Efficacy of a Multimedia Educational Module on Best Practices of Anesthesia Patient Safety for Neuromuscular Blockade

John Matthew Lohman

School of Nursing, Cedar Crest College

Author Note

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DNP Project Chair: Donna Martonik, DNP, ANP, AGACNP, Cedar Crest College

DNP Project Mentor: Amy Colon, DNP, CRNA, Tower Health: Reading Hospital

Correspondence concerning this paper should be addressed to John Matthew Lohman, Cedar Crest College, 100 College Dr, Allentown, PA 18104. Email: JMLohman@cedarcrest.edu

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Abstract

The use of neuromuscular blocking agents during surgery has increased the risks associated with residual weakness. Due to the subjective nature of tactile and visual assessment, the only reliable method to assess for level of neuromuscular blockade is via a quantitative monitor. A dosing protocol for reversal agents, based on quantitative assessment, allows a systematic and consistent practice among anesthesia professionals. The purpose of this project was to evaluate the efficacy of an online multimedia educational module designed to educate anesthesia professionals about best practices in anesthesia patient safety regarding neuromuscular blockade. The educational module provided evidence-based content and an application of patient safety topics in a simulated clinical scenario. Efficacy of the educational module was evaluated with an assessment of acquired knowledge through a pre-test and post-test survey, and evaluation of the anesthesia professional's willingness to implement concepts in future practice. The educational module was published and accessible online via website link emailed to participants. Twenty-four anesthesia professionals with various levels of education and experience participated in the project. Data was obtained over a two-week period and analysis of the data took place following the data collection phase. Descriptive statistics were used for the collected data points, McNemar's test was used to analyze the marginal frequencies of correct responses in individual knowledge-based questions, and a standard t-test was used to evaluate the collective data from all knowledge-based questions. Based on the analysis, participation in the educational module resulted in an increase in knowledge and willingness to implement anesthesia patient safety concepts into future anesthesia practice.

Key words: *anesthesia patient safety, best practices in neuromuscular blockade, multimedia educational module, neuromuscular blockade, quantitative monitor, residual weakness.*

Efficacy of a Multimedia Educational Module on Best Practices of Anesthesia Patient Safety for Neuromuscular Blockade

Neuromuscular blockade is commonly used during surgical procedures requiring general anesthesia to provide optimal intubating conditions and provide surgical exposure. After surgery, it is essential for anesthesia professionals to antagonize the effects of neuromuscular blockade to prevent residual neuromuscular weakness (RNMW). The effects of RNMW following surgery are an unanticipated event. The level of neuromuscular blockade is typically assessed using tactile and visual assessment with a train-of-four (TOF) twitch monitor, or more accurately a quantitative monitor, such as acceleromyography or electromyography. Dosing of neuromuscular blocking agents (NMBAs) and reversal agents should be guided by the level of blockade present to avoid overdosing and underdosing. Certain patient populations, for example pediatrics, geriatrics, morbidly obese, and the parturient, are at an increased risk of adverse pulmonary complications related to their physiology and/or pathophysiology in combination with RNMW.

Chapter 1: Introduction and Overview of the Problem of Interest

Background and Significance

In the United States, 30.8 million patients are treated with NMBAs yearly, 1/3 of patients receiving reversal will exhibit RNMW, and 0.8% will experience a critical respiratory event (Brull & Kopman, 2017). Residual neuromuscular weakness after surgery can lead to disastrous complications, such as airway obstruction, hypoxemia, postoperative respiratory complications, and muscle weakness (Brull & Kopman, 2017; McLean et al., 2015). McLean et al. (2015) noted the significant patient safety concerns that "postoperative respiratory complications are the second most common postsurgical complication" and a source of a significant financial burden to health care institutions. Ineffective monitoring and/or inadequate reversal of blockade is to blame for 20-40% of patients arriving to the Post Anesthesia Care Unit (PACU) with evidence of RNMW, 0.05%–0.19% needing to be reintubated in PACU (Brull & Kopman, 2017; Luo et al., 2018; Naguib et al., 2018).

The use of a quantitative monitor is the only reliable way to assess neuromuscular blockade intraoperatively and dose reversal agents to achieve the consensus of full reversal, train-of-four-ratio (TOFr) ≥ 0.9 (Brull & Kopman, 2017; McLean et al., 2015; Naguib et al., 2018). The quantitative monitor stimulates muscle contractions along a peripheral nerve path and the TOFr is calculated based on the measurement of the strength of the fourth twitch compared to the first twitched evoked. Residual neuromuscular weakness and pharyngeal impairment is associated with a TOFr 0.7-0.9 (Adembesa et al., 2018). Although the literature supports the use of quantitative monitors as the only reliable method of assessing neuromuscular blockade, Stoelting (2016), president of the Anesthesia Patient Safety Foundation acknowledged routine qualitative or quantitative monitoring of neuromuscular blockade as part of the "Standards for

Basic Anesthetic Monitoring" is not endorsed, however, by any of North American professional anesthesia associations. As a result, NMBAs and their antagonists are dosed without proper guidance (Naguib et al., 2018).

Although research demonstrates benefits of using a quantitative monitor to assess level of neuromuscular blockade, use of subjective TOF twitch devices is more commonly used in practice (McLean et al., 2015). The TOF twitch device is used to stimulate muscle contractions along a peripheral nerve path and requires a visual and tactile assessment of the quantity and quality of twitches evoked. The TOF assessment requires the anesthesia professional to compare the quality of the fourth twitch to that of the first twitch evoked. Detection of a fade in the fourth twitch is evidence of residual neuromuscular weakness (Brull & Kopman, 2017). Brull and Kopman (2017) noted the effectiveness of this assessment is dependent on the anesthesia professional's ability to detect a fade, conversely, even when no fade is detected there is still a 50% risk the actual measured TOFr is < 0.7.

Neuromuscular blocking agents, aminosteroidals and benzylisoquinolines, and the common antagonist neostigmine, an anticholinesterase, are associated with a dose-dependent increase in risk of postoperative respiratory complications (McLean et al., 2015). Even the use of sugammadex, a γ-cyclodextrin that encapsulates the aminosteroidal NMBAs, is not without complications if it is not dosed appropriately (Brull & Kopman, 2017). The timing of the last dose of NMBA, the depth of block before antagonist administration, duration of time until full reversal of block prior to extubation decreases the risk of RNMW (Brull & Kopman, 2017; McLean et al., 2015; Tajaate et al., 2018).

The original plan for this project was designed to address the importance of the timing and dosing of agents used to antagonize neuromuscular blockade through the implementation of a dosing protocol to be used in patients undergoing laparoscopic bariatric surgery, however, the COVID-19 pandemic interrupted the ability for the project to be carried out in a clinical setting. Understanding that neuromuscular blockade is an important topic for patient safety in all surgical patients receiving neuromuscular blocking agents, it was especially important to continue to educate anesthesia professionals about how they can enhance patient safety and increase empirical knowledge by applying best practices into clinical practice. Particularly in these times of increased stress and demands on anesthesia professionals, disseminating evidence-based information that can improve patient safety can ensure that best practices are continued even in unconventional times.

Castanelli et al. (2015) found that greater than 50% of anesthesia professionals have never accessed a medical education article and that a vast knowledge-practice gap exists. Potential explanations for this deficit can be attributed to time constraints and traditional modalities of learning have proven to be time consuming and inflexible in today’s fast paced healthcare system. The use of contemporary modalities, like e-learning, journal clubs, multimedia presentations, online workshops, lectures, seminars, and simulation, that foster intrapersonal development of the three domains of learning (cognitive, psychomotor, and affective), help to increase knowledge, skills, and the attitudes required to obtain both technical and nontechnical skills (Robertson et al., 2017). Rouleau et al. (2019) identified the affirmative effects of e-learning on continuing education in the context of nursing care, citing that nursing skills demonstrated the greatest increase, followed by knowledge and overall, respondents reported a positive perception of multimedia education.

Due to the limitations imposed by the COVID pandemic, the need to provide patient safety education, and the literature supporting the use of e-learning, a group of four (4) senior student nurse anesthetists (SRNAs) collaborated to create a multimedia educational module that incorporated education on multiple topics regarding best practices in anesthesia patient safety that could be delivered in a convenient online environment. This novel approach of dissemination of education has the potential to increase the number of participants, since it is not limited by geography or clinical site- thus reflecting a true population-based intervention.

Purpose, Aim, and Objectives

The purpose of this project is to educate anesthesia professionals about best practices in anesthesia safety regarding the timing and dosing of NMBAs and antagonists, and assessment of neuromuscular blockade with evidence-based practice. The aim is to use current evidence-based information to develop an educational module to disseminate best practices in anesthesia patient safety regarding neuromuscular blockade. The objectives of this project are to increase knowledge regrading best practices of anesthesia patient safety regarding neuromuscular blockade and increase the anesthesia professional's willingness to implement the knowledge into future practice.

The stakeholders in this project include all anesthesia professionals who participate in the educational module. Additionally, patients who receive care from anesthesia professionals who participate in the education benefit indirectly from the increased knowledge obtained from the module through decreased risk of post-operative respiratory complications. Lastly, the health care institution is an indirect benefactor from the educational module through decreased costs associated with complications and increased efficiency.

PICO Question

The combination of the timing and dosing of neuromuscular blocking agents and antagonists, and proper assessment of neuromuscular blockade is paramount for patient safety. Patients who receive neuromuscular blocking agents, due to physiological and/or pathophysiological factors, are at an increased risk of a critical respiratory event, obstruction, hypoventilation, hypercapnia, and hypoxia, during the postoperative period (Cammu, 2018). This project will examine, in anesthesia providers, does a multimedia simulation-based educational intervention increase knowledge about current best practice for patient safety, monitoring and administering medications in accordance with evidence-based practice guidance?

Chapter 2: Review of the Literature

Search Methodology

A review of the literature was conducted through electronic databases PubMED, and CINAHL. Following are the search terms used: neostigmine protocol, neuromuscular reversal protocol, acceleromyography, neuromuscular blockade, quantitative neuromuscular monitors, residual weakness, and postoperative respiratory complications. An advanced search feature was used to limit articles to full-text and limited the range of publication years to 2015-current. In addition to the database search, cited works in the literature were also utilized to find relevant articles. The search yielded 45 articles. Twenty-six articles were chosen based on their relevance to the use of quantitative monitors, current practice behaviors and attitudes, and the use of a dosing protocol for reversal agents.

