deborah Swavely DNP, RN
Senior Director Nursing Clinical Inquiry and Research | 484-628-9105
deborah.swavely@towerhealth.org | TowerHealth.org

Appendix D

Letter of Support

Reading Hospital
TOWER HEALTH
Advancing Health. Transforming Lives.

5/10/2021

re: Rebecca Satterfield, SRNA

Dear Cedar Crest IRB Committee,

I am entirely supportive of Ms. Satterfield's study/project.

As a result of significant data on increased perioperative morbidity for patients who require neuromuscular blockade and recommendations for improved management, over the past year, we have instituted the use of quantitative monitors for the use of neuromuscular blockade in the operating rooms at Reading Hospital/Tower Health. Despite significant education and the development of a written/laminated cognitive aid, the compliance with the use of the monitors is still underwhelming. Ms. Satterfield's efforts will identify the obstacles and help to educate in order to augment understanding and facility with this important aspect of anesthetic care. It is clear form the literature that this will decrease postoperative pulmonary complications for our patients.

I will be available to provide support for this project and for Ms. Satterfield and will ensure that Reading Hospital's rsources are available for her use.

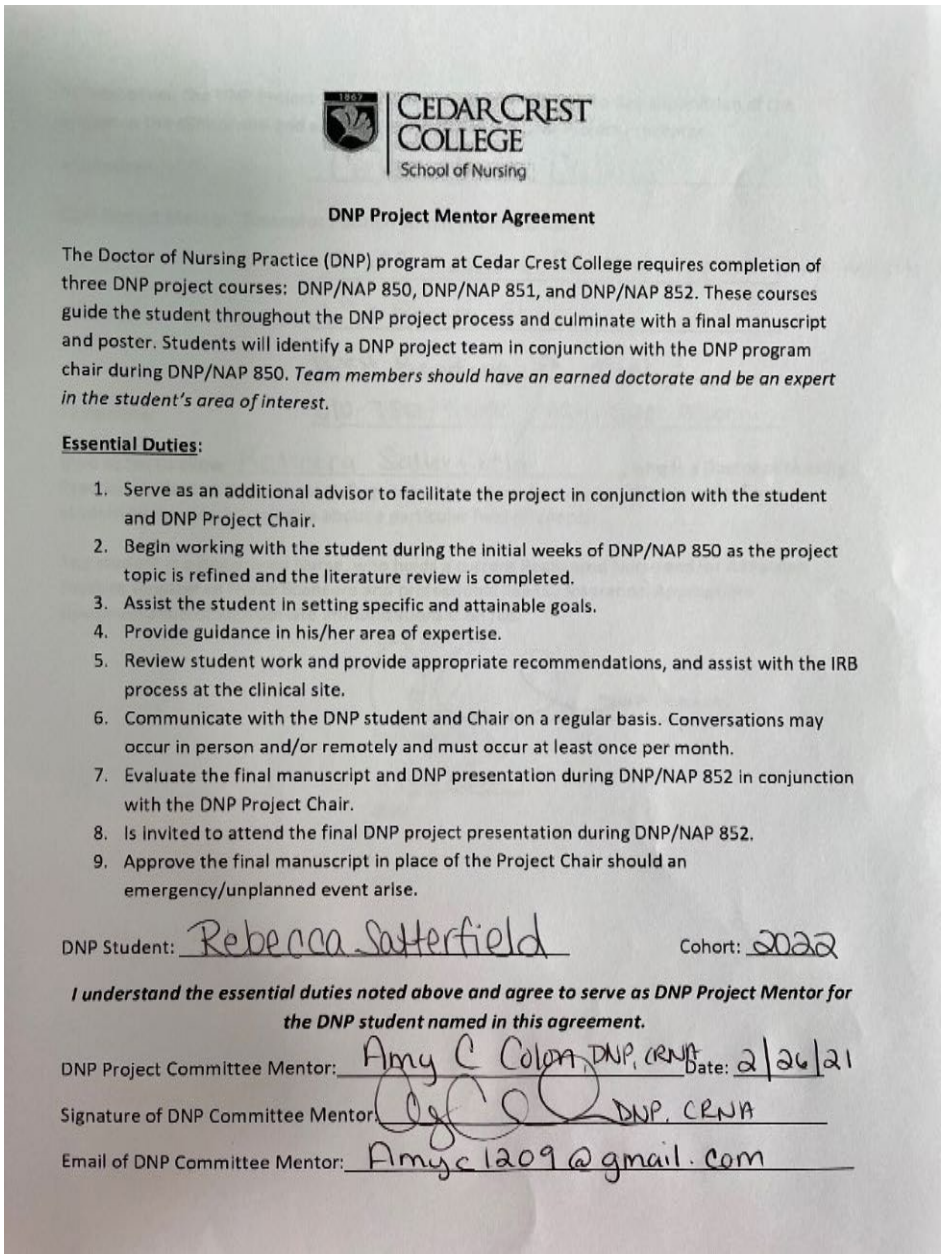
Respectfully,

David A. Matson, DO
Chair, Department of Anesthesiology
Program Director, Anesthesiology Residency
Reading Hospital/Tower Health
Clinical Faculty, Drexel University College of Medicine

PO Box 16052, Reading, PA 19612-6052
Phone: 484-628-8000

Appendix E

DNP Mentor Agreement



CEDAR CREST COLLEGE
School of Nursing

DNP Project Mentor Agreement

The Doctor of Nursing Practice (DNP) program at Cedar Crest College requires completion of three DNP project courses: DNP/NAP 850, DNP/NAP 851, and DNP/NAP 852. These courses guide the student throughout the DNP project process and culminate with a final manuscript and poster. Students will identify a DNP project team in conjunction with the DNP program chair during DNP/NAP 850. *Team members should have an earned doctorate and be an expert in the student's area of interest.*

