Neuromuscular Blockade Monitoring: Qualitative Versus Quantitative

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Abstract

Anesthesia providers primarily utilize peripheral nerve stimulators (PNS) to monitor train-of-four count to assess neuromuscular function in surgical cases where akinesia is desired by neuromuscular blocking medications. As current studies show, there is a discrepancy between the use of qualitative measurements and quantitative values. When anesthesia providers solely utilize qualitative peripheral nerve stimulator count measurements, such as train-of-four, an over or underestimation of neuromuscular blockade depth can result, contributing to post-operative residual muscle weakness. The goal of this project was to increase the knowledge base of a group of student nurse anesthetists at the Adventist University of Health Sciences on qualitative versus quantitative measures in neuromuscular blockade monitoring, while identifying the superiority of quantitative monitoring. The project was implemented by evaluating student baseline of neuromuscular blockade monitoring knowledge with a pre-test, then presenting a Microsoft PowerPoint on evidence-based research and then administering a post-test. The forms were collected and the data was analyzed utilizing a paired sample t-test for statistical analysis to compare the mean scores and evaluate for an increase in knowledge base in the post-tests as compared to the pre-tests. Based on the results, it can be concluded that the mean test scores increased significantly between the two tests, indicating that the PowerPoint presentation was effective in increasing the knowledge base of the study participants. The increase in mean scores from the pretest to the post-test was 37%. The obtained t value is -10.499 ($p < .001$).

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Introduction/Problem Statement

Neuromuscular blockade is medically and surgically indicated for a wide variety of procedures and operations throughout the realms of surgery and medicine. There are levels of neuromuscular blockade depth, dependent on the dose administered, patient volume of distribution, comorbidities and gene mutations. Subsequently, the level of blockade must be monitored to maintain an ideal plane of akinesia and muscle relaxation, as well as for its reversal, to allow the body to return to independent functioning when these aspects of muscle relaxation are no longer needed. For these reasons, it is important to identify best practices in neuromuscular blockade monitoring in terms of qualitative versus quantitative measures. Quantitative monitoring utilizes electromyography to measure very fine movements when muscle twitching is elicited to evaluate the depth of muscle relaxation. These fine movements are measured by a special PNS, which evaluates the percentage of muscle relaxation and displays a ratio to the provider. The use of a quantitative neuromuscular monitoring takes the subjectivity away from the human evaluation of the elicited muscle twitches by individual anesthesia providers utilizing qualitative monitoring devices.

Peripheral nerve stimulators (PNS) are used to monitor the degree of neuromuscular blockade. Practitioners commonly measure a train-of-four (TOF) count or double-burst stimulation to determine the level of neuromuscular blockade. The TOF count is conventionally measured by the anesthesia provider’s judgment, utilizing visual and tactile methods. A nerve stimulator generates impulses and the twitch count is resulted wherever the provider has chosen to evaluate the count, such as the adductor pollicis muscle or orbicularis oculi muscle. As the muscle blockade becomes deeper, fewer twitch counts are displayed. With continually improving technology, research has shifted to suggest that quantitative measurements supersede the conventional qualitative measurements. However, not every institution has adopted this practice, including the U.S. Anesthesia Partners (USAP) of Florida.

From differences in clinical experience and literature reviews, questions emerge. Are providers properly monitoring train-of-four to situate positive post-operative outcomes? In adult patients who have been administered non-depolarizing neuromuscular blocking agents, how does qualitative versus quantitative analysis affect postoperative outcomes? Does a PowerPoint presentation on qualitative versus quantitative neuromuscular monitoring to Adventist University of Health Sciences student registered nurse anesthetists increase their knowledge base as evidenced by higher mean posttest scores compared to mean pre-test scores?

Literature Review and Synthesis

Monitoring the level of neuromuscular blockade can be assessed via qualitative or quantitative measurements. With qualitative monitoring, the strength of the evoked potential generated by a nerve stimulator is determined by the provider either visually or by tactile feel. Quantitative monitoring is employed utilizing various technological advances, such as mechanomyography, kinemyography, electromyography (EMG) and acceleromyography (AMG). These devices display a train-of-four ratio (TOFR) to the provider after the evoked potential is generated and is measured objectively. Therefore, quantitative monitoring gives a more accurate account of the degree of blockade. The current standard of practice for an adequate recovery of muscle strength is a TOFR of at least 0.9, measured at the adductor pollicis muscle (Lien and Kopman, 2014). To obtain this measurement via a qualitative assessment of sight and tactile feel is difficult and entirely subjective. Residual neuromuscular blockade after reversal is a common occurrence and is associated with various post-operative pulmonary complications, including hypoxia, aspiration and atelectasis, as well as a decrease in patient satisfaction (Lien & Kopman, 2014; Murphy et al., 2011). Providers must know and remember that neuromuscular blockade is a crucial factor in patient satisfaction after anesthesia (Lien & Kopman, 2014; Murphy et al., 2011). Therefore, performing the best practices in neuromuscular blockade monitoring is important in dosing the appropriate amounts of neuromuscular blocking agents and anticholinesterases to facilitate recovery of muscle strength and guarantee adequate pharyngeal muscle functioning after tracheal extubation.