Findings

The literature is filled with data supporting the use of different monitors to assess neuromuscular blockade; however, Brull and Kopman (2017) identified that subjective monitoring is used in less than 40% of procedures and quantitative monitors in 17% of procedures. As a result, over half of the procedures use either a qualitative or quantitative neuromuscular monitor, while the remainder of procedures use clinical assessment alone to assess neuromuscular blockade. Brull and Kopman (2017) defined the levels of neuromuscular blockade in Figure 1. Adembesa et al. (2018) evaluated use of clinical assessment versus quantitative assessment of neuromuscular blockade prior to reversal and extubation, and found that clinical assessment alone was associated with higher post-operative respiratory complications.

Figure 1

Suggested Definitions of Depth of Neuromuscular Block Based on Subjective and Measured (Objective) Criteria

Depth of Block	Posttetanic Count	Train-of-Four Count	Subjective Train-of-Four Ratio	Measured Train-of-Four Ratio
Intense (profound) block	0	0	0	0
Deep block	≥ 1	0	0	0
Moderate block	NA	1–3	0	0
Light (shallow) block	NA	4	Fade present	0.1–0.4
Minimal block (near recovery)	NA	4	No fade	> 0.4 but < 0.90
Full recovery (normal function)	NA	4	No fade	≥ 0.90–1.0

NA = not applicable

Note. Table from “Current status of neuromuscular reversal and monitoring: Challenges and opportunities,” by S. J. Brull and A. F. Kopman, 2017, *Anesthesiology*, *126*, p. 175. Copyright 2017 by Wolters Kluwer Health, Inc. Used with permission granted by Wolters Kluwer Health, Inc.

When using clinical assessment and the discretion of the anesthesia professional alone, without assessment from a neuromuscular device, a dosing protocol for reversal of neuromuscular blockade was shown to lower the incidence of RNMW (Santos et al., 2017). Wardhana et al. (2019) compared a dosing protocol for reversal agents based on clinical assessment with a protocol based on the quantitative assessment and found that although the groups were optimized, the clinical assessment group was associated with a higher incidence of RNMW (16.7 versus 3.3%). In the clinical assessment group, the timing of administration of neostigmine was 5 minutes prior to extubation (Wardhana et al., 2019). All studies without the use of neuromuscular monitoring devices demonstrate that clinical assessment alone is an insensitive indicator of the true blockade (McLean et al., 2015). A protocol for dosing neuromuscular blocking agents and antagonists created less variation from anesthesia provider to anesthesia provider, however, studies that utilized the quantitative monitor provided a consistent and reliable source of neuromuscular blockade prior to extubation (Adembesa et al., 2018; Brull

& Kopman, 2017; Hunter, 2017; Kaufhold et al., 2016; Naguib et al, 2018; Rudolph et al., 2018; Wardhana et al., 2019).

Neostigmine, a reversal agent for neuromuscular blockade, is associated with a dose-dependent risk of RNMW, especially with large cumulative doses of NMBAs (Hunter, 2017; McLean et al., 2015). Larger doses of neostigmine do not expedite recovery times, due to the ceiling effect of its action (Tajaate et al., 2018). High doses of neostigmine (>60 mcg/kg) or administration after full recovery is associated with upper airway collapsibility and impaired pharyngeal pressure (Luo et al., 2018; McLean et al., 2015). Sugammadex has been associated with faster recovery time, but due to high cost in comparison to neostigmine, access can be limited or restricted in certain surgical facilities. The dosing practices of sugammadex still depends on an assessment of the level of neuromuscular blockade for adequate reversal. With subjective monitoring, reliable assessment of level of block is hard to determine and can lead to sub-recommended doses of sugammadex, resulting in RNMW (De Boer et al., 2018). Residual neuromuscular weakness can lead to disastrous consequences in high-risk patient populations, like bariatric patients (De Robertis et al., 2016).

Quicker recovery time and reliability of dosing of sugammadex has led to inquiry related to the efficiency and turnaround time for surgical suite utilization (De Robertis et al., 2016). In laparoscopic bariatric surgical cases, sugammadex (2mg/kg after recovery of T2) did demonstrate quicker recovery time compared to neostigmine (50mcg/kg after recovery of T2), saving 19.4 hours of time in between cases (De Robertis et al., 2016). De Robertis et al. (2016) encouraged the clinical application of a TOF-driven protocol for reversal in morbidly obese patients. The combination of using a dosing protocol and a quantitative neuromuscular monitor to assess neuromuscular blockade provides the best opportunity to decrease the risk of RNMW and postoperative respiratory complications.

Rudolph et al. (2018) implemented a quality improvement project aimed at optimizing a neostigmine reversal protocol based on quantitative assessment of neuromuscular blockade. This multifaceted project included a reduction in the aliquot of neostigmine, use of a cognitive aid, ongoing education and financial incentives for documentation of TOFr; resulting in a decrease in post-operative respiratory complications and efficient resource allocations (Rudolph, 2018). Although this dosing protocol does not include sugammadex and is not aimed specifically for bariatric surgery, it does optimize the use of a TOF-driven protocol that De Robertis et al. (2016) encouraged.

Drzymalski et al. (2019) created a dosing protocol to decrease the utilization of sugammadex in the clinical environment based on the qualitative TOF monitors; however, included an adaptation for the use with quantitative monitors. This dosing protocol, like Rudolph's et al. (2018), utilizes neostigmine as the reversal agent of choice for light and moderate level of blocks. Since neostigmine is not recommended for reversal of deep neuromuscular blockade, instead of waiting for return of twitches, the protocol warrants the use of sugammadex (Drzymalski et al., 2019). This study revealed acquisition cost savings via a reduction in sugammadex use, while decreased utilization was not associated with an increase in adverse events (Drzymalski et al., 2019).

Brull and Kopman (2017) developed a dosing protocol using level of neuromuscular blockade present at time of reversal (Figure 2) based on the review of evidence from various research studies. Although sugammadex is effective with aminosteroidal NMBAs, neostigmine is the reversal of choice for reversal of neuromuscular blockade with benzylisoquinolines. Total body weight should be used in dosing of sugammadex, while ideal body weight is used to dose NMBAs and neostigmine (Brull and Kopman, 2017). Effective antagonization of neuromuscular blockade is dependent on appropriate assessment of the level of blockade present at the time of reversal (Brull and Kopman, 2017). Additionally, the timing of administration of neostigmine, approximately 10 minutes prior to extubation, is important to ensure adequate time to reach peak effect (Brull and Kopman, 2017).

Figure 2

Recommendations for Pharmacologic Antagonism of Nondepolarizing Blockade According to the Depth of Block

Depth of Block	Neostigmine Dose (mg/kg)	Sugammadex Dose* (mg/kg)
Posttetanic count < 2	Delay reversal	4–16†
Posttetanic count ≥ 2 TOF count 0–1	Delay reversal	2–4†
TOF count 2–4 TOF with fade by tactile or visual means TOF < 0.40‡	0.05–0.07	1.0–2.0†
TOF count 4, no tactile or visual fade TOF = 0.40–0.90‡	0.02–0.03	0.25–0.5†
TOF ratio ≥ 0.90‡	Reversal unnecessary	Reversal unnecessary

*Dose ranges reported in the literature; cited doses may be deviate from package insert recommendations. †When reversing vecuronium, use higher end of dosing range. ‡TOF ratio confirmed by quantitative monitoring.
TOF = train-of-four.

Note. Table from "Current status of neuromuscular reversal and monitoring: Challenges and opportunities," by S. J. Brull and A. F. Kopman, 2017, Anesthesiology, 126, p. 179. Copyright 2017 by Wolters Kluwer Health, Inc. Used with permission granted by Wolters Kluwer Health, Inc.

Increasing the use and understanding of quantitative neuromuscular monitors in the clinical environment is an important step in quality improvement (Bedsworth et al., 2019). Bedsworth et al. (2019) acknowledged that although an initiative is successful in increasing use of quantitative neuromuscular monitors, dosing practices of the anesthesia professionals may not demonstrate a meaningful link to objective data that is obtained from these devices. This deficit emphasizes the importance of education of new technology and reinforcement of clinical knowledge regarding best practices in anesthesia safety.

Limitations

Although there is sufficient information sourced from systematic reviews and meta-analyses, a limitation to the literature review includes the nine studies that were conducted outside the United States. In at least two of those studies, the anesthesia professionals were not blinded to the cohort, which may impact the validity and reliability of the evidence. Additionally, though the evidence suggests use of a neuromuscular monitor to assess level of blockade, there is inconsistency in making this a requirement amongst North American anesthesia professional associations in comparison to other international groups including the Association Anaesthetists of Great Britain and Ireland that mandate the use of peripheral nerve stimulators (Stoelting, 2016). The Anesthesia Patient Safety Foundation’s panel of experts concluded that quantitative monitors should be used whenever neuromuscular blocking agents are given, and at minimum a peripheral nerve stimulator used during the transition. Additionally, the panel called on anesthesia professional associations to develop practice standards and guidelines to address these issues (Murphy, 2018). Lastly, there is a knowledge gap amongst anesthesia and post-anesthesia care professionals related to the assessment of neuromuscular blockade, reversal of neuromuscular blockade, and the incidence of inadequate reversal in RNMW that needs to be addressed (Murphy, 2018).

Conclusions

The review of literature demonstrates the following ongoing themes:

1. Quantitative monitoring of neuromuscular blockade is the only reliable measure of depth of blockade.
2. Neuromuscular blocking agents and reversal agents should be dosed based on the level of blockade, as evident by quantitative measurement.

3. Inadequate assessment of neuromuscular blockade prior to reversal or failure to achieve a TOFr ≥ 0.9 results in RNMW.
4. A protocol for dosing reversal agents, based on level of blockade, helps reduce anesthesia professional variability in practice.
5. Neuromuscular blocking agents and reversal agents have a dose-dependent level of risk of RNMW.
6. Postoperative complications associated with RNMW are an ongoing issue, despite advances in technology in quantitative assessment.