Essential Duties:

1. Serve as an additional advisor to facilitate the project in conjunction with the student and DNP Project Chair.
2. Begin working with the student during the initial weeks of DNP/NAP 850 as the project topic is refined and the literature review is completed.
3. Assist the student in setting specific and attainable goals.
4. Provide guidance in his/her area of expertise.
5. Review student work and provide appropriate recommendations, and assist with the IRB process at the clinical site.
6. Communicate with the DNP student and Chair on a regular basis. Conversations may occur in person and/or remotely and must occur at least once per month.
7. Evaluate the final manuscript and DNP presentation during DNP/NAP 852 in conjunction with the DNP Project Chair.
8. Is invited to attend the final DNP project presentation during DNP/NAP 852.
9. Approve the final manuscript in place of the Project Chair should an emergency/unplanned event arise.

DNP Student: Rebecca Satterfield Cohort: 2022

I understand the essential duties noted above and agree to serve as DNP Project Mentor for the DNP student named in this agreement.

DNP Project Committee Mentor: Amy C Colon, DNP, CRNA Date: 2/26/21

Signature of DNP Committee Mentor: DNP, CRNA

Email of DNP Committee Mentor: Amyc1209@gmail.com

Appendix F

Current Reading Hospital Reversal Protocol

Tower Health/Reading Hospital
Department of Anesthesiology
Guidelines for the Reversal of Neuromuscular Blockade

Sugammadex 200mg- $102.00
Neostigmine 5mg/Glycopyrrolate 1.0 mg- $25.50

Quantitative Assessment of Neuromuscular Blockade is the standard. Using traditional qualitative assessments, 30% of patients have clinically significant NMB at the conclusion of an operation causing an increase in postoperative pulmonary complications.

The goal is a TOF of 4 with a Ratio of >.9
Reversal dosing based on Actual Body Weight up to Ideal Body Weight +40% (see chart on opposite side)
Maximum dose of neostigmine is 5 mg. Glycopyrrolate dosing is .2mg/1mg Neostigmine.
For longer operations/higher cumulative doses of NMBs, err on the side of more aggressive reversal dosing.