The reported incidence of postoperative residual neuromuscular blockade with a TOFR less than 0.9 where quantitative monitoring was not utilized is approximately 25-30% and noted to be as high as 64% (Lien and Kopman, 2014; Murphy, et al., 2011). It is additionally reported that 10-15% of these patients are taken to the post-operative anesthesia care unit (PACU) with a TOFR less than 0.7 (Lien and Kopman, 2014). Research has also shown, that once the TOFR reaches a value of 0.4, many practitioners are unable to detect the presence of faded twitches on TOF counts utilizing the limited qualitative method of assessment, regardless of the individual's clinical experience (Bhananker et al., 2015; Lien and Kopman, 2014; Welliver et al. 2015). This poses an issue when considering proper effectiveness of the administration of neuromuscular blocking agents during the intraoperative period. The use of visual qualitative estimation of TOF may be over or under estimated based on the individual clinician's assessment. With inappropriate monitoring of neuromuscular blockade and subsequent decisions made on reversal agents, post-operative complications are bound to occur. Therefore, use of acceleromyography by anesthesia providers can decrease the occurrence of residual paralysis with the use of paralytic drugs during the intraoperative period (Lien and Kopman, 2014; Murphy et al., 2011). This notion limits the incidence of postoperative muscle weakness during recovery. Overall, the use of quantitative monitoring is superior to qualitative methods and takes the individual subjectivity and guesswork out of the equation. Quantitative monitors provide better guidance for titration of non-depolarizing neuromuscular blocking agents, the best timing for tracheal extubation and when anticholinesterases should or should not be administered, as they do not come without undesirable side effects. These implications and effects play an important role in post-operative outcomes.

Statistical information shows that patients in which acceleromyography devices are utilized are less likely to exhibit neuromuscular blockade residual than if a qualitative peripheral nerve stimulator is used (Murphy, Szokol, Avram, Greenberg, Marymont, Vender, Grady, Landry & Gupta, 2011). The implementation of an acceleromyography device provides positive benefits and decreases the undesirable symptoms of lingering paralysis during the period of recovery from anesthesia (Murphy et al., 2011; Weilliver, Murphy, Kopman & Brull, 2015). During the immediate postoperative period, it is extremely important that the patient has optimal muscle strength. Contrary to popular belief among anesthesia providers, modern evidence is suggesting that residual blockade after the administration of paralytics does impair clinical recovery (Murphy et al., 2011). Residual blockade can be described as any level of neuromuscular blockade that is present after the completion of anesthesia and tracheal extubation (Weilliver, Murphy, Kopman & Brull, 2015).

Harmful respiratory events associated with TOF ratios less than 0.9 include decreased respiratory upper airway volume, airway obstruction and hypoxemia, along with increases in cost related to major delays in PACU discharge (Lien and Kopman, 2014; Murphy et al. 2011). These negative respiratory outcomes greatly impact the patients and the anesthesia practice overall. One benefit of using a quantitative method of assessment is that small amounts of residual blockade can be accurately detected. This aids the anesthesia provider in the precise monitoring of intraoperative TOF ratios, which can minimize the prevalence of residual blockade in the PACU (Murphy et al., 2011).

Residual neuromuscular blockade, such as a patient with a TOFR of 0.7-0.8, is also coupled with negative effects like dysphagia, dysarthria, diplopia and blurred vision (Murphy et al., 2011). Visual complications and generalized fatigue may even be prevalent at a TOFR of 0.85-0.9 (Murphy et al., 2011; Welliver et al., (2015). These symptoms of systemic muscle insufficiency associated with residual neuromuscular blockade should be abated as much as possible with the appropriate neuromuscular blockade monitoring system. Since a higher TOFR can still be associated with a significant number of junctional receptors occupied by the neuromuscular blocking agents, muscular blockade must be adequately and correctly assessed. With quantitative monitoring, a specifically calculated TOFR is provided to the provider, without subjectivity and with a more appropriate evaluation of neuromuscular blockade. Therefore, quantitative measuring devices are superior to the qualitative ways of assessing muscular blockade.

Research has shown that provider TOF counts are statistically noted to be higher than a quantitative form of measurement when measured at the same time interval (Bhananker, S., Treggiari, M., Sellers, B., Cain, K., Ramaiah, R., & Thilen, S., 2015). The percentage disparities of over and under estimation of TOF counts judged by providers versus quantitative measurements are significant (Bhananker et al., 2015). It has been shown that some anesthesia providers have reported a TOF count of two twitches 4.5 minutes earlier, with an interval of greater than 10 minutes in approximately 15% of measurements, compared to a quantitative nerve stimulator named the TOF-Watch SX (Bhananker et al., 2015). Therefore, subjective measurements provided by anesthesia providers utilizing qualitative PNS and TOF count greatly overestimated at different time intervals than actual intrinsic muscle function. With a quantitative measurement, the result is measured objectively, consistently and much more accurately (Bhananker et al., 2015).