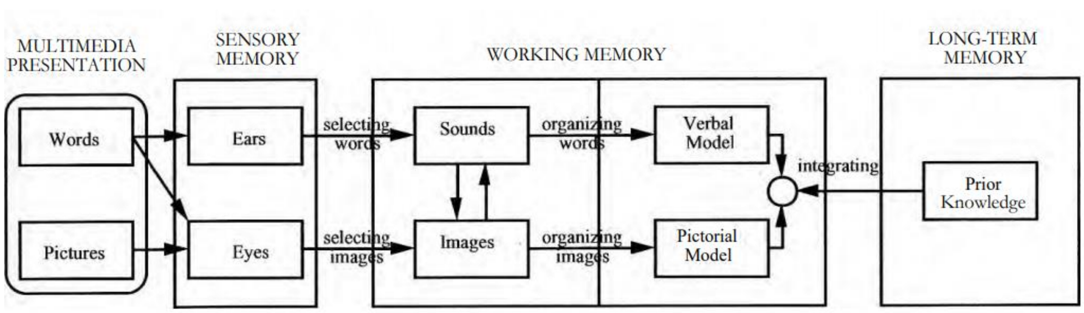
Chapter 3: Organizational Framework of Theory

Conceptual Definitions of Theoretical Framework

In a technology-driven era, rapid advances in technology and accessibility enable the development of a broad range of instructional multimedia (Rudolph, 2017). Instructional designers, multimedia designers, and instructors are challenged with finding a balance between technology and multimedia that fosters meaningful learning (Mayer, 2005; Rudolph, 2017). The Cognitive Theory of Multimedia Learning (CTML) is a theoretical framework (Figure 3) that helps to create meaningful learning by structuring multimedia "in light of how the human mind works (Mayer, 2005)."

Figure 3

Cognitive Theory of Multimedia Learning



Note. Diagram from "The Cambridge Handbook of Multimedia Learning," by R. E. Mayer, 2005, p. 37. Copyright 2005 by Cambridge University Press.

The three major assumptions of how the human mind work in CTML are: dual channels, limited capacity, and active processing (Mayer, 2005; Rudolph, 2017). Mayer (2005) noted that humans process information presented in dual channels as auditory/verbal channels and a visual/ pictorial channel. With this information, the learner integrates the new information into working memory (Rudolph, 2017). Since the capacity of the channels is limited, learners are forced to allocate their cognitive resources to build connections between pieces of new information and existing knowledge (Mayer, 2005). Active learning involves selecting, organizing, and incorporating information with previous experience, and filtering extraneous details not relevant to core materials presented. Through active processing, individuals learn and convey information more efficiently from a combination of words, animations, audio, and pictures than words alone (Mayer, 2005; Rudolph, 2017).

To develop an effective multimedia module, it is essential to balance the visual and verbal information to engage the learner and minimize extraneous distractions (Rudolph, 2017). The presented material should have a coherent structure and reflect guidance for the learner on building structure (Mayer, 2005). Learning outcomes can be measured through retention, recall of information presented, and ability to understand information presented to solve new problems (Mayer, 2005). The combination of words and images form the theoretical basis for CTML by capturing the learners' interest, engaging memory, preventing cognitive overload, and stimulating reflection (Rudolph, 2017). The goal of CTML is to demonstrate how words and pictures contribute to a meaningful learning experience.

Application of Theoretical Framework

This project incorporated the principles of the CTML framework into the design of the multimedia educational module and assessments. The content was delivered in a format that encompassed the dual-channel processing system of the human mind by combining animation, sounds, images, and words. The CTML framework reduces cognitive loads and facilitates the presentation of the four evidence-based anesthesia safety topics in a clear and concise manner for anesthesia professionals. The design of the educational module website helped to capture the attention of anesthesia professionals and stimulate cognitive processing through integration of prior knowledge activated from long-term memory. The assimilation of content from the four anesthesia patient safety topics into a patient scenario simulation was used to help demonstrate the application of concepts in clinical practice.

The presentation was developed based on the following fundamental principles of effective instructional multimedia elements: redundancy, signaling, segmentation, animation vs. static images, control, interactivity, and engagement/feedback (Rudolph, 2017). The information was presented in a succinct manner to avoid redundancy and was segmented into individual anesthesia patient safety topics. Utilizing the signaling principle, cues were used to highlight key points to help facilitate the learner’s allocation of cognitive resources. Anesthesia safety points were animated to facilitate a mental representation of content (Rudolph, 2017). The control principle was incorporated by allowing the learner to view and navigate content at their own pace. Questions related to key points were integrated into the module to incorporate principles of interactivity and engagement. The pre-test and post-test survey assessments were utilized to evaluate outcomes of learner’s retention and transfer of information presented in the module to demonstrate efficacy of the multimedia educational module on best practices of anesthesia patient safety.

Chapter 4: Project Design

The original project design was created to address the importance of timing and dosing of agents used to antagonize neuromuscular blockade through implementation of a dosing protocol, used in conjunction with quantitative neuromuscular monitors, in patients undergoing laparoscopic bariatric surgery. Development of the project included collaboration with the DNP mentor Amy Colon, DNP, CRNA and the clinical stakeholders Dave Matson, MD, Chief of Anesthesiology at Tower Health: Reading Hospital and Connie Bohn, MSN, CRNA Chief CRNA at Tower Health: Reading Hospital. The COVID-19 pandemic interrupted the ability for the project to be carried out in a clinical setting. In response to the limitations created by the pandemic, the project design was revised into a collaborative multimedia educational module to present four best practice topics in anesthesia patient safety.

The new collaborative project design was based on a compilation of 4 senior SRNA's original projects on multiple topics regarding best practices in anesthesia patient safety. Utilizing CTML principles as the theoretical framework to guide the project design, the project aimed to facilitate knowledge transfer, improve knowledge, and increase anesthesia professional's willingness to implement concepts in future clinical practice.

The educational module website, https://athernan2.wixsite.com/website, (Appendix A) was created using Wix.com Ltd. for website design and Blackmagic Design's Davinci Resolve 16™ software for film editing. The DNP team and CRNA mentors validated the module for educational content, format, and accuracy before disseminating the content to participants. Supplemental information (Appendix B) was created for each of the anesthesia patient safety topics and included on the website for download by participants. Data from participation was collected and analyzed via pre-test survey (Appendix C) and post-test survey (Appendix D) assessments developed using Survey Monkey™ software.

Institutional Review Board (IRB) Approval

Each member of the group completed an online Collaborative Institutional Training Initiative (CITI) program (Appendix E) and the group obtained Cedar Crest College (CCC) Internal Review Board (IRB) approval (Appendix F) before the initiation of the project on August 26th, 2020. The group conducted the work on the project according to the approved IRB proposal.

Implementation Plan

The implementation plan for this project was developed based on the Iowa Model framework for implementing evidence-based practice. The four components of the Iowa Model Framework include: (1) creating awareness and interest, (2) building knowledge and commitment, (3) promoting action and adoption, and (4) pursuing integration and sustained use (Iowa Model Collaboration, 2017; Cullen et al., 2018).

Creating Awareness and Interest

Creating awareness and interest involved cultivating a spirit of inquiry, identifying clinical problems/conducting a needs assessment, and collecting and/or appraising best evidence that supports a practice change. These three subphases were operationalized pre-COVID-19 within each senior SRNA's clinical site. The need assessment was conducted by direct observation of anesthesia providers at their respective clinical sites and via anecdotal conversations with key stakeholders. To overcome barriers in implementing the practice change, the principal investigators employed change agents and champions to spread the word about evidence-based best practice advantages and its impact on healthcare. Utilizing this strategy helped highlight the institution's unique culture and desire for change among stakeholders, organizational leaders, and clinicians (Cullen et al., 2018). The use of journal clubs, attendance to quality improvement meetings, and placement of evidence-based practice articles in anesthesia break rooms helped raise awareness and a sense of personal responsibility to influence change. Lastly, investigation into utilizing knowledge brokers (Chief Anesthesiologists and Chief CRNAs) at each clinical site helped highlight the institution's support for evidence-based practice initiatives, available resources, institutional barriers, and necessary partnerships required to foster sustainable institutional change.

Building Knowledge and Personal Commitment

After awareness and interest was established, the second phase of the implementation plan commenced. Building knowledge and personal commitment took place through a team approach with a gap analysis and development of an action plan. The pinnacle development during this phase of the implementation plan was adaptation of the individual projects in response to the COVID-19 pandemic into a collaborative multimedia educational based project. The new project design provided an opportunity to deliver a cohesive multimedia educational module with simulation and dissemination of credible evidence with a clear implication for clinical practice. The educational module was designed to obtain clinician input and inform practicing clinicians on best practice recommendations of anesthesia patient safety. Since the clinical problem and needs assessment was conducted at the clinical sites, it was decided to invite anesthesia professionals at each clinical site to participate in the project. This approach helped to secure buy-in, stimulate commitment, promote action and adoption, and provide a foundation for optimizing knowledge synthesis on each topic of anesthesia patient safety.

Promoting Action and Adoption

The project design is limited by the number of interventions that can be operationalized to promote action and adoption within the clinical setting without developing a protocol or purchasing of equipment. However, to support implementation strategies that strengthen action and acceptance of the project may include reminders and practice prompts that encourage clinicians to embrace the presented best practice recommendations. Implementation strategies employed to promote change and adoption include senior SRNA's functioning as change champions at their respective clinical sites, advocating for practice change, reporting updates on study findings, and emailing supplemental educational handouts to anesthesia professionals. These strategies created awareness, adoption, enthusiasm, and support for the practice change initiatives (Melnyk & Fineout-Overholt, 2018).

Pursuing Integration and Sustained Use

The final phase of the implementation plan includes pursuing integration and harnessing the sustained use of best practice recommendations. To promote the sustained integration of practice change, the post-test survey included questions related to participants' willingness to change their future clinical practice and provide feedback related to the educational intervention. Sustained use of best practice recommendations is achieved by providing periodic updates of information about the project and clinical practice recommendations to participants and stakeholders. The senior SRNAs functioned as peer influencers and transformational leaders throughout project development, implementation, and dissemination. Additional means to promote integration and sustained use included educational handouts placed in the anesthesia breakroom and locker rooms to facilitate compliance and continued forward momentum. The project results and findings were disseminated at the Eastern Nursing Research Society's 33rd

Annual Scientific Sessions virtual conference and in a local presentation at Cedar Crest College to support the growth of EBP culture, stimulate innovation, and enhance nursing knowledge.

Data Collection Tools

The pre-test survey (Appendix C) and post-test survey (Appendix D) tools were utilized for data collection. The surveys were submitted to the project team to ensure they were clear, comprehensible, reliable, and valid. The project team determined the surveys measured appropriate outcomes to support objectives of the project. The pre-test and post-test surveys each contain 10 questions (4 demographic and current practice questions, and 6 paired knowledge-based questions) for participants to complete. Participants were asked the following demographic questions in the pre-test survey: number of years practicing anesthesia and their educational background. This information was obtained to draw correlations between this data and a willingness to change current practice. The questions pertaining to the participant's willingness to change practice were included on the post-test survey. The remaining knowledge-based content questions were designed to assess the participant's knowledge of each of the best practice topics presented both before and after completion of the educational module.