Block Depth	Quanitative TOF	PTC	Reversal (Vec/Roc)		Reversal (Cis)
			First Choice	Alternative	Only Choice
Profound/Emerger	TOF 0	0	Sugammadex 16 mg/kg	[redacted]	Wait
Profound/Non-Emergent			Wait		
Deep	TOF 0	>1	Suggammadex 2 mg/kg. Repeat if necessary.		Wait
	TOF 1		Suggamadex 2 mg/kg		Wait
Moderate	TOF 2-3	NA	Neostigmine 70mcg/kg	Suggamadex 2 mg/kg	Neostigmine 70mcg/kg
Light	TOF 4 (Ratio .1-.4)	NA	Neostigmine 50 mcg/kg	Suggamadex 2 mg/kg	Neostigmine 50 mcg/kg
Minimal	TOF 4 (Ratio .4-.9)	NA	Neostigmine 30 mcg/kg	[redacted]	Neostigmine 30 mcg/kg
Full Recovery	TOF 4 (Ratio >.9)	NA	NONE		NONE

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Feb-21

Appendix G

Recruitment Email

Dear Clinician,

You are being invited to participate in a Doctor of Nursing Practice project regarding the use of quantitative neuromuscular monitoring (QNM). The purpose of the project is to educate anesthesia providers on the use of QNM. Specifically, education about the Philips IntelliVue QNM device and use, troubleshooting methods, pharmacokinetics of non-depolarizing neuromuscular medications, and the current reversal protocol. You are invited to participate because you are a certified registered nurse anesthetist or anesthesiologist that works in the operating room at Reading Hospital Tower Health. Agreement to participate includes your attendance to an in person educational presentation, followed by completion and submission of a post educational survey. Participation in the survey is an indication of your consent to participate within the project. The total time required to complete this DNP project is approximately 20 minutes.

An Institutional Review Board at Cedar Crest College reviewed this project and granted approval. There are no anticipated risks to you as a result of your participation in this study. However, if you feel uncomfortable or upset when answering any questions, you can stop and discontinue your participation. You will not receive any direct benefit from participation in this study. The benefits of this study include the advancement of nursing knowledge and evidence-based practice.

All research data collected in this project will be anonymous; your name will never be linked to the data. All data will be kept confidential and will only be used for project purposes. All data will be stored on an encrypted and password protected computer. This data will be destroyed at the completion of the project. The findings of this project may be included in a publication, but your name will never be used.

Participation in this project is voluntary. You have the right not to participate and you may choose not to complete the survey. You may end your involvement at any time without personal or professional penalty or consequence. Your submission of the survey is an indication of your implied consent to allow your responses to be used for the purposes of this project. Once your responses are submitted it is not possible to remove them.

If you have any questions about this project, or want to discuss any concerns, you may contact the DNP student at any time. I would greatly appreciate your participation as it is crucial to the successful implementation of this project.

Thank you for your consideration and time.

Sincerely yours,

Rebecca Satterfield RN, BSN, CCRN, SRNA

Doctor of Nursing Practice Candidate

Cedar Crest College School of Nursing, Nurse Anesthesia Program

Email rlsatter@cedarcrest.edu

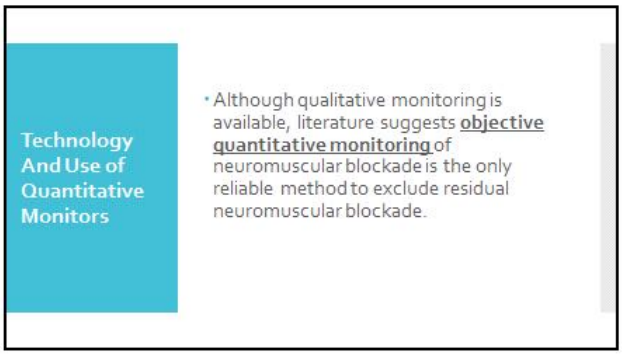
Phone (570) 292-4041

Appendix H

Power Point Educational Material

1

2



3

4

Monitor Placement

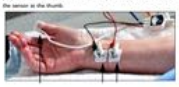
Frequently Asked Questions

How important is the skin preparation?