It is common for anesthesia providers to assess a higher TOF count utilizing visual and tactile techniques with qualitative monitoring compared with quantitative monitors, especially during intermediate levels of blockade depth (Bhananker et al., 2015; Lien and Kopman, 2014; Murphy, et al., 2011). There is reasonable argument that when the TOF count is more extreme, as in twitch counts of 0 or 4, the qualitative and quantitative measurement methods are more in agreement. However, anesthesia providers are typically unable to discern fade on TOF count compared to the TOF-Watch SX (Bhananker, 2015). This data supports the notion that subjective overestimation of TOF counts and subsequent depth of neuromuscular blockade is an issue of common occurrence.

It is important to remember that the timing and dosage of neuromuscular blockade reversal agents are determined by the TOF count. Subjective overestimation of TOF count may result in inadequate dosing of anticholinesterases and contribute to residual muscle weakness or paralysis in the post-anesthesia care unit. It has been shown that 20 minutes after a full reversal dose of neostigmine with a TOF count of 4, the incidence of post-operative residual weakness was 27%, with an increase to 56% when neostigmine was administered at a TOF count of 2 instead of 4 (Kirkegaard et al., 2002). This data can also be applied to the use of sugammadex, as it’s dosing guidelines are also contingent on the observed or reported TOF count. It is important to remember and note that the experience level of the anesthesia provider has no implication on the subjective ability to more accurately assess TOF count utilizing a PNS (Bhananker et al., 2015; Lien and Kopman, 2014).

It is important to establish evidence-based suggestions for the anesthesia industry to improve the overall monitoring conditions of neuromuscular function after paralytic medication administration and the recording of findings. Many experts believe quantitative monitoring is the gold standard to decrease residual muscles weakness related to intraoperative paralysis before tracheal extubation (Motamed, Bourgain & D'Hollander, 2013). Kinemyographic monitoring is described as a device in which a small flexible item is placed on the thumb that detects movement once the forefinger is impaired (Motamed et al., 2013). These suggestions include proper arm and hand position to accurately support the kinemyographic transducer, akinesia during reference time, place specific protection from thumb movement and automatic equipment calibration. Proper equipment usage is imperative to provide appropriate patient management and treatment. During equipment malfunction, the provider must acknowledge failure and treat based on other clinical findings. The sole use of a quantitative monitoring device without meeting any further criteria for extubation might not be the best practice for patient safety. It is important to note current quantitative monitoring practices and engage in appropriate use of the equipment to lead to exceptional patient care.

The Anesthesia Association of Nurse Anesthetists standard of care number 5 states that the use of a neuromuscular monitoring device is necessary when paralytics are administered to patients (Welliver, Murphy, Kopman, Brull, 2015). Despite being a standard of care, recent studies have identified that the use of these monitors, qualitative and quantitative, are inconsistent in some practices. The most commonly used monitoring equipment is a PNS, which generates a qualitative result. A large limitation to the use of a PNS is the subjective data that it provides the clinician. As stated, when the TOF ratio goes beyond 0.4, many anesthesia providers cannot distinguish the presence of twitch fade (Bhananker et al., 2015; Lien and

Kopman, 2014; Welliver et al. 2015). It has been identified that with the use of PNS devices, the more reliable modes to assess the neuromuscular function is the double burst stimulation and sustained tetany functions. The fact that there are deemed more reliable settings in which neuromuscular monitoring can be assessed qualitatively speaks to the subjectivity of the results between various practitioners. This again leads to the conclusion that a form of quantitative monitoring is superior.

Current clinical practices observed at USAP of Florida sites include the use of a qualitative PNS device when neuromuscular blocking agents are administered. However, it has been observed that there is provider discrepancy with PNS monitoring and the validity of results. The use of accelerometry/kinemyography provides a solution to distinguish fade and eliminate PNS limitations (Welliver et al., 2015). More accurate determination of neuromuscular function to provide safer care intraoperatively and postoepratively for patients undergoing anesthesia is of the utmost importance. The suggested change in the current method of assessment is the use of the accelerometry and kinemyography devices. With these quantitative devices, TOF ratios measured at the ulnar nerve are more consistent and dependable.

Acceleromyography is capable of quantifying moderate to deep levels of paralysis, which may be indistinguishable with the PNS value (Welliver et al., 2015). With the use of a quantitative method, the practitioner can titrate paralytic drugs based on reliable, scientific results. The margin of error based on visual and tactile subjective data would then be eliminated. Additionally, literature states that the older reversal agents are unable to reverse a profound blockade (TOF count of 0) (Bhananker et al., 2015; Welliver et al. 2015). Therefore, improved monitoring techniques could guide clinicians when administering and reversing paralytic agents. Based on literature reviews, incorporating kinemyogrpahy or accelerometry devices into current anesthesia practice across the country may lead to decreased postoperative respiratory complications and improved patient outcomes (Lien and Kopman, 2014; Murphy et al., 2011).

