MALIGNANT HYPERTHERMIA CRISIS: IMPROVING KNOWLEDGE, RECOGNITION, AND PREPAREDNESS OF THE LABOR AND DELIVERY REGISTERED NURSE

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Table of Contents

Dedication and Acknowledgments

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Abstract

Background: Malignant Hyperthermia or Malignant Hyperpyrexia (MH) is a rare, potentially lethal patient syndrome caused by a hyper-metabolic state that can be precipitated by the administration of volatile inhalational anesthetic agents or a depolarizing neuromuscular blocking agent. **Purpose:** The purpose of this DNP project is to provide education, increase awareness, and increase proficiency in early recognition and management of an MH crisis, specifically relating to labor and delivery nurses. **Methods:** A quantitative methods design was used to evaluate knowledge and confidence following the education and mock MH scenario. The quantitative data collected was divided into two categories, category A and category B. Category A consisted of the entire sample of participants (n=20) who completed either the pre-evaluation survey or the post-evaluation survey. Category B was the sample of participants who completed both the pre-evaluation and post-evaluation surveys (n=20). Each category underwent descriptive statistical analysis while the paired questionnaires were evaluated using paired t-tests to determine statistical significance. **Results:** Results provided information consistent with increased average mean scores of both knowledge and confidence across all categories. The education provided will be incorporated into the unit's annual competency training and orientation program for L&D nurses at this facility. **Recommendations and Conclusion**: The results of this project have shown that knowledge and confidence improved for the L&D registered nurse. It is recommended that MH crisis management training be incorporated into the new employee orientation and annual continuing education program.

"Key Words" Malignant Hyperthermia simulation, Malignant Hyperthermia in Labor and Delivery, crisis management, simulation.

Background and Significance

Malignant Hyperthermia or Malignant Hyperpyrexia (MH) is a rare, potentially lethal patient syndrome caused by a hyper-metabolic state that can be triggered by the administration of volatile inhalational anesthetic agents or a depolarizing neuromuscular blocking agent (Fracassi et. al, 2017).

Education to all nursing staff caring for patients undergoing procedures or surgery that utilize the anesthesia triggering agents is essential. Although MH is a rare event, reaction and recognition to the initial signs and symptoms followed by prompt treatment is essential to ensure effective, life-saving treatment. However, the awareness, foundational knowledge base, and confidence of the provider to recognize and respond to an MH crisis may be inadequate given the rarity of this critical event. It is essential to be prepared for this rare event which has a very high risk of death if it occurs without immediate treatment with Dantrolene (Cain et al., 2014). It has been suggested that providers manage critical events, such as MH, at an accelerated rate more quickly after participating in event-specific, simulation-based training and education (Park et al., 2010). Simulation of low-volume catastrophic events has been shown to increase the knowledge and knowledge retention of perioperative healthcare workers while simultaneously improving self-confidence, communication, and teamwork (Bevil et al., 2020).

There is a lack of training and knowledge regarding appropriate measures to adequately manage and recognize the occurrence of an MH crisis in labor and delivery (L&D) nurses. Volatile inhalational anesthetic gases and succinylcholine used during cesarean section are the same agents used by anesthesia providers in the main surgical operating rooms. Although the intraoperative period is the most common time of occurrence for MH to develop, signs and symptoms may not appear for twelve hours after the administration of triggering agents.

According to Harvard Health Publishing (2018), symptoms of malignant hyperthermia usually occur within the first hour after exposure to the triggering medications but can be delayed for up to 12 hours. L&D nurses must be prepared so that they can respond appropriately to an MH crisis. After completion of general anesthetic and the delivery of a newborn, L&D nurses are the responsible providers for the parturient during after an emergent or scheduled C-section. Because general anesthesia is infrequently administered for cesarean section, L&D staff will rarely encounter an MH crisis. With proper training and education, however, L&D nurses will be more prepared to manage an MH crisis if it were to occur and ultimately lead to increased patient safety and improved outcomes.

Purpose

The purpose of this DNP project is to provide education, increase awareness, and promote early recognition and management of an MH crisis for L&D nurses.

The objectives of this DNP project are as follows:

- To determine L&D registered nurses' baseline knowledge of MH crisis management.
- To identify L&D registered nurses' confidence in MH management.
- To develop a hands-on MH crisis management simulation in a local hospital setting.
- To measure knowledge, confidence, and recognition of L&D registered nurses prior to an educational PowerPoint presentation and hands-on MH crisis simulation, and again four weeks post-intervention.