Resources Needed

The resources required to complete this project include personnel, supplies, technology, and facilities. Personnel for the project design included the project team and Cedar Crest College's Simulation Coordinator. The supplies required for completion of the project included primarily components for the simulation filming, including: high fidelity simulation mannequin, pulse oximeter probe, endotracheal tube, laryngoscope, anesthesia machine, one-inch adhesive tape, prone-view device, stethoscope, quantitative neuromuscular monitor (TwitchView™ EMG monitor), infusion pump, syringes, surgical hats, and gloves. The crucial resources required for completion of this project included the following technology components: handheld Canon™ VIXIA HF R5000 camcorder, SIM IQ™ software, Wix.com Ltd., DaVinci Resolve 16™ software, Survey Monkey™ software, Microsoft Teams™ application, and a laptop computer. The facilities required for completion of the project included access to the Simulation Operating Room Suite and a conference room at Cedar Crest College.

Budget Justification

Most of the resources needed for the completion of this project were available without cost through Cedar Crest College’s Simulation Center. The DaVinci Resolve 16™ film editing software was available as a free download. The only financial requirements for this project include Wix.com Ltd. annual subscription fee for development and hosting the education module, a poster to disseminate the results, and Survey Monkey™ subscription for creation of the survey tools and collecting the data. The nominal fees incurred were divided and shared by each member of the project group. 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, as well as indirect benefits for health systems through potential decrease in adverse events, increased patient satisfaction, and improved efficiency.

Chapter 5: Implementation Procedures and Processes

The implementation of this project took place via e-mail recruitment of prospective anesthesia professionals (i.e., physician anesthesiologist, CRNA, SRNA) from established clinical sites and a peer-network of professional contacts. The recruitment e-mail (Appendix G), with transmittal heading of "Evidence-Based Practices of Anesthesia Patient Safety" contained a brief description of the project, informed consent to participate in the project, instructions to complete the pre-test and post-test surveys via Survey Monkey™, a link to the educational module website, and contact information for each of the principal investigators. Participants were notified that their participation in the project was voluntary and anonymous. The educational module website was available to participants for a two-week period and participants had the option to decline participation in the project until the final submission of the post-test survey.

The educational module was delivered in an online on-demand format with an estimated completion time of one hour. The module consisted of an introduction, four 10-minute EBP presentations on each anesthesia patient safety topic, a 12-minute-high fidelity simulation scenario, and a conclusion. Participants were instructed to view each of the four EBP topics prior to viewing the simulation. Supplemental resources for each topic were available for download from the educational module website to enhance content delivered in the module and for future reference.

After completion of the educational module, participants were instructed to complete the post-test survey. Data collected from the pre-test and post-test surveys were tracked via Survey Monkey™. Statistical Package for the Social Sciences™ (SPSS™) v.25 was used to further analyze the data and acquire statistics. Due to the small sample size ($n = 24$) and design of the survey tool, a nonparametric statistics test was used to measure the change in knowledge by comparing each participant's pre-test and post-test surveys. Based on the methodology of the project, McNemar's test was utilized to analyze the data generated from each individual knowledge-based question. McNemar's test was chosen to evaluate the marginal frequencies of the two-group categorical data from the pre-test and post-test surveys to determine if participation in the educational module resulted in a significant improvement in the participant's knowledge (Pembury Smith and Ruxton, 2020). An increase in post-test survey scores indicates that there was an improvement in knowledge. After assessment of each individual knowledge-based questions, all knowledge-based questions were analyzed collectively using a paired t-test to compare the mean of correct responses between the pre-test and post-test surveys. A willingness to change practice was measured by participants selecting "yes" that they are willing to change their practice on the post-test survey tool.

Chapter 6: Evaluation and Outcomes

The implementation phase for this project spanned a two-week period, from January 23, 2021 until February 5, 2021, to allow sufficient time for participants to review the educational module and complete the pre-test and post-test surveys. After the two-week period, the pre-test and post-test data was collected in Survey Monkey™ and extracted to a Microsoft Excel™ spreadsheet. The data was reviewed and analyzed by the principal investigators. McNemar's test was performed for each individual knowledge-based question and a paired t-test was performed for the correct responses in all knowledge-based questions with SPSS™. Although contact information for the principal investigators was listed in the recruitment e-mail and on the website for the project, no questions or concerns were raised by participants at any time during the implementation phase.

Demographics

Following approval by Cedar Crest College's IRB, a convenience sample of 40 anesthesia professionals were recruited by email to participate in this project. There was an overall response rate of 60% (n = 24) who volunteered to participate in this project. The final sample of participants included a variety of anesthesia professionals (physician anesthesiologists, CRNAs, SRNAs) with varying levels of experience ranging from 0 to 15 years (Figure 4).

Figure 4

Anesthesia Professional Role and Years of Experience

		N	% Total		Category	N	%Total
Anesthesia Role:	MDA	4	16.67%	**Years of Experience:**	0-5 years	16	66.67%
	CRNA	8	33.33%		6-10 years	5	20.83%
	SRNA	12	50.00%		11-15 years	3	12.50%
Total Sample Size:		24	100.00%	**Total:**	-	24	100.00%

Evaluation

Due to the design and nature of this project, a power analysis was not performed prior to recruitment. Additionally, the pre-test and post-test assessment of the educational module include questions regarding each of the best practice topics covered in the module. The focus of this project pertained to the use of quantitative assessment and timing and dosing of reversal agents. Pre-test and post-test survey questions pertinent to the topic were included in the evaluation. The topic-specific knowledge-based question pairs were analyzed using McNemar's test, to determine if the marginal frequencies between the pre-test and post-test surveys were the same (Pembury Smith and Ruxton, 2020). A 95% confidence level ($\alpha = 0.05$) was selected to evaluate the significance of results. The collective results from all individual topic questions will be discussed to evaluate the entire multimedia educational module.

Current Practice Question

What is your current methodology to assess neuromuscular paralysis? Participants identified in the pre-test survey that the two most common methodology used in current practice include the use of qualitative ($n = 22$) and quantitative ($n = 2$) assessment.

Knowledge-based Question 1

What degree of paralysis is present when 4/4 Train of four twitches are elicited with a peripheral nerve stimulator? Although there was a 4.17% increase in correct responses in the post-test survey, the analysis of frequencies of participant responses was not statistically significant ($p = 1.000$).

Knowledge-based Question 2

What is the appropriate dose of Neostigmine to reverse a Train of Four ratio (TOFr) of 0.5% in a patient who weighs - TBW: 100kg and IBW: 70kg? There was a 44.39% increase in correct responses in the post-test survey, the analysis of frequencies of participant responses was noted to be statistically significant (p = 0.004).

Knowledge-based Question 3

What is the ideal recovery TOFr to achieve prior to extubation? Although there was a 4.16% increase in correct responses in the post-test survey, the analysis of frequencies of participant responses was not statistically significant (p = 1.000).

Knowledge-based Question 4

What modality is the MOST accurate at depicting the depth of neuromuscular paralysis? Participants unanimously (n = 24) identified the correct response in the post-test survey that the use of quantitative assessment is the most accurate modality at depicting the depth of neuromuscular paralysis.

Willingness to Change Practice Question

Are you willing to make a change in your practice based on the information you were presented with about timing and dosing of reversal agents? Participants unanimously (n =24) identified in the post-test survey that they are willing to change their practice based on information that was presented about timing and dosing of reversal agents.

The efficacy of the educational module, evaluation of the pre-test and post-test results were used to answer the two main variables of the projects PICOT question:

1. Does a multimedia simulation-based educational intervention increase knowledge about current best practice for patient safety, monitoring and administering medications in accordance with evidence-based practice guidance?

2. Are anesthesia professionals willing to change their practice based on information that was presented in the multimedia simulation-based educational module?

Outcomes

The pre-test and post-test survey tools included current practice and knowledge-based questions from each of the individual principal investigator's topic. Two current practice questions, three knowledge-based question pairs, and one knowledge-based practice question pertained to the use of neuromuscular monitoring and the dosing of reversal agents. Most participants, 91.67%, noted in the pre-test survey that they use qualitative monitoring to assess neuromuscular blockade, while 100% of the participants in the post-test survey identified that quantitative monitoring is the most accurate at depicting the depth of neuromuscular paralysis.

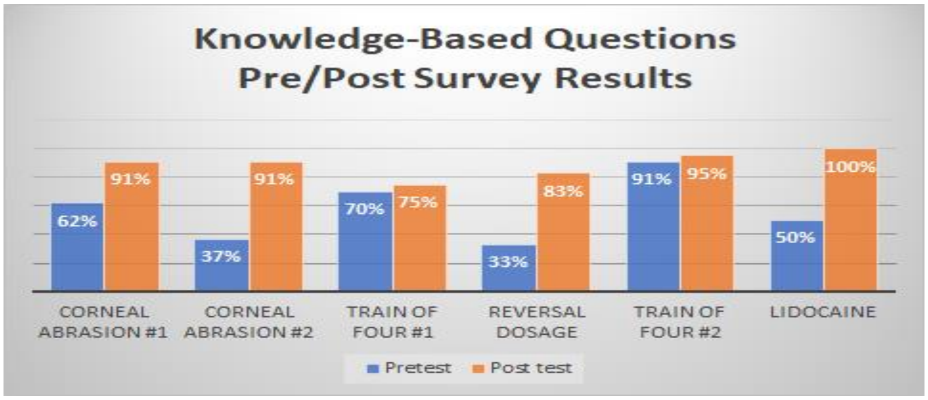
After completing the educational module, a positive change was noted in all knowledge-based questions. Using McNemar's test to evaluate the marginal frequencies in dichotomous variables, Knowledge-based Question 1 and Knowledge-based Question 3 were noted to have a p-value of 1.000, indicating possible homogeneity in frequencies between the pre-test and post-test data (Pembury Smith and Ruxton, 2020). The p-value of 1.000 is greater than the significance value $\alpha = 0.05$, therefore the results are not statistically significant.

Evaluation of the Knowledge-based Question 2 using McNemar's test revealed a p-value of 0.004, indicating the comparative frequencies are not the same and the change is due to an outside influence. The p-value of 0.004 is less than the significance value $\alpha = 0.05$, therefore the results are statistically significant.