Contribution and Dissemination/Justification

This project contributes to provider awareness of best practices in neuromuscular blockade monitoring by providing evidence-based research and identifying how quantitative measurement data may positively affect post-operative patient outcomes. The USAP of Florida anesthesia providers practice at various Florida Hospitals across the state. These institutions currently practice neuromuscular monitoring by qualitative measurement devices, mainly a PNS. Therefore, student registered nurse anesthetists at the Adventist University of Health Sciences historically have limited knowledge regarding quantitative neuromuscular monitoring. Since no quantitative neuromuscular blockade monitors are available at the Florida Hospital sites, nurse anesthesia students have had no exposure to this type of advanced monitoring. By utilizing these students as the target population, they have received exposure to neuromuscular blocking agents with a PNS and the difficulties in interpretations of neuromuscular blockade depth utilizing only qualitative measurements. With this timeframe of project dissemination, it allowed for evaluation of newer, unbiased anesthesia providers who have not had the opportunity to compare qualitative and quantitative forms of measurement. Educating these providers has provided the possibility for enhancement of individual practices.

Project Aims

The primary goal of this project was to increase the knowledge base of Adventist University of Health Sciences student nurse anesthetists as it pertains to quantitative neuromuscular monitoring and the implications for utilizing advanced, evidence-based practices. The secondary goal was to increase the knowledge base of the anesthetic, perioperative and postoperative implications for neuromuscular blockade monitoring. These goals were directed towards 50 student registered nurse anesthetists in the cohorts of 2018 and 2019 at the Adventist University of Health Sciences, implemented on December 14th, 2017. The content measured included knowledge of TOF ratios and subsequent implications, knowledge regarding the comparison of qualitative and quantitative forms of neuromuscular monitoring and how to implement best practices with the devices available in the clinical setting. This content was assessed first as individual baseline knowledge in the form of pre-tests and then reevaluated with a duplicate posttest after a PowerPoint presentation. The independent variable identified is the developed PowerPoint presentation, while the dependent variable is the difference between the mean pre-test and mean posttest scores. It was projected, that after receiving the PowerPoint presentation on neuromuscular blockade monitoring, the mean posttest scores would increase, indicating that the presentation was effective in increasing the participants knowledge base.

Project Methods

This study is a quantitative design. A convenience sample method was for participant selection. The project was implemented utilizing a presentation created in Microsoft PowerPoint and presented to the Nurse Anesthesia Program (NAP) cohorts of 2018 and 2019 during one of the courses in the Fall of 2017. The cohort included 50 students. Inclusion criteria was selective to students currently enrolled in the 2018 and 2019 NAP cohorts at the time of the presentation. The Scientific Review Committee (SRC) and Institutional Review Board (IRB) approval was obtained prior to the implementation of the study. Informed consent was obtained, then a 10-question pre-test assessment of their baseline knowledge of neuromuscular blockade monitoring was administered. After the PowerPoint presentation, a posttest, duplicate of the pre-test, was administered. No names were identified on the assessments, but each participant's pretest matched a subsequent posttest via a designated numbering system for evaluation.

Only the authors of this study, Cierra Byrne and Lauren Sarmiento, as well as the statistical analyst, have access to this data. The collected data is now destroyed via crosscut shredding project since the project, data retrieval and SRC/IRB approval is now finished.

Timeline

The capstone project was completed on December 14th, 2017 during the required clinical conference class. In Spring 2018, the authors will develop an electronic PowerPoint version of the proposed poster of the project by March 9, 2018. The poster will then be printed once finalized and approved by the Project Chair, Dr. Steven Fowler. The final project poster will be created and ready to present to the faculty during capstone project presentations. An electronic copy of the complete final Scholarly Project paper (including all Appendices) and final Scholarly Poster will be submitted to Neal Smith in the ADU library by April 9, 2018. On April 9, 2018, scholarly project poster presentations will take place in the ADU Graduate building.

Data Collection

Data was collected via written pre-tests and posttests completed by the NAP cohort participants. The pre-test and posttest were utilized as the research instrument to gather the information and consisted of 10 multiple-choice questions. The questions assessed the knowledge base of TOF ratios, qualitative versus quantitative assessments, best practices and provider implications. The questions were generated from evidence-based practices and research found in the literature review. The pre-test and posttest were administered to each individual participant and completed on the day of the project implementation. The data was collected by the study designers, Cierra Byrne and Lauren Sarmiento. The pre-test papers were collected prior to the PowerPoint presentation and the posttest papers collected after the presentation implementation. The informed consents were collected in the same manner, prior to administration of the pre-test. The data was collected on the same day as the PowerPoint presentation, and this was the only exchange with the participants.

Evaluation

This scholarly project was evaluated via a comparison in test scores from the pre-tests to the posttests. This was done to evaluate the efficacy of the PowerPoint presentation. The data was then entered into Microsoft Excel on Lauren Sarmiento's personal laptop and sent for statistical analysis. Dr. Lukman (Adventist University of Health Sciences statistician) conducted the data analysis (See Appendix D). The Statistical Package for the Social Sciences (SPSS) is the computer programing that was utilized for analysis.

Results/Findings

The paired samples t test was conducted to analyze the data for a difference of means between pre-test and post-test. The mean pretest scores were 39%, with a standard deviation of 15% and the mean post-test scores were 74%, with a standard deviation of 18%. The increase in mean scores from the pretest to the post-test was 37%. The obtained t value is -10.499 ($p < .001$). The average scores increased comparatively between the pre-tests and the posttests and the data was statistically significant with a confidence interval of 95% and p value < 0.05 (See Appendix D).