The long-term goal is to provide a durable educational tool that is useful for the L&D staff and assists them with the recognition of the signs and symptoms of an MH crisis and the

evidence-based treatment plan. A PowerPoint presentation will be provided, and an educational simulation will be provided for the staff to participate. It is anticipated that this will lead to the integration of MH simulation training and education for new registered nurses on the L&D unit during their initial orientation.

Review of Current Evidence

The UNC Greensboro online library advanced search tool was used to search PubMed, ProQuest Central, and CINAHL databases. Keywords "malignant hyperthermia", "PACU", "labor and delivery", "simulation training", and "post-operative", were used alone or in conjunction with "AND" as the Boolean operator. The searches were limited to the past ten years and full-text publications. Over fifty articles meeting the criteria were identified. Exclusion criteria included publication language, article type, or year of publication. To establish an enhanced foundation of how the topic has been presented in the past by previous graduate students, the keywords "malignant hyperthermia", "PACU", "labor and delivery", and "simulation training" were entered individually into university DNP repositories from Northshore University, University at Buffalo, University of Pittsburgh, Southern Illinois University Edwardsville, and Vanderbilt University. The UNC at Greensboro online library advanced search tool was also used to further narrow search results.

History of Malignant Hyperthermia

In July 1960, the first paper was published which identified an inherited condition that would eventually be named Malignant Hyperthermia Syndrome (MH). Malignant Hyperthermia Syndrome had never been previously described in any of the medical journals or anesthesia literature. By the mid-1960s, cases similar to the first had been reported all over the world. By 1966, the first symposium on MH was published in the Canadian Journal of Anesthesiology.

When MH was first recognized as a complication of anesthesia, the mortality rate was 70-80%, (Britt & Kalow, 1970). By the mid-1980s MH was defined by not only the clinical manifestations of the syndrome but also by its reversibility with Dantrolene. Litman et al. (2005) suggest improved monitoring standards, allowing for early detection of hypercarbia during general anesthesia, and the availability of dantrolene have reduced the mortality from acute MH to less than 5%. According to Kim (2012), "Even though the mortality rates of MH are low, the morbidity rate of MH is 34.8%. High morbidity rates emphasize the need for continuing education to promote early diagnosis and treatment MH" (p. 392). In an in-depth review Rosenberg et al. (2015) reported the estimated incidence of MH in children to be about 1:10,000 anesthetics and in adults, 1:50,000 anesthetics.

Clinical Manifestations of MH

Manifestations of MH are precipitated by volatile anesthetic agents such as isoflurane, sevoflurane, desflurane, halothane, and enflurane, either alone or in conjunction with the depolarizing muscle relaxant, succinylcholine (Rosenberg et al., 2015). These triggering substances cause the uncontrolled release of calcium from the sarcoplasmic reticulum through the skeletal muscle calcium release channel RyR1, resulting in uncontrolled and sustained skeletal muscle contraction and cellular hypermetabolism.

In classic MH presentation, the initial signs are tachycardia, rapidly rising end-tidal $C0_2$, and tachypnea. Elevation of end-tidal CO_2 greater than 55 mmHg is one of the earliest signs of MH. Heart rate and blood pressure may increase and are often associated with ventricular arrhythmias induced by sympathetic nervous system stimulation from hypercarbia, hyperkalemia, and catecholamine release (Riazi, 2018). Muscle rigidity or increased muscle

tone may become apparent as the core body temperature increases at a rate of 1°-2° C every five minutes.

Of note, an MH episode may not occur with every exposure to "trigger" agents; clinical manifestations depend on genetic predisposition, the dose of the triggering agent, and the duration of exposure to the trigger (Larach et al., 2010). MH commonly occurs in the early postoperative period, usually within the first hour of recovery from anesthesia. Typically, tachycardia, tachypnea, hypertension, and arrhythmias preclude an MH episode.

Malignant hyperthermia (MH) is a rare, potentially lethal patient syndrome caused by a hyper-metabolic state precipitated by the administration of volatile inhalational anesthetic agents or depolarizing muscle relaxants. It is essential to be prepared for this rare event which carries a very high risk of death without immediate recognition and treatment (Fracassi et al., 2017).