Good electrode-to-skin contact is important for a good stimulation pulse. Insufficient cleaning of the skin can cause high skin resistance which could cause the stimulation to stop.

Placing the NMT Electrodes and Sensor

As shown in the following graphic, place the electrodes on the prepared site over the ulnar nerve on the palmar side of the wrist, and the sensor at the thumb.



Frequently Asked Questions

Can I use the IntelliVue NMT measurement for electrode placements other than on the hand?

The IntelliVue NMT Measurement is developed to be used on the hand.

What can I do if the hand or any other finger twitches and not only the thumb?

Reposition the electrodes to find the best position to stimulate the ulnar nerve only.

Should the thumb be fixed?

No, the thumb should be able to move freely.

Should the other fingers be fixed?

As long as the thumb is able to move freely, you can fix the other fingers or not.

5

Calibration Issues

Frequently Asked Questions

Is calibration necessary?

To perform objective and quantitative (Twitch only) measurements, calibrate the IntelliVue NMT measurement.

Neuromuscular monitoring should be initiated during anesthesia induction. In this phase, the calibration of the NMT measurement is intended.

For this reason, the IntelliVue NMT module can keep the calibration values for transport, in case the induction is performed in a separate induction room.

Although it is not mandatory regarding the accuracy of the measurement, we recommend calibrating to determine and apply the individual supramaximal stimulation current for a patient. Calibration also checks and ensures the proper working of the NMT measurement system.

What if there is no time or possibility for calibration? Can I calibrate when a patient is at early in deep relaxation?

No, then simply use the stimulation Current that is manually set. Use the NMT measurement only for qualitative assessment of the muscle relaxation, for example by observing the changing volume height.

If I did not calibrate, can I change the stimulation Current for the current NMT mode?

Yes, you can change the stimulation Current at any time.

Must the NMT cable need be connected to the NMT module to store the calibration values inside the NMT module from one patient monitor to the other?

No, the values are stored in the NMT module itself.

What do I have to consider if I use the TOF measurement for multiple patients during the day?

The stimulation Current and reference twitch are kept stored in the NMT module, even if you admit and discharge your patients.

If you use calibration

Select Clear Reference in the Setup NMT menu, or the pop-up key One-Fell that is accessible if you select the NMT application field.

Select the Confirm key to reset the stored supramaximal stimulation current and the reference twitch to the default values

6

Calibration Issues continued

NMT Cal Failed	The NMT calibration cycle failed. Check that the sensor and the electrodes are placed properly, then start another calibration. Ensure that patient's arm is kept still before and during the calibration cycle. If calibration fails again, replace the patient cable. If INOP persists, contact your service personnel.

7

My monitor was functioning but now I am getting a question mark

Invalid Results

To indicate an invalid measurement result a question mark is displayed instead of a measurement value, for example <?>.

Invalid results may happen if, within 3 seconds before the start of the electrical impulses or during the pattern, **significant** movement of the NMT sensor is detected, which is higher compared to the actual muscle response. Invalid results are **excluded from trends**.

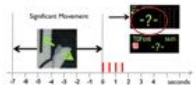


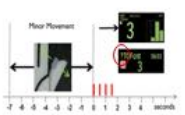
Figure 26 Invalid Result

Another reason for a questionable or an invalid result could be interference caused by electrosurgery.

Questionable Results

To indicate a questionable measurement result a question mark is displayed in front of the NMT measurement label, for example ?TOFcnt.

Questionable results may happen if, within 3 seconds before the start of the electrical impulses, **minor** movement of the NMT sensor is detected. Another reason for questionable results is a very low twitch strength. Questionable results are **included in trends**.