Conclusions

The average scores increased comparatively between the pre-tests and the posttests and the data was statistically significant with a confidence interval of 95% and p value < 0.05. This means that the presentation was effective in increasing the knowledge base of the participants.

The goal of this study was effectively achieved, as evidenced by the significant increase in mean post-test scores. The obtained t value is -10.499 ($p < .001$) which is statistically significant (See Appendix D). Since a statistical significance was found, it can be concluded that the PowerPoint presentation was effective in increasing the knowledge base of the participants. The goal was the study was achieved.

Limitations

Firstly, the target population was a small, convenience sample of 41 student registered nurse anesthetists at a single University. Only 41 students participated in the study due to absences resulting from unplanned circumstances. None of the 41 students who were present were late, therefore, each student indeed did sign the informed consent and none of the 41 were excluded from the study. In addition, the participants and presenters had received education in the same schooling system. Therefore, the baseline knowledge was anticipated to be homogenous. Secondly, the target population, as well as the presenters, have only had the opportunity to utilize qualitative TOF measurements via a PNS for assessing neuromuscular blockade in the clinical setting. Finally, the participants were exposed to an educational lecture by faculty on quantitative neuromuscular monitoring prior to this study, which may have influenced their baseline knowledge and subsequently, the study results.

References

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Appendix A

ADU NAP CAPSTONE PROJECT – INFORMED CONSENT

Our names are Cierra Byrne and Lauren Sarmiento, and we are MSNA students in the Nurse Anesthesia Program (NAP) at Adventist University of Health Sciences (ADU). We are doing a Capstone Project called *Neuromuscular Blockade Monitoring: Qualitative Versus Quantitative*. This project is being supervised by Dr. Steven Fowler. We would like to invite you to participate in this project. The main purpose of this form is to provide information about the project so you can make a decision about whether you want to participate.

WHAT IS THE PROJECT ABOUT?

The purpose of this project is to increase the knowledge of a specific targeted population about qualitative versus quantitative measures in neuromuscular blockade monitoring, while identifying the superiority of quantitative monitoring. By increasing the knowledge regarding quantitative measurements, a change in individual practices can be implemented and geared toward evidence-based and best practices.

WHAT DOES PARTICIPATION IN THIS PROJECT INVOLVE?

If you decide to participate in this project, you will be asked to complete an anonymous pre-test, attend a classroom presentation, and then complete an anonymous posttest. The assessment will address neuromuscular blockade monitoring, train-of-four ratios, qualitative versus quantitative assessments, best practices and provider implications. These questions will be generated from evidence-based practices found in a literature review conducted by the Capstone Project authors. Your participation by attendance at the presentation and completion of the pre-test and posttest is anticipated to take approximately one hour.

WHY ARE YOU BEING ASKED TO PARTICIPATE?

You have been invited to participate as part of a convenience sample of students currently enrolled in the ADU NAP. Participation in this project is voluntary. If you choose not to participate or to withdraw from the project, you may do so at any time.

WHAT ARE THE RISKS INVOLVED IN THIS PROJECT?

Although no project is completely risk-free, we don’t anticipate that you will be harmed or distressed by participating in this project.

ARE THERE ANY BENEFITS TO PARTICIPATION?

We don't expect any direct benefits to you from participation in this project. The possible indirect benefit of participation in the project is the opportunity to gain additional knowledge about qualitative and quantitative measuring practices in neuromuscular blockade monitoring.

HOW WILL THE INVESTIGATORS PROTECT PARTICIPANTS' CONFIDENTIALITY?

The results of the project will be disseminated, but your name or identity will not be revealed. To maintain confidentiality of assessments, the investigators will conduct this project in such a way to ensure that information is submitted without participants' identification. No names will be identified on the assessments, but each participant's pretest will match a subsequent posttest via a designated numbering system for evaluation. The data will then be entered into Microsoft Excel on the authors' personal laptop and sent for statistical analysis. Only the authors of this study, Cierra Byrne and Lauren Sarmiento, as well as the statistical analyst, will have access to this data. Once the data is compiled and the project is completed, no part of the study will be changed and the collected data will be destroyed via cross-cut shredding. Thus, the investigators will not have access to any participants' identities.

WILL IT COST ANYTHING OR WILL I GET PAID TO PARTICIPATE IN THE PROJECT?

Your participation will cost approximately one hour of your time, but will require no monetary cost on your part. You will not be paid to participate.

VOLUNTARY CONSENT

By signing this form, you are saying that you have read this form, you understand the risks and benefits of this project, and you know what you are being asked to do. The investigators will be happy to answer any questions you have about the project. If you have any questions, Cierra Byrne at Cierra.bryne@my.adu.edu or Lauren Sarmiento at Lauren.sarmiento@my.adu.edu. If you have concerns about the project process or the investigators, please contact the Nurse Anesthesia Program at (407) 303-9331.