The Centers for Medicare and Medicaid Services (CMS) released data in 2016 showing that, from 2011 through 2015, inspections at eight hospitals and health systems revealed deficiencies related to MH preparedness. Commonly identified deficiencies included an insufficient supply of dantrolene and a lack of staff training in the drugs administration, (Traynor, 2016). A literature review of the response to an MH crisis by L&D registered nurses in the operating room and recovery area, revealed a need for better preparation as well as the importance that hospitals respond appropriately to cases of MH (Fracassi et al., 2017).

The Malignant Hyperthermia Association of the US (MHAUS) is a national organization dedicated to educating, advising, helping, encouraging and supporting healthcare professionals, medical facilities, patients and their families, and continuing research for MH. MHAUS provides a myriad of MH resources and has a national crisis intervention hotline number.

Prevention, Management, and Treatment of MH

Treatment of manifestations: Early diagnosis of an MH episode is essential. Successful treatment of an acute episode of MH includes discontinuation of potent inhalation agents and succinylcholine; increase in minute ventilation to lower end-tidal CO_2; use of MHAUS helpline; administration of dantrolene sodium intravenously; cooling measures if body temperature is >38.5° C; treatment of metabolic abnormalities; treatment of cardiac arrhythmias if needed with the exception of calcium channel blockers; monitoring blood gases, serum concentrations of electrolytes and CK, blood and urine for myoglobin, and coagulation profile. Even with treatment and survival, the individual is at risk for life-threatening renal failure, disseminated intravascular coagulation (DIC), compartment syndrome, and recrudescence of the syndrome within the first 24-36 hours following the episode (Larach et al., 2010).

Prevention of primary manifestations*:* Individuals with MHS should not be exposed to potent volatile agents and succinylcholine. Patients with MHS undergoing general anesthetia that exceeds 30 minutes in duration should have their temperature continuously monitored (Larach et al., 2010). Early diagnosis and treatment are lifesaving and lead to a reduction of complications. It should be noted that modern anesthetic care and monitoring often allow for early detection of MH.

Treatment with dantrolene results in much lower morbidity and mortality than when MH was recognized in the 1960s (Larach et al., 2008); however, mortality may still be as high as 11% (Rosero et al., 2009). The likelihood of complications increases 2.9 times per 2° C increase in maximum temperature and 1.6 times per 30-minute delay in dantrolene administration (Larach et al., 2010). It has been suggested that all facilities have a plan to deal with MH and hold practice drills at regular intervals.

According to MHAUS (2018), all locations utilizing drugs that can trigger an MH crisis need to have protocols in place to respond appropriately. There is little published specific to MH protocols for L&D personnel. Cain et al., (2014), suggest many clinicians are unprepared to manage an MH crisis in the perioperative setting because it requires the use of low-frequency, high-risk skills and procedures. This is especially true of L&D nurses due to the limited use of general anesthesia in obstetrics. In a cross-sectional study Greenfield et al., (2014) surveyed obstetric nurses' knowledge of BLS and ACLS protocols, management of cardiac arrest, and basic airway management. The L&D nurses were then asked which key topics were encountered occasionally or more often in their clinical practice. The findings from this study were quite remarkable in that the obstetric nurses' responses yielded a 96% (46/48) encounter rate with ACLS. However, only 33% (16/48) felt confident in managing an emergency crisis. These results demonstrate the need for continuing education and simulation-based training related to emergencies on the L&D unit.

Diagnosis/Genetic Testing

Malignant hyperthermia susceptibility (MHS) is an autosomal dominant disorder. Autosomal dominant inheritance of a trait results when an individual inherits a copy of the mutated gene from one parent, causing the genetic condition. Offspring then have a 50% chance of inheriting a mutated gene from an affected parent. Although either parent may possess the mutated gene it does not mean they have or will experience an MH episode. The diagnosis of MHS is confirmed with vitro muscle contracture testing by measuring the contracture responses of biopsied muscle samples to halothane and graded concentrations of caffeine. The primary gene which has been definitively associated with MH causative mutations is on the RYR1 (Rosenberg et al., 2015).