8

Residual Blockade and Its Negative Effects

- Research suggests that residual muscular blockade is present in as much as forty percent of the patient population arriving to PACU after a surgical procedure.
- Postoperative respiratory complications are the second most common postoperative surgical complications (McLean et al., 2015).
- Residual muscular blockade results from inadequate recovery from neuromuscular blocking agents, and is a potential serious patient safety issue.
- Residual muscular blockade can result in
  - Generalized weakness
  - Respiratory depression
  - Airway obstruction
  - Increased risk of aspiration
  - Dysphasia
  - Pneumonia
  - Postoperative respiratory failure (Bedsworth, Hamis, Vacchiana, Thompson, Grant, and Goode, 2019).
- It is a responsibility of the anesthesia provider to ensure patient safety is maintained during surgery.

9

Residual Blockade

- Inadequate reversal or failure to achieve a TOFr > 0.9 results in residual neuromuscular weakness.

10

Neuromuscular Blocking Medications

11

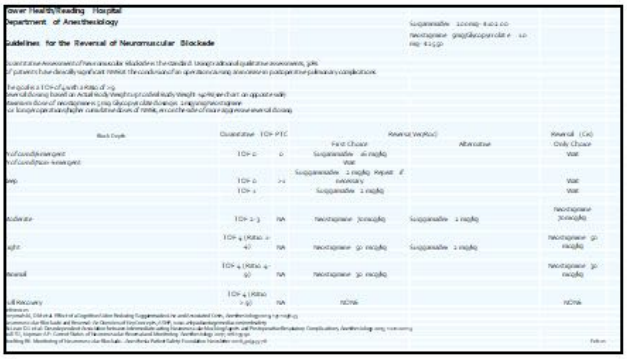
Education Related to the Most Commonly Used Nondepolarizing Muscle Relaxants in Reading Hospital .....

Rocuronium (Zemeron)

- Dose: 0.6-1.2mg/kg
- Onset: 45-90 seconds
- Duration: 30-60 minutes
- Maintenance dosing by bolus: 0.15 mg/kg
- Classified as an intermediate duration relaxant
  - The administration of 0.6mg/kg resulted in T1
    - 10% recovery in within 5 minutes
    - 25% recovery in 5.6 minutes
    - 75% recovery in 6.2 minutes
    - 90% recovery in 6.2 minutes
- Literature suggests aTOFr >0.8 when rocuronium was administered with sevoflurane, isoflurane, and propofol occurred in anywhere from 30.7 minutes to 21.1 minutes.
- Patients with liver or kidney disease will have a prolonged effect.