____ **Date** _______________

Participant Signature/ Participant Name (PRINTED LEGIBLY)

_______________________________________ **Participant Name (PRINTED LEGIBLY)**

Appendix B

Pre-and Posttest Questions

Bold = Correct Answer

1. The current standard of practice suggests that for adequate muscular recovery after the administration of neuromuscular blocking agents, peripheral nerve stimulation should be monitored at which muscle?
    a. first dorsal interosseous muscle (ulnar nerve)
    b. **adductor pollicis muscle (ulnar nerve)**
    c. abductor digiti minimi muscle (ulnar nerve)
    d. orbicularis oculi muscle (facial nerve)
2. Which of the following anesthesia providers are better able to detect fade on train-of-four?
    a. Student registered nurse anesthetist
    b. Experienced CRNA
    c. New CRNA
    d. **None of the above**
3. Which of the following complications **is not** associated with a TOF ratio <0.9?
    a. decreased respiratory upper airway volume

   b. **decreased respiratory lower airway volume**
   c. decreased patient satisfaction
   d. diplopia

4. A patient has undergone a laparoscopic cholecystectomy and it is now time to reverse the nondepolarizing neuromuscular blocking agent and emerge the patient from anesthesia. The nurse anesthetist assesses the train-of-four count and administers the appropriate dose of neostigmine based on the twitches he/she observes. Based on current studies, which of the following is true?
   a. TOF 4 and neostigmine administered: <10% residual muscle weakness may still be prevalent
   b. **TOF 4 and neostigmine administered: 25% residual muscle weakness may still be prevalent**
   c. TOF 2 and neostigmine administered: 40% residual muscle weakness may still be prevalent
   d. TOF 2 and neostigmine administered: <20% residual muscle weakness may still be present
5. At which train-of-four ratio are providers likely to be unable to discern fade on train-of-four?
   a. **0.4**
   b. 0.5
   c. 0.6
   d. 0.7
6. Which of the following statements are incorrect?

   a. **Quantitative TOF monitoring may solely be relied on for criteria for extubation**
   b. Quantitative TOF monitoring should be combined with other clinical indicators for extubation parameters
   c. Quantitative monitoring is considered the gold standard for TOF assessment by many providers
   d. Quantitative monitoring is underutilized compared to qualitative monitoring

7. With the use of qualitative peripheral nerve stimulator devices, which of the following is the most reliable mode to assess neuromuscular function?
   a. **Double burst stimulation**
   b. Train-of-four
   c. Twitch
   d. Post-tetanic count

8. Which of the following statements is true?
   a. Qualitative monitoring is objective
   b. Quantitative monitoring is subjective
   c. **Quantitative monitoring is objective**
   d. Quantitative neuromuscular monitoring is based on non-numerical data

9. Which of the following **is not** a quantitative neuromuscular monitoring device?
   a. mechanomyography
   b. **dynamyography**
   c. electromyography (EMG)

d. acceleromyography (AMG)

10. Which of the following statements is true regarding qualitative and quantitative nerve stimulators?

    a. **They are likely to reflect an agreement in TOF when the TOF count is considered extreme**

    b. They are likely to reflect an agreement in TOF when the TOF count is at an intermediate level

    c. They are likely to reflect an agreement in TOF at all levels of neuromuscular blockade

    d. They never reflect an agreement in twitch count and TOF ratios

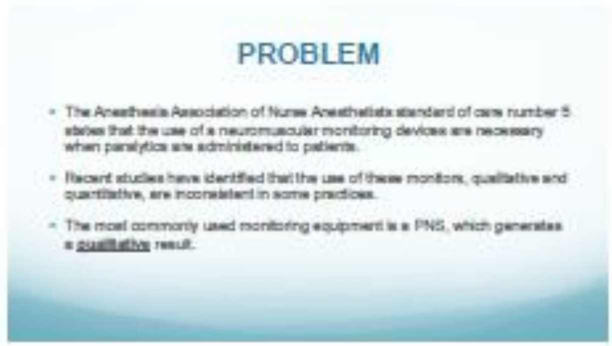
Appendix C

PowerPoint Presentation


Neuromuscular Blockade Monitoring: Qualitative Versus Quantitative


OBJECTIVES
Define quantitative versus qualitative neuromuscular blockade monitoring
Identify best practices in neuromuscular blockade monitoring
Identify misconceptions
Identify the superiority of quantitative monitoring
To provide quantitative monitoring education to Adventist University Nurse Anesthesia students

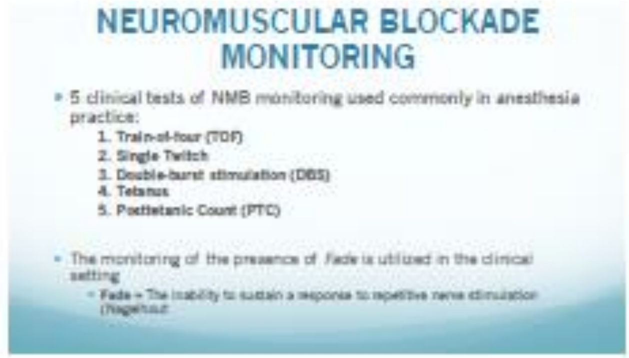

TERMS
TOF: Train-Of-Four
TOFR: Train-Of-Four Ratio
PNS: Peripheral Nerve Stimulator
PACU: Post-Anesthesia Care Unit
NMBD: Neuromuscular Blocking Drugs


PROBLEM
The Anesthesia Association of Nurse Anesthetists standard of care number 5 states that the use of a neuromuscular monitoring devices are necessary when paralytics are administered to patients.
Recent studies have identified that the use of these monitors, qualitative and quantitative, are inconsistent in some practices.
The most commonly used monitoring equipment is a PNS, which generates a qualitative result.