Using Simulation for Perioperative MH Training

Preparation for an MH crisis is crucial for all clinical professionals involved with patient care in settings where general anesthesia is administered. These professionals have a responsibility to react swiftly and appropriately in the event of an MH crisis. The necessity for continuing education in conjunction with simulation-based training exercises is supported in an article by Park (et al., (2020). The authors suggest that healthcare providers can adequately manage critical events, such as MH, more quickly after participating in event-specific, simulation-based training and education. Furthermore, simulation of low-volume catastrophic has been shown to promote increased knowledge and knowledge retention in perioperative healthcare workers while simultaneously improving self-confidence, communication, and teamwork (Bevil et al., 2020). Simulated experience is an efficient training method that provides a conduit between formal education and professional practice. In a quality improvement study by Cain et al. (2014), providing simulation-based learning to perioperative personnel, led to early recognition, treatment, and management of MH.

Conceptual Framework/Evidence Based Practice Model

Jerome Bruner's Discovery Learning Theory was used to frame this DNP project. This theory is a constructivism theory that builds off the works of Jean Piaget and Seymour Papert. Bruner describes discovery learning as a method where individuals in problem-solving situations draw on previous knowledge and experiences to build and improve knowledge through questioning, manipulating, and experimenting (1961). Essentially, there is a foundation of knowledge, and upon this foundation, greater or new knowledge is achieved through increased personal experiences with an emphasis on hands-on experimentation. A principle of learning

theory is that learners are more likely to remember tangible learning experiences in comparison to traditional classroom education through lecture and text.

Bruner's discovery learning theory has led to various learning models, including simulation-based learning. The simulation of an MH crisis will introduce L&D staff to a critical event that they may have only read or heard about, but likely have not witnessed in clinical practice. According to Bruner's theory (1961), providers will have a greater understanding of the clinical manifestations of MH and the correct sequence of events that is needed to prevent catastrophic outcomes in this low volume, high acuity event. As a result of the discovery learning theory, learners are more likely to remember tangible learning experiences in comparison to traditional classroom education. Hirshey-Dirksen et al., (2013), suggest high fidelity simulation combined with lectures can assess learners' current skill levels and identify areas in need of improvement. This combination of learning also provides learners with the repetition needed to acquire the knowledge and skills necessary to manage high-impact events such as MH in a safe learning environment.

Knowledge retention of MH management was assessed four weeks post-simulation. The expected outcomes are increased awareness and proficiency in early recognition and management of an MH crisis by L&D registered nurses. Furthermore, when challenged with an MH event, confidence and proficiency should lead to effective management and improved patient outcomes.

Methods

There is a lack of training and knowledge regarding appropriate measures to adequately manage and recognize the occurrence of an MH crisis in the L&D nurse population. Simulation of low-volume catastrophic events has been shown to increase knowledge and knowledge

retention of perioperative healthcare workers while simultaneously improving self-confidence, communication, and teamwork (Bevil et al., 2020). The purpose of this DNP project is to provide education, increase awareness, and increase proficiency in early recognition and management of an MH crisis.

Design

A quality improvement (QI) project using a quantitative methods approach was used to evaluate knowledge, recognition, and confidence following the education and a simulated MH event. A quantitative design allows a better understanding of perioperative staff knowledge and confidence. This was achieved by gathering quantitative data from the sample, analyzing the data, and adding qualitative measures to improve the understanding of the project question.

When the DNP scholarly project intends to initiate change through an intervention or innovation, the choice of design includes experimental research or a QI approach (Polit & Beck, 2012). In clinical practice, this design is capable of measuring the change in a health-related outcome after treatment or intervention when it is not feasible to use a true experiment.

The L&D MH project consisted of three parts. First, a pre-test was administered to the sample before any educational interventions. Second, a PowerPoint presentation and hands-on simulation drill occurred after the pre-test was administered. Lastly, a post-intervention survey was administered approximately three to four weeks after the presentation. The pre-test and post-test were identical and consisted of 13 questions that focus on MH causes, signs and symptoms, treatment, staff responsibilities, location of MH cart, and who, when, and how additional personnel are to be notified in the event of an MH crisis.

Translational Framework

The Iowa Model of Evidence Based Practice is a model developed in the 1990s used to help drive practice change through the implementation of evidence found in research (Buckwalter et al., 2017). This model was utilized in this project as it provides a pathway to help identify and implement practice change.

The first step in the Iowa model is to identify opportunities for clinical improvements. For this project, an improvement of labor and delivery registered nurses' knowledge, recognition, and confidence regarding MH and the