In addition to questions related to neuromuscular monitoring, the remainder of knowledge-based question pairs for the other topics (corneal abrasion prevention and lidocaine infusions) in this educational module were also noted to have positive changes in the post-test survey results (Figure 5).

Figure 5

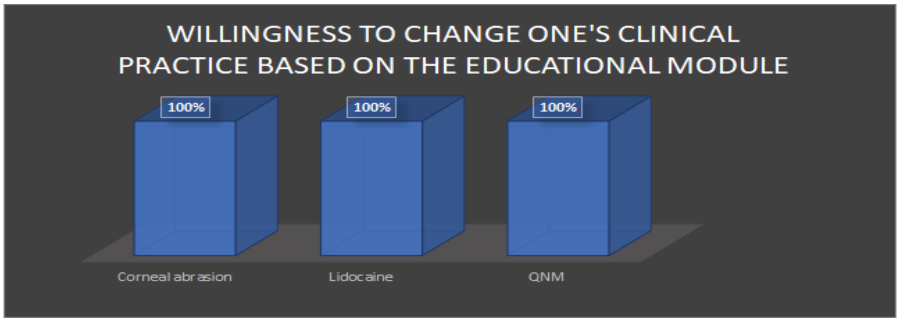
Participant's correct responses for all knowledge-based question pairs.



A paired t-test was used to evaluate the collective correct responses for all individual topic specific knowledge-based question pairs included in the module and was found to be statistically significant (p = 0.0218). All participants (n=24) indicated that they were willing to incorporate best practice recommendations from each individual topic into their future anesthesia practice (Figure 6).

Figure 6

Participant's willingness to change current practice.



Discussion

With the prevalence of neuromuscular blocking agents used in clinical practice and the relative risk of complications with their use, it is essential for anesthesia professionals to be updated on current best practice recommendations. The use of e-learning and virtual learning platforms has been reported as both effective and enjoyable; a multimedia educational module was created to increase anesthesia professional knowledge and help institute a practice change for best practices in anesthesia patient safety (Rouleau et al., 2019). The virtual learning platform proved to be invaluable during the pandemic; effective at reaching different anesthesia professionals (physician anesthesiologists, CRNAs, SRNAs). Data was gathered during the project implementation phase and analyzed to determine the efficacy of the educational module in increasing knowledge and willingness to implement new knowledge into practice.

It was concluded that the educational module was effective for both increasing provider knowledge and creating a practice change. Although most of the analyses in this project demonstrated statistical significance, the primary focus of this project is to demonstrate a positive impact on clinical practice. The results demonstrated that anesthesia professionals were able to increase knowledge and showed a willingness to make a practice change. Clinical significance is crucial within anesthesia and healthcare since evidence-based recommendations can be inferred to increase positive patient outcomes (Polit & Beck, 2017). This project demonstrated a clinical significance and positive impact on anesthesia professionals who participated in the project.

Chapter 7: Implications for Nursing Practice

Implications for Practice

The Institute of Medicine set a goal that 90% of clinical decisions made by healthcare professionals are backed by research and evidenced-based findings (Lehane et al., 2019). The purpose of this project was to educate anesthesia professionals with evidence-based anesthesia patient safety recommendations that can be used in current practice to improve patient safety outcomes. All anesthesia patient safety topics discussed in this project are supported by evidence-based practice. Anesthesia professionals utilizing evidence-based findings in their clinical decision making will provide a competent and safe practice environment for patients in their care (Lehane et al., 2019).

Implications for future practice would be to continue to influence practice change by gaining stakeholder support for education in evidence-based anesthesia patient safety topics and a willingness to implement evidence-based recommendations in current practice.

Strengths and Limitations of the Project

Strengths of this project include the flexibility and accessibility of the virtual education module that could be completed at the convenience of the participant's schedule. This project was able to reach a diverse group of anesthesia professionals (physician anesthesiologists, CRNAs, SRNAs) with varying years of experience (0-15 years). Another strength of this project includes the design of the educational module to best fit the way the human mind works. Individual topic segments, application of topic concepts in a simulation scenario, and additional resources provided various methods of delivery allowing the best opportunity for dissemination into clinical practice. The total participation time was less than one hour allowing students to gain knowledge on four evidenced-based anesthesia patient safety topics in an efficient manner.

There are several limitations to this project that need to be addressed, including the small convenience sample. A sample size of 24 participants does not allow for the generalization of data to a larger population of anesthesia professionals. Additionally, the limited time frame for review of the educational modules may have impacted some anesthesia professional's ability to participate. Lastly, given the scope of the project, the investigators were unable to determine whether actual change in clinical practice occurred despite unanimous agreement that this would be done.

Linkage to DNP Essentials

The essentials of doctoral education for advanced nursing practice that have been met with this project include essentials I, II, III, IV, V, VI, VII, and VIII.

Essential I is the application of scientific underpinnings for practice. This essential was met by synthesizing evidence-based research and applying it to practice through educating anesthesia professionals with an educational module and simulation-based clinical scenario. The CTML framework and the Iowa Model were the scientific underpinnings utilized throughout this project.

Essential II is the application of organizational and systems leadership for quality improvement and systems thinking. This essential was met through collaboration with stakeholders in the anesthesia department leadership to identify quality improvement needs.

Essential III is the application of clinical scholarship and analytical methods for evidence-based practice. This essential was met through the development of a DNP proposal, IRB submission, and creation of an educational module with 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 with a poster presentation an Eastern

Nursing Research Society conference and DNP presentation at Cedar Crest College are additional elements that fulfill essential III.

Essential IV is the application of information systems/technology and patient care technology for the improvement and transformation of health care. This essential was met using film editing software and a website building platform to create an educational module for anesthesia patient safety topics and simulation. The virtual platform was utilized for all aspects of this project, such as consent to participate, participation in the evidence-based education, and collection and analysis of data. Participation in a training session for the Philips quantitative neuromuscular monitor module 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. This essential was met through the development of an educational module on anesthesia patient safety topics meeting the theme of the Anesthesia Patient Safety Foundation's mission to "improve the safety of patients during anesthesia care." This essential was also met through participation in activities with the government relations committee with the Pennsylvania Association of Nurse Anesthetists, such as Lobby Day and meetings with congressmen to discuss nurse anesthesia issues.

Essential VI is the application of interprofessional collaboration for improving patient and population health outcomes. This essential was met through various meetings with stakeholders and interprofessional collaboration with anesthesia leadership, DNP mentor, DNP chair, DNP group members, and a statistician. The target audience for this project included the interprofessional anesthesia team, including physician anesthesiologists, CRNAs, and SRNAs.

Essential VII is the application of clinical prevention and population health for improving the nation's health. This essential was met through a needs assessment of hospital quality needs, and development of a project to educate anesthesia professionals on anesthesia patient safety topics. The results from this project have been disseminated to a broad audience of health care professionals at the ENRS conference and Cedar Crest College presentation.

Essential VIII is the application of advanced nursing practice. 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 8: Summary of Project

Summary and Conclusions

Residual neuromuscular weakness results in postoperative respiratory complications that contribute a significant burden to the patient and health system (McLean et al., 2015). The use of a quantitative monitor is the only reliable way to assess neuromuscular blockade intraoperatively and dose reversal agents to achieve the consensus of full reversal, TOFr ≥ 0.9 (Brull & Kopman, 2017; McLean et al., 2015; Tajaate et al., 2018).

The purpose of this project was to educate anesthesia professionals about best practices in anesthesia patient safety. This was achieved with the use of current evidence-based information to develop an educational module to disseminate best practices in anesthesia patient safety regarding neuromuscular blockade. CTML framework was used to help design the educational module to deliver content in a way that is meaningful, fosters new knowledge and builds upon previous knowledge.

The findings in this project were consistent with current literature regarding neuromuscular blockade and the dosing of reversal agents. Although anesthesia professionals are aware that quantitative monitoring is the most accurate modality to assess neuromuscular paralysis, most anesthesia professionals depend on qualitative assessment in current practice. Additionally, there is variability between anesthesia professionals about the appropriate dosing of reversal agents.

The objectives of this project were met by demonstrating an increase in knowledge, as evidenced by improvement in knowledge-based post-test survey scores, and a willingness to implement the knowledge in future practice.

Dissemination

This project was disseminated via virtual poster (Appendix H) presentation in March 2021 at the Eastern Nursing Research Society's 33rd Annual Scientific Sessions conference. Presenting at this conference provided an opportunity to disseminate to a broad audience across the eastern United States. In addition to presenting at a professional research conference, this project was also virtually disseminated to students and faculty at Cedar Crest College in April 2021.

Future Ideas

The findings from this project were consistent with the literature that although anesthesia professionals properly identify that quantitative monitoring is a more accurate assessment of the depth of neuromuscular blockade, qualitative assessment is consistently used in actual practice. In clinical sites that have quantitative monitors, future projects should aim to identify and address barriers to implementing the use of quantitative monitors in current practice. For example, a project directed at training anesthesia professionals on the use of quantitative monitors and how to utilize the data generated may help to address the barrier of apprehension to new technology. Although the COVID-19 pandemic resulted in an adaptation of the original project, a future project could evaluate patient outcomes with the use of dosing protocols in conjunction with quantitative monitoring in the clinical setting.