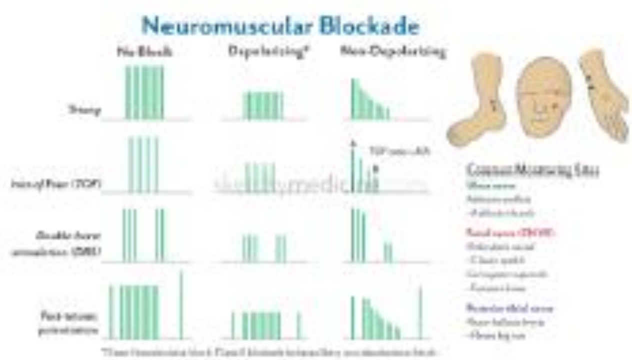

PROBLEM
There is a discrepancy between the use of qualitative measurements and quantitative values.
With qualitative PNS count measurements, an over or underestimation of neuromuscular blockade depth can result.
→Qualitative measurements are suggested to contribute to post-operative respiratory dysfunction, an increased risk of aspiration, and a decrease in patient satisfaction.
Research has shifted to suggest that quantitative measurements supersede the conventional qualitative measurements. However, it is underutilized in practice.

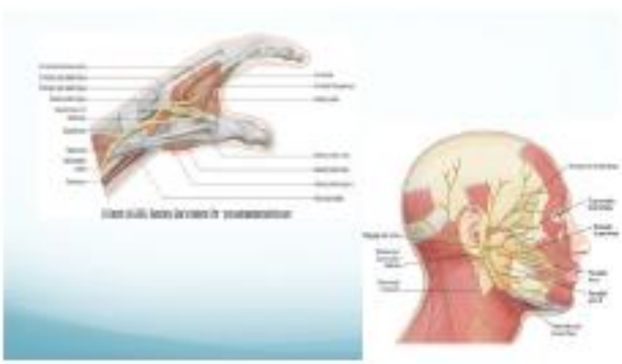

NEUROMUSCULAR BLOCKADE MEDICATION REVIEW
Depolarizing NMB (Agonist)
Succinylcholine
Mimics the action of acetylcholine at the motor endplate
Metabolized: Plasma Cholinesterase (Pseudocholinesterase)
Block: Phase I (can produce a phase II block with large doses)
Nondepolarizing NMB (Antagonist)
Rocuronium, Vecuronium, Pancuronium, Cisatracurium, & Atracurium
Prevents access of Ach to neuromuscular receptor and prevents depolarization at motor endplate
Block: Phase II block


Phase I Block
Muscle fasciculation present
Sustained tetany
Absence of posttetanic potentiation, stimulation, or facilitation
Lack of fade to tetanus, TOF, or DBS
Block potentiated by anticholinesterase drugs
Block antagonized by prior administration of nondepolarizer as pretreatment
Phase II Block
No muscle fasciculation present
Appearance of tetanic fade and posttetanic stimulation
TOF and DBS fade
Reversal with anticholinesterase drugs
Succinylcholine doses greater than 6 mg/kg


NEUROMUSCULAR BLOCKADE MONITORING
5 clinical tests of NMB monitoring used commonly in anesthesia practice:
1. Train-of-four (TOF)
2. Single Twitch
3. Double-burst stimulation (DBS)
4. Tetanus
5. Posttetanic Count (PTC)
The monitoring of the presence of Fade is utilized in the clinical setting
Fade = The inability to sustain a response to repetitive nerve stimulation


COMMON QUALITATIVE NEUROMUSCULAR MONITORING TESTS


Neuromuscular Blockade
No Block
Depolarizing
Non-Depolarizing
Train-of-Four (TOF)
Double-burst stimulation (DBS)
Post-tetanic potentiation
Common Monitoring Sites




BACKGROUND
Quantitative monitoring
Utilizes electromyography to measure fine movements
Evaluates the percentage of muscle relaxation & displays a ratio
Removes the subjectivity of human evaluation
Qualitative monitoring
The strength of evoked potentials are determined by the provider either visually or by tactile feel
Commonly measured by TOF count or double-burst stimulation

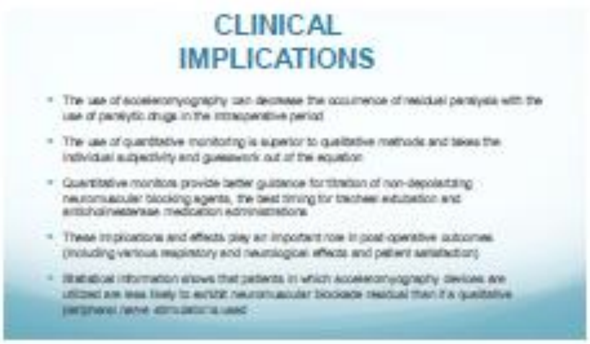

QUALITATIVE
MONITORING


QUANITATIVE
MONITORING
Quantitative monitoring gives a more accurate account of the degree of blockade.