12

13



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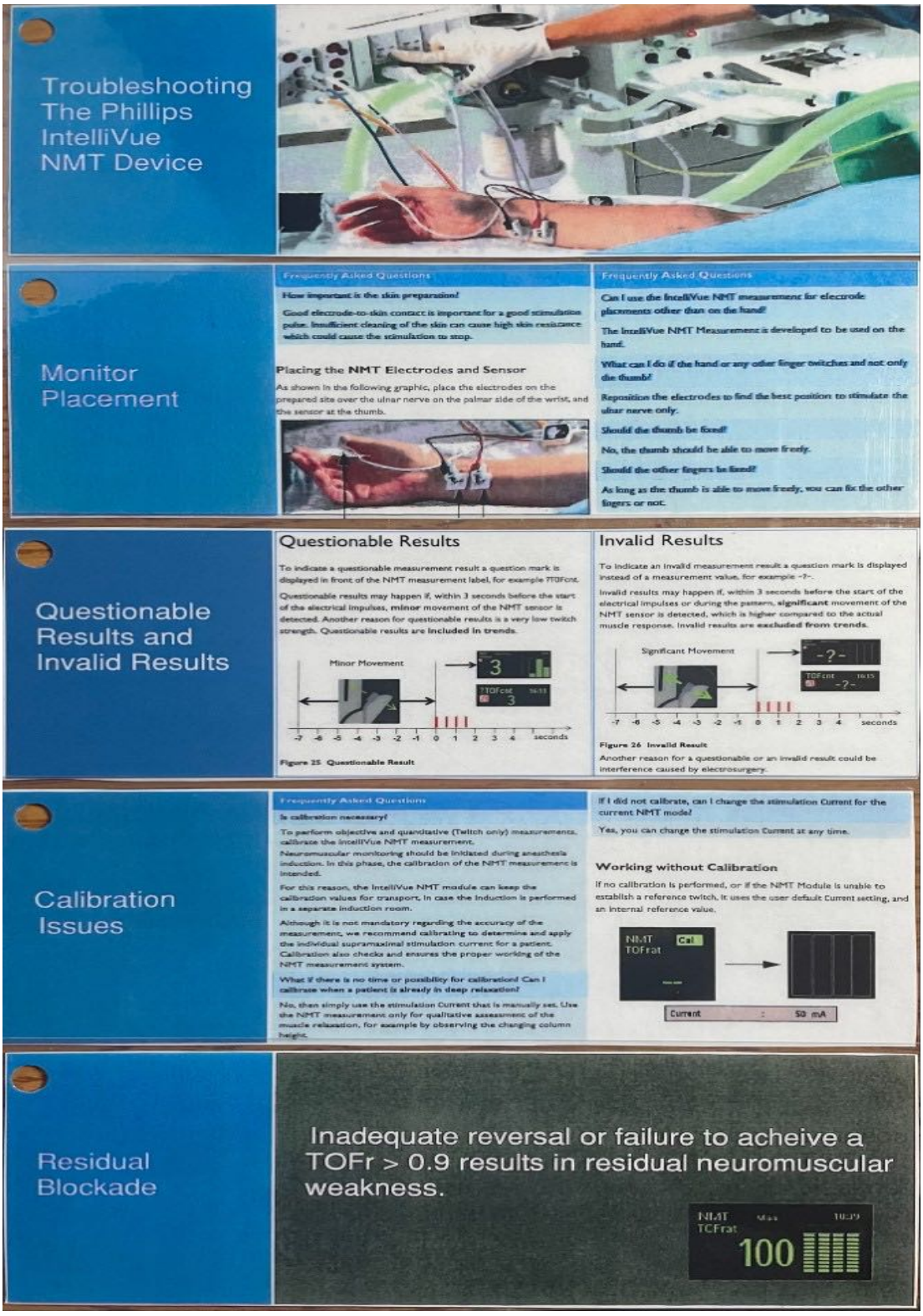
Appendix I

Quick Look Guide



Appendix J

Evaluation Survey

1. What is your primary role?

a. Anesthesiologist

b. Certified Registered Nurse Anesthetist

2. How many years have you been practicing?

a. 0 - 5 years

b. 6 – 10 years

c. 11 – 15 years

d. 16 – 20 years

e. ≥ 21 years

ITEM	Rarely	25% of the time	50% of the time	75% of the time	Always
• **How often have you witnessed negative side effects secondary to residual neuromuscular blockade?**					
• **How often do you find yourself using a quantitative neuromuscular monitoring device in one day?**					
• **How often do you encounter technological difficulties using the quantitative neuromuscular monitoring device in one day?**					
• **Upon calibration of the quantitative neuromuscular monitoring device, how often do you experience a failed calibration or technical difficulties?**					
• **After participation in the education initiative how likely are you willing to change your practice and use the quantitative neuromuscular device in your practice?**					

Appendix K

Poster

CEDAR CREST COLLEGE

An Educational Initiative to Increase Anesthesia Providers Use of Quantitative Neuromuscular Monitoring

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Background

Yearly, 30.8 million patients are administered neuromuscular blocking agents (NMBAs) in the United States (Brull & Kopman, 2017). NMBAs are administered to facilitate endotracheal intubation and provide skeletal muscle relaxation improving patient safety and operating conditions (Naglehout, 2014).

Residual neuromuscular blockade (rNMB) results from inadequate recovery from NMBAs and is a potential serious patient safety issue.

RNMB can result in generalized weakness, respiratory depression, airway obstruction, increased risk of aspiration, dysphasia, pneumonia, and postoperative respiratory failure in the surgical patient (Bedsworth et al., 2019).