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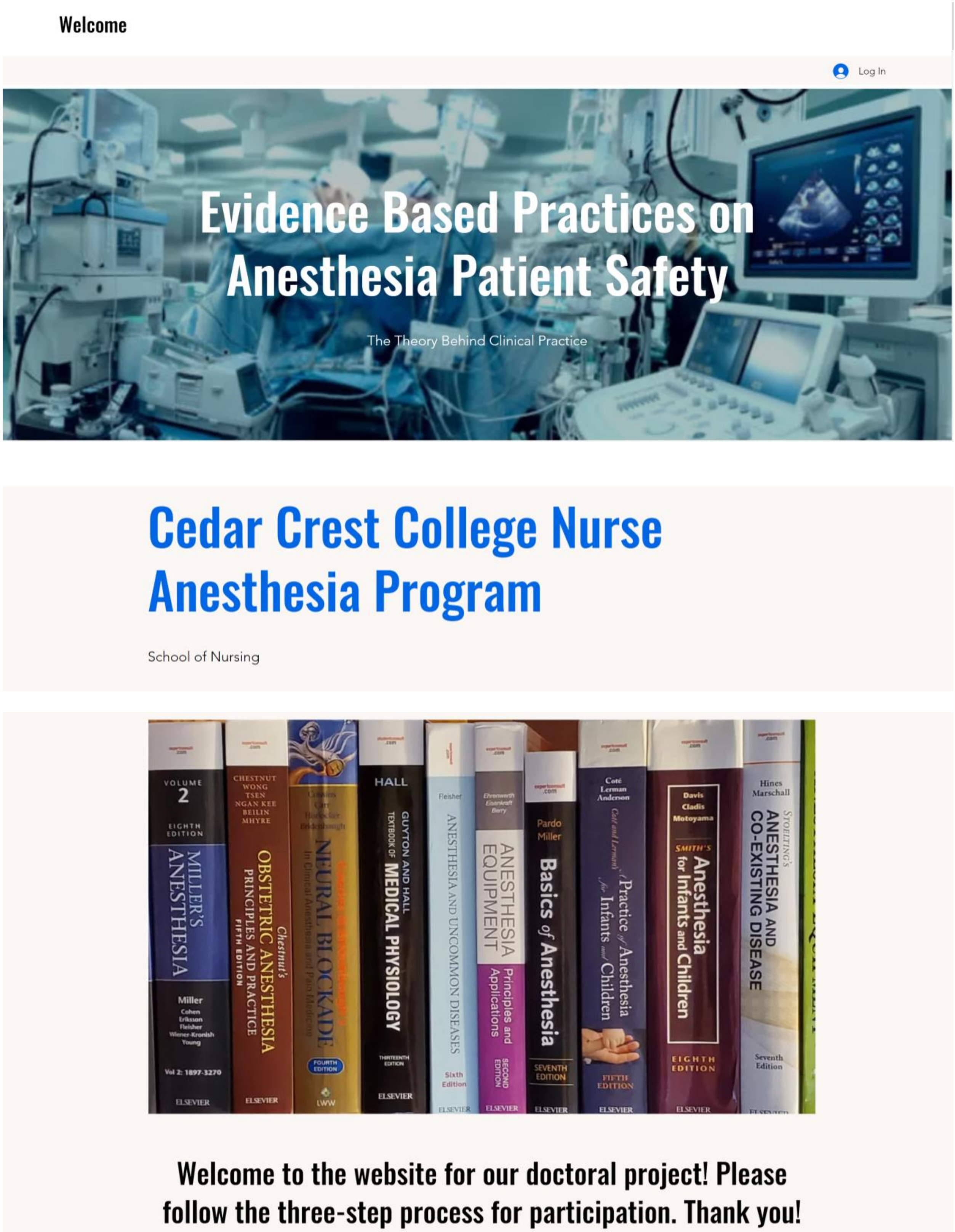
Appendix A

Project Website: https://athernan2.wixsite.com/website



Discussions related to Individual Doctoral Projects:

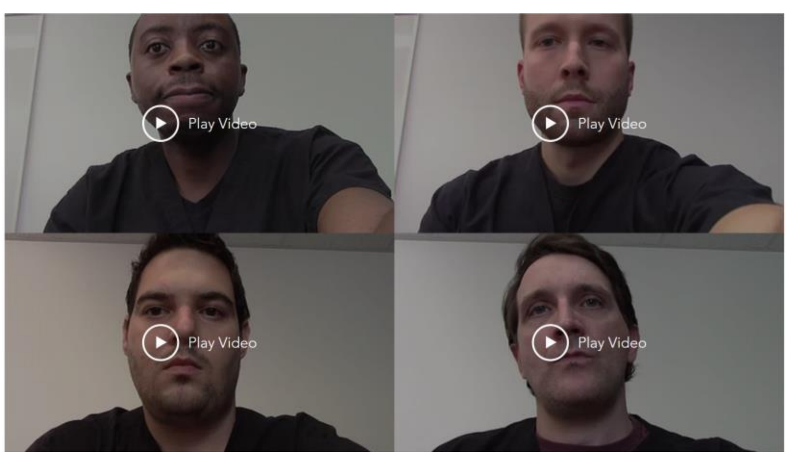
1) Prevention of corneal abrasions
2) Intraoperative multimodal pain management with lidocaine infusions
3) Quantitative neuromuscular monitoring for neuromuscular blocking agents
4) Timing and dosage of reversal agents based on quantitative neuromuscular monitoring

Step #1 - Take Pre-test

Please click the link below to take the Pre-test

Pre-test Survey

Step #2 - Watch Simulation and Supplemental Information Videos



Supplemental Information for Individual Doctoral Projects

Prevention of Corneal Abrasions

By Hakeem Sanou, BSN, RN, CCRN, SRNA

Hsanou@cedarcrest.edu

Download

Intraoperative Lidocaine Infusions

By Dan Byorick, BSN, RN, CCRN, SRNA

dbyoric@cedarcrest.edu

Download

Quantitative Neuromuscular Monitoring

By Anthony Hernandez, BSN, RN, CCRN, SRNA

athernan@cedarcrest.edu

Download

Timing and Dosage of Reversal Agents

By Matt Lohman, MBA, BSN, RN, CCRN, SRNA

Jmlohman@cedarcrest.edu

Download

Step #3 - Take Post-test

Please see the forum's tab above for questions and answers!

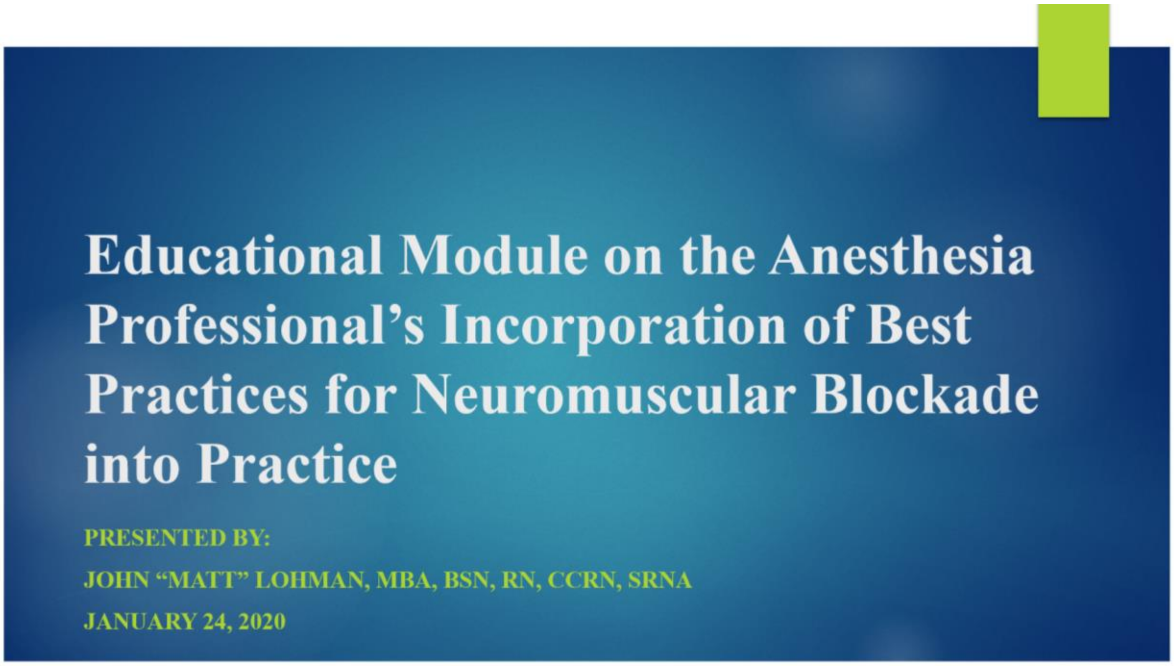
Post-test Survey

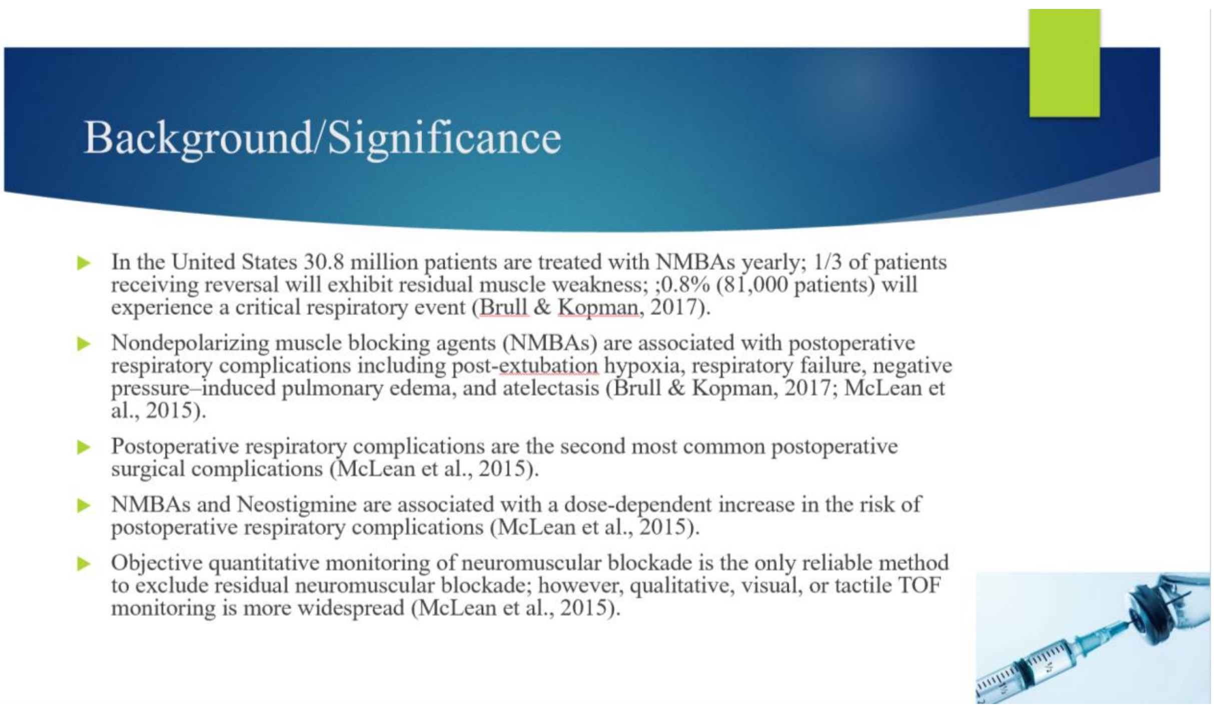
Contact Us

Feel free to get in touch any time with questions regarding our research

100 College Drive, Allentown PA, 18104

Appendix B


Educational Module on the Anesthesia Professional’s Incorporation of Best Practices for Neuromuscular Blockade into Practice
PRESENTED BY:
JOHN “MATT” LOHMAN, MBA, BSN, RN, CCRN, SRNA
JANUARY 24, 2020


Background/Significance
In the United States 30.8 million patients are treated with NMBAs yearly; 1/3 of patients receiving reversal will exhibit residual muscle weakness; ;0.8% (81,000 patients) will experience a critical respiratory event (Brull & Kopman, 2017).
Nondepolarizing muscle blocking agents (NMBAs) are associated with postoperative respiratory complications including post-extubation hypoxia, respiratory failure, negative pressure–induced pulmonary edema, and atelectasis (Brull & Kopman, 2017; McLean et al., 2015).
Postoperative respiratory complications are the second most common postoperative surgical complications (McLean et al., 2015).
NMBAs and Neostigmine are associated with a dose-dependent increase in the risk of postoperative respiratory complications (McLean et al., 2015).
Objective quantitative monitoring of neuromuscular blockade is the only reliable method to exclude residual neuromuscular blockade; however, qualitative, visual, or tactile TOF monitoring is more widespread (McLean et al., 2015).

Peripheral Nerve Stimulator

- A Peripheral Nerve Stimulator (PNS) used to stimulate muscle contractions along a peripheral nerve path and requires a subjective visual and/or tactile assessment of the quantity and quality of twitches evoked.
- The train-of-four (TOF) assessment requires the anesthesia professional to compare the quality of the fourth twitch to that of the first twitch evoked.
- Detection of a fade in the fourth twitch is evidence of residual neuromuscular weakness (Brull & Kopman, 2017).

Quantitative Neuromuscular Monitor

- Like the PNS, the quantitative neuromuscular monitor, for example the acceleromyography, stimulates muscle contractions along a peripheral nerve path and using a piezoelectric technology (Newton's law of motion) to quantify neuromuscular function.
- A train-of-four ratio TOFr is calculated based on the measurement of the strength of the fourth twitch compared to the first twitched evoked.

Depth of Block Subjective vs. Quantitative

Depth of Block	Posttetanic Count	Train-of-Four Count	Subjective Train-of-Four Ratio	Measured Train-of-Four Ratio
Intense (profound) block	0	0	0	0
Deep block	≥ 1	0	0	0
Moderate block	NA	1–3	0	0
Light (shallow) block	NA	4	Fade present	0.1–0.4
Minimal block (near recovery)	NA	4	No fade	> 0.4 but < 0.90
Full recovery (normal function)	NA	4	No fade	≥ 0.90–1.0

NA = not applicable

Brull & Kopman, 2017

Evidence

- Key points:
  - A TOFr of 0.9 is necessary to exclude clinically significant muscle weakness which implies that QNM is warranted (Brull & Kopman, 2017).
  - RNMW and pharyngeal impairment is associated with a TOFr 0.7-0.9 (Adembesa et al, 2018).
  - Once the TOF ratio exceeds 0.4, most clinicians cannot detect either tactile or visual fade.
  - Full dose reversal after full spontaneous recovery may be result in paradoxical weakness (Brull & Kopman, 2017).
  - Implementation of a dosing protocol/cognitive aid based on assessment of NMB was associated with a decrease in amount of postoperative residual weakness (Drzymalski et al., 2019; Rudolph et al., 2018; Santos et al., 2017; Wardhana et al., 2019).
  - After antagonism with subjective assessment, recovery will be grossly incomplete in more than 70% of patients, yet clinicians would be completely unaware of this, unless quantitative neuromuscular monitoring is utilized.
  - Improved use and understanding of quantitative monitors does not change the dosing and timing of reversal agents in a quality improvement project (Bedsworth et al., 2019).

Example of Dosing Protocol

Depth of Block	Neostigmine Dose (mg/kg)	Sugammadex Dose* (mg/kg)
Posttetanic count < 2	Delay reversal	4–16†
Posttetanic count ≥ 2 TOF count 0–1	Delay reversal	2–4†
TOF count 2–4 TOF with fade by tactile or visual means TOF < 0.40‡	0.05–0.07	1.0–2.0†
TOF count 4, no tactile or visual fade TOF = 0.40–0.90‡	0.02–0.03	0.25–0.5†
TOF ratio ≥ 0.90‡	Reversal unnecessary	Reversal unnecessary

*Dose ranges reported in the literature; cited doses may be deviate from package insert recommendations. †When reversing vecuronium, use higher end of dosing range. ‡TOF ratio confirmed by quantitative monitoring.

TOF = train-of-four.

Brull & Kopman, 2017

Evidence (continued)

- Themes identified in review of literature:
  - 1. Quantitative monitoring of neuromuscular blockade is the only reliable measure of depth of blockade.
  - 2. NMBAs and reversal agents should be dosed based on the level of blockade, as evident by the quantitative measurement.
  - 3. Inadequate reversal or failure to achieve a TOFr ≥ 0.9 results in RNMW.
  - 4. A protocol for dosing reversal agents, based on level of blockade, helps to reduce anesthesia provider-to-anesthesia provider variability and RNMW.
  - 5. NMBAs and reversal agents have a dose-dependent level of risk of RNMW.
  - 6. Postoperative complications associated with RNMW are an ongoing issue, despite the advances in technology in quantitative assessment.

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Appendix C

Pretest Questions

1. What is your primary role?
a. Anesthesiologist
b. Certified Registered Nurse Anesthetist
c. Student 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

3. What is your current methodology to assess neuromuscular paralysis? (select all that apply)
a. Qualitative techniques (i.e. PNS)
b. Quantitative techniques (i.e. AMG, EMG, KMG)
c. Physical Assessment
d. No monitoring

4. What degree of paralysis is present when 4/4 twitches are elicited with a peripheral nerve stimulator?
a. 90%
b. 70%
c. 50%
d. 30%

5. Do you implement eye protection to patient's corneal prior to or post mask ventilation/laryngoscopy?
a. Prior to mask ventilation
b. Post mask ventilation

6. What is the appropriate dose of Neostigmine to reverse a TOFr of 0.5 in a patient who weighs TBW:100kg and IBW:70kg?
a. 20mcg/TBW
b. 20mcg/IBW
c. 40mcg/TBW
d. 40mcg/IBW

7. What is the ideal TOFr to achieve prior to extubation?
a. TOFr 0.1
b. TOFr 0.9
c. TOFr 0.8
d. TOFr 0.7

8. What is the recommended infusion rate for multimodal intraoperative lidocaine infusions?
a. 0 – 1 mg/kg/hr IBW
b. 1 – 2 mg/kg/hr IBW
c. 2 – 3 mg/kg/hr IBW
d. Not sure

9. Do you currently use multimodal intraoperative lidocaine infusions in your practice?
a. Yes
b. No

10. Which of the following is not a risk factor for corneal abrasion?
a. Dangling ID badge
b. Pulse oximeter on the index finger
c. Incomplete eyelid closure
d. Taping the eyelid after induction

Appendix D

Posttest Questions

1. Are you willing to change your practice based on the information you were presented about corneal abrasion prevention?
a. Yes, I will make changes based on the highlighted evidence-based recommendations
b. No, I will not make any changes

2. Based on the simulation, when is the best time to initiate eye protection?
a. Prior to intubation
b. After induction

3. What is the recommended infusion rate for multimodal intraoperative lidocaine infusions?
a. 0 – 1 mg/kg/hr IBW
b. 1 – 2 mg/kg/hr IBW
c. 2 – 3 mg/kg/hr IBW
d. Not sure

4. Are you willing to change your practice based on the information you were presented about multimodal intraoperative lidocaine infusions?
a. Yes
b. No

5. What is the appropriate dose of Neostigmine to reverse a TOFr of 0.5 in a patient who weighs TBW:100kg and IBW:70kg?
a. 20mcg/TBW
b. 20mcg/IBW
c. 40mcg/TBW
d. 40mcg/IBW

6. What is the ideal TOFr to achieve prior to extubation?
a. TOFr 0.1
b. TOFr 0.9
c. TOFr 0.8
d. TOFr 0.7

7. Are you willing to make a change in your practice based on the information you were presented about timing and dosing of reversal agents?
a. Yes
b. No

8. What degree of paralysis is present when 4/4 twitches are elicited with a peripheral nerve stimulator?

a. 90%
b. 70%
c. 50%
d. 30%

9. What modality is the MOST accurate at depicting the depth of neuromuscular paralysis?

a. Qualitative techniques (i.e. PNS)
b. Quantitative techniques (i.e. AMG, EMG, KMG)
c. Physical Assessment (i.e. HR, Vt, RR, etc.)
d. Sustained head lift for 5 seconds

10. Which of the following is not a risk factor for corneal abrasion?

a. Dangling ID badge
b. Pulse oximeter on the index finger
c. Incomplete eyelid closure
d. Taping the eyelid after induction

Appendix E

CITI PROGRAM

Completion Date 28-Oct-2018
Expiration Date 27-Oct-2021
Record ID 29250043

This is to certify that:

John Lohman

Has completed the following CITI Program course:

Biomedical Research - Basic/Refresher (Curriculum Group)
Biomedical 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/?w367e2519-8ce2-4085-bb61-016171ceabf8-29250043

Appendix F

IRB Committee Response - Proposal Number 2020-263

Flag for follow up. Start by 6/20/2020. Due by 6/20/2020.

M

mycedarcrest@cedarcrest.edu
Thu 6/18/2020 4:40 PM
To: Daniel Byorick
Cc: Catherine Zurawski; Hakeem Sanou **+2 others**

The IRB Committee has reviewed your proposal and has made the following response:

Proposal Name:	Effectiveness of a Multimedia Educational Module on Best Practices of Anesthesia Patient Safety
Lead Researcher:	Daniel Byorick
Project Advisor:	Catherine Zurawski
Additional Researcher(s)	Hakeem Sanou Anthony Hernandez John Lohman
Committee Response:	Approved by IRB
Comments:	5/28/2020: 6/18/2020:

This document contains personal information from a student's educational records. It is protected by the Family Educational Rights and Privacy Act (20 U.S.C. 1232g) and may not be re-released without consent of the parent or eligible student.

Reply | Reply all | Forward

Appendix G

Dear Participant,

On behalf of the Cedar Crest College: School of Nursing's Nurse Anesthesia Program, we cordially invite you to participate in a doctoral project proposed by four student registered nurse anesthetists. Our project was unfortunately transitioned from the clinical setting to a virtual platform due to the unprecedented times amidst the COVID-19 pandemic. We ask that you participate in our project to help continuously advocate for implementing evidence-based practice into the clinical setting to improve anesthesia patient safety practices.

If you choose to voluntarily participate, you can follow the link below to our custom website for our project. There is a simple 3-step process to follow for participation. Step 1 will consist of a brief 10-question pre-test survey. After completion of the pre-test survey, Step 2 will be to watch our educational module on best practices of anesthesia patient safety. This module consists of four individual topic presentations that are approximately 10 minutes each. After the presentation segment, watch the robust simulation scenario video. The entire duration of the module is approximately 1 hour. After viewing the module, Step 3 will consist of a brief 10-question post-test survey to help us gather pertinent data to test the effectiveness of this educational module. Although this is 100% voluntary, completion and submission of the online survey is an indication of your consent to participate in the project. You can stop participation at any time up until submission of the post-survey, during Step 3.

Institutional Review Board (IRB) approval was obtained prior to the project's implementation. Each student nurse anesthetist author of this project completed the Collaborative Institutional Training Initiative (CITI) training. It is anticipated that participants will be at no physical, psychological, or emotional risk at any time during this project. We assure that all survey data is anonymous and will be collected and stored on an encrypted and password protected electronic device.

Your participation is crucial to the implementation of this project and would be greatly appreciated! Provided below is a link to the website. We hope that you are as interested as we are in advocating for the improvement of evidence-based practices on anesthesia patient safety.

Please feel free to contact any of us with any question, comments, or concerns regarding this project.

WEBSITE LINK:

https://athernan2.wixsite.com/website

Sincerely,

Anthony Hernandez, BSN, RN, CCRN, SRNA
Principle Investigator
Doctor of Nursing Practice Candidate
Cedar Crest College: School of Nursing Nurse Anesthesia Program
athernan@cedarcrest.edu
Phone: (347) 255-5133

Dan Byorick, BSN, RN, CCRN, SRNA
Principle Investigator
Doctor of Nursing Practice Candidate
Cedar Crest College: School of Nursing Nurse Anesthesia Program
dbyoric@cedarcrest.edu
Phone: (570) 574-1642

J. Matt Lohman, MBA, BSN, RN, CCRN, SRNA
Principle Investigator
Doctor of Nursing Practice Candidate
Cedar Crest College: School of Nursing Nurse Anesthesia Program
Jmlohman@cedarcrest.edu
Phone: (610) 914-7502

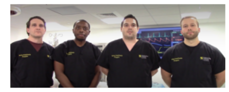
Hakeem Sanou, BSN, RN, CCRN, SRNA
Principle Investigator
Doctor of Nursing Practice Candidate
Cedar Crest College: School of Nursing Nurse Anesthesia Program
Hsanou@cedarcrest.edu
Phone: (267) 298-8511

Appendix H

Efficacy of a Multimedia Educational Module on Best Practices of Anesthesia Patient Safety

Cedar Crest College
School of Nursing

Anthony Hernandez, BSN, RN, CCRN, SRNA, Daniel Byorick, Jr., BSN, RN, CCRN, SRNA,
J. Matthew Lohman, MBA, BSN, RN, CCRN, SRNA, and Hakeem Sanou, BSN, RN, CCRN, SRNA



Background

- The Institute of Medicine set a goal that by 2020 that 90% of all clinical decisions are to be supported by accurate and timely evidence-based research (Lehane et al., 2019).
- E-learning has proven to be an efficient way of translating EBP findings into current practice for both new and experienced providers (Elkman, 2018). Surveys show that nursing learners are both satisfied with virtual learning and find it an effective means of education (Rouleau et al., 2019).
- Anesthesia providers are responsible to ensure that patient safety is maintained, therefore it is crucial to continually update standards of care with evidence-based practices (EBPs). Since the COVID-19 pandemic placed an insurmountable amount of stress on the healthcare delivery system, the Doctor of Nursing practice (DNP) projects were unable to be carried out in the clinical setting. Therefore, a group of senior student registered nurse anesthetists collaborated to create a multimedia simulation-based educational module about current EBPs for anesthesia patient safety
- Corneal abrasion (CA) are the most common eye complications during general anesthesia. Their prevalence ranges from as low as 0% and up to 44% without evidence-based prophylactic measures. EBP recommendations include taping the eyelids after induction, careful application and removal of tape, and developing educational initiatives to increase providers knowledge on CA risk factors (Grixti et al., 2013; Papp et al. 2019).
- Intraoperative lidocaine infusions have evidence to decrease opioid consumption, reduce postoperative constipation, nausea/vomiting, ileus, and pruritis, and decrease length of hospital stay when compared to opioid monotherapy (Eipe, Gupta, & Penning, 2016; Moeen & Moeen, 2019; Cooke et al., 2019).
- Quantitative neuromuscular monitoring allows for an objective real-time measure of neuromuscular responses to train of four (TOF) stimulation and is a more accurate tool when compared to the traditionally used peripheral nerve stimulator (Bhananker et al., 2015; Grabitz et al., 2019).
- Neuromuscular blocking agents (NMBAs) and reversal agents should be dosed based on the level of blockade and quantitative measurement. A protocol for dosing reversal agents, based on level of blockade, helps to reduce anesthesia provider-to-anesthesia provider variability and residual muscle weakness (Brull & Kopman, 2017; Rudolph et al., 2018).

Purpose

- Objectives:
  - 1. To improve anesthesia providers' knowledge on topics of anesthesia safety which include: corneal abrasion prevention, intraoperative lidocaine infusions, the use of quantitative neuromuscular monitoring, and timing/dosing of reversal agents through a multimedia educational intervention.
  - 2. Create a willingness to change one's clinical practice based on EBP recommendations

PICO Question

In anesthesia providers, does a multimedia simulation-based educational intervention increase knowledge about current best practice for patient safety, monitoring, and administering medications in accordance with evidence-based practice (EBP) guidance?

Methodology

- Collaboration with multi-institutional anesthesia stakeholders, leaders, coordinators, providers, and educators occurred to obtain common patient safety concerns within the clinical arena
- Cognitive Theory of Multimedia Learning (CTML) provided the theoretical framework to develop the multimedia educational module to bridge the gap between purposeful learning and how the human mind operates.
- A multimedia education module was created with four individual 10-minute EBP anesthesia patient safety videos with supplemental materials and one 12-minute robust simulation-based scenario demonstrating the patient safety recommendations.
- Objectives were measured using a 10-question pre/post surveys which paired individual participant responses.
- The pre-survey included 2 demographic-based questions, 6 knowledge-based questions, and 2 current participant practice questions. The post-survey included 6 knowledge-based questions, 3 willingness to change practice questions, and 1 assessment question
- Implementation spanned a two-week period from January 23, 2021 to February 5, 2021 to permit for adequate time for participants to complete the modules and pre/post surveys.
- A convenience sample of 40 anesthesia professionals was used for data collection purposes.

Results

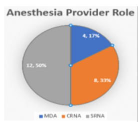
- Of the 40 anesthesia professionals who were invited, 60% (n=24) were full participants in the project with varying levels of experience:

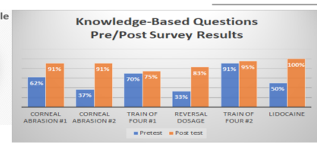
Table 1: Demographics

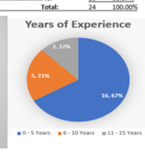
		N	% Total		Category	N	%Total
Anesthesia Role:	MDA	4	16.67%	Years of Experience:	0-5 years	16	66.67%
	CRNA	8	33.33%		6-10 years	5	20.83%
	SRNA	12	50.00%		11-15 years	3	12.50%
Total Sample Size:		24	100.00%	Total:	-	24	100.00%

Table 2: Current Practices:

Question:		N	% Total
Current methodology to assess neuromuscular paralysis:	Qualitative:	22	91.67%
	Quantitative:	2	8.33%
	Total:	24	100.00%
Intraoperative use of Multimodal Lidocaine Infusions:	Yes:	8	33.33%
	No:	16	66.67%
	Total:	24	100.00%







Knowledge-based Questions:

- McNemar's Test was used to evaluate the frequency of correct responses in each of the pre/post survey knowledge-based questions pairs. A 95% confidence level (α= 0.05) was selected to evaluate the significance of the results.

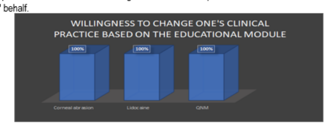
Table 3: Survey Question P - Values

Corneal Abrasions #1	p = 0.002	Reversal Dosing	p = 0.004
Corneal Abrasions #2	p = 0.016	Train of Four	P = 1.000
Train of Four #1	P = 1.000	Lidocaine	P = <0.001

- A paired t-test was used to evaluate the collective correct responses in pre/post survey of knowledge-based question pairs for the module.
  - Sample mean for pre-survey of 14 and a sample mean for post-survey of 21.33. Observed difference of 7.33 was tested and resulting p=0.0218.
- Post-survey assessment of which modality is the most accurate at depicting the depth of neuromuscular paralysis, 100% (n=24) of participants chose quantitative neuromuscular monitoring.

Willingness to Change Clinical Practice:

- 100% (n=24) of participants showed a willingness to make a practice change based on the education received for all topics of anesthesia patient safety based post-survey data.
- Despite inferential analysis showing statistical significance for most knowledge-based questions, the goal was to acquire clinical significance. Knowledge acquisition of EBP's resonates throughout the healthcare profession as the foundation for making informed, educated, and smart decisions on patients' behalf.



Conclusions

- The fourfold increase in odds of correctly answering the knowledge-based questions after reviewing the module infers that participants' knowledge increased related to the anesthesia patient safety topics.
- This project's outcome has shown that when anesthesia providers are provided with current evidence, providers are willing to change one's practice based on evidence-based recommendation.
- The knowledge that participants acquired from the simulation-based educational module will ultimately reduce the incidence of corneal abrasion, post-operative pain and opioid consumption, and residual neuromuscular blockade.
- It can be inferred that increased knowledge and willingness to change practice based on the EBP recommendations from the module will lead to improved anesthesia patient safety, decreased healthcare costs, and increased patient satisfaction and positive outcomes.
- Limitations: research design, validity of the data collection tool, small sample size, lack of generalizability

References