TOFR <0.9
COMPLICATIONS
Residual neuromuscular blockade after reversal is a common occurrence
TOFR < 0.9 is associated with:


TOFR <0.9
COMPLICATIONS
TOFR less than 0.9 where quantitative monitoring was not utilized is approximately 25-30% (noted to be as high as 64%)

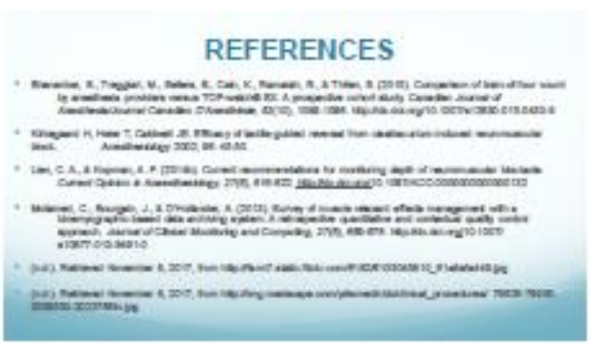

MISCONCEPTIONS
FALSE
FALSE

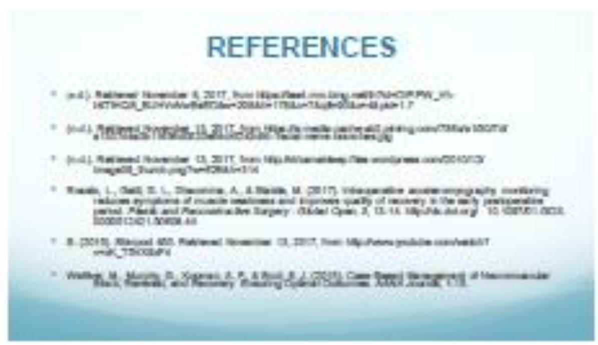

CLINICAL IMPLICATIONS
The use of acceleromyography can decrease the occurrence of residual paralysis with the use of paralytic drugs in the intraoperative period
The use of quantitative monitoring is superior to qualitative methods and takes the individual subjectivity and guesswork out of the equation
Quantitative monitors provide better guidance for titration of non-depolarizing neuromuscular blocking agents, the best timing for tracheal extubation and anticholinesterase medication administrations
These implications and effects play an important role in post-operative outcomes (including various respiratory and neurological effects and patient satisfaction)
Statistical information shows that patients in which acceleromyography devices are utilized are less likely to exhibit neuromuscular blockade residual than if a qualitative peripheral nerve stimulator is used


CONCLUSION
Subjective overestimation of TOF counts and subsequent depth of neuromuscular blockade is an issue of common occurrence
Subjective overestimation of TOF count may result in inadequate dosing of anticholinesterases and contribute to residual muscle weakness in the PACU
It is important to remember that the experience level of the anesthesia provider has no implication on the subjective ability to more accurately assess TOF count utilizing a PNS
Many experts believe quantitative monitoring is the gold standard to decrease residual muscle weakness related to intraoperative paralysis before tracheal extubation


VIDEO DEMONSTRATION
http://www.youtube.com/watch?v=K_T5VX9oF4


QUESTIONS?


REFERENCES


REFERENCES

Appendix D

Student #	# Correct Out of 10 (Pre)	% Correct (Pre)	# Correct Out of 10 (Post)	% Correct (post)
1	3	30%	10	100%
2	4	40%	7	70%
3	1	10%	7	70%
4	4	40%	7	70%
5	2	20%	10	100%
6	1	10%	9	90%
7	4	40%	7	70%
8	3	30%	9	90%
9	5	50%	7	70%
10	4	40%	8	80%
11	5	50%	7	70%
[redacted]				
13	5	50%	6	60%
14	4	40%	6	60%
[redacted]				
16	2	20%	3	30%
17	3	30%	4	40%
18	5	50%	7	70%
19	6	60%	10	100%
20	2	20%	6	60%
21	4	40%	6	60%
22	5	50%	5	50%
23	2	20%	5	50%
24	3	30%	5	50%
25	3	30%	8	80%
26	5	50%	9	90%
27	2	20%	9	90%
28	4	40%	9	90%
29	1	10%	10	100%
30	2	20%	9	90%
[redacted]				
33	5	50%	10	100%
34	6	60%	9	90%
35	5	50%	8	80%
36	5	50%	9	90%
37	5	50%	8	80%
38	4	40%	8	80%
39	6	60%	5	50%
40	5	50%	9	90%
[redacted]				
42	1	10%	5	50%
[redacted]				
44	3	30%	7	70%
45	6	60%	8	80%
46	3	30%	8	80%

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	.3732	41	.15170	.02369
	Post-Test	.7439	41	.18035	.02817

Paired Samples Test

		Paired Differences				
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	
					Lower	Upper
Pair 1	Pre-Test - Post-Test	-.37073	.22610	.03531	-.44210	-.29937

t	df	Sig. (2-tailed)
-10.499	40	.000