Despite an abundance of evidence that postoperative residual weakness is prevalent and exposes patients to significant risk, many anesthesia providers fail to employ adequate quantitative neuromuscular monitoring (QNM) when utilizing nondepolarizing neuromuscular medications.

Objectives

The aim of this project is to increase provider knowledge and overall use of intraoperative QNM through an evidence-based educational session and Quick Look Guide.

The objectives of this project are to close the knowledge gap regarding the use of QNM that exists among providers within this facility that is contributing to the lack of use of the QNM.

PICO Question: In anesthesia providers, does an educational initiative regarding QNM improve the intraoperative use of this technology over a six-week period following the presentation?

Methodology

Databases:
- CINAHL
- MEDLINE
- Ebscohost
- Google Scholar

Search Inclusion Criteria:
- Keywords: residual muscular blockade, quantitative neuromuscular monitoring, nondepolarizing neuromuscular blockers, medications, anesthesia, anesthesia providers, train of four (TOF), peripheral nerve stimulator
- Peer reviewed evidence-based articles
- English language
- 2015-2021

Results:
- 89 articles
- 8 were selected and analyzed
- 5 articles used to support PICO question

Recommendations for Practice

Anesthesia professionals utilizing evidence-based findings in their clinical decision making will provide a safe clinical environment for patients in their care (Lehane et al., 2019).

Expert consensus is that patients receiving NMBAs should receive neuromuscular monitoring with the use of a quantitative TOF monitor (Naguib et al., 2010).

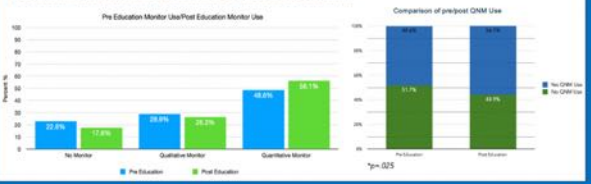
On behalf of The Anesthesia Patient Safety Foundation (APSF),Stoelting (2016) states that, "Residual neuromuscular Blockade in the postoperative period is a patient safety hazard that will ultimately require quantitative monitoring along with traditional subjective observations to eliminate this problem completely."

Evidence-based findings suggest the top three educational deficits related to QNM are as follows:
- Mechanism of action and pharmacology of muscle relaxants.
- Residual muscular blockade and signs of inadequate reversal and its negative effects.
- Use of the quantitative neuromuscular monitoring technology to be used in their current practice to improve patient safety outcomes (Todd et al., 2014).

Todd et al. (2014) suggests that extensive education efforts with repeated feedback can sustain the use of QNM in practice.

Translation

- Education regarding neuromuscular blocking medications, rNMB and its negative effects, and the use of the Philips IntelleVue neuromuscular monitoring technology, was presented face-to-face and was also streamed virtually via Microsoft Teams to anesthesia team members.
- A Quick Look Guide which includes the most pertinent points related to troubleshooting the device was laminated and placed in the operating rooms. The Quick Look Guide serves as a cognitive aid to standardize information and help to facilitate decision-making about common troubleshooting issues related to the QNM.
- Following the educational offering, participants were asked using a 5-point Likert scale (rarely to always) to determine their likelihood to change their practice after completion of the educational initiative. Also, a pre/post educational chart review was obtained to evaluate the use of QNM.



Conclusion

While healthcare costs continue to rise each year, it is imperative for anesthesia providers to deliver safe, evidence-based care to avoid unwarranted negative patient outcomes potentially contributing to increased healthcare costs.

QNM is superior to qualitative monitoring and clinical judgement and is best practice in the clinical setting.

The Quick Look Guide placed in all operating rooms containing troubleshooting tips for the technology was reported by providers to be, "A nice resource that helped troubleshooting."

After the education, 95% of the participants reported they would change their practice and use the QNM in their daily practice.

A chart review indicated an increase in the use of QNM following the educational initiative.

Limitations:
- Convenience sampling
- Small sample size
- Time constraints for educational presentation

Implications for future practice would be to continue yearly education on rNMB and the use of QNM device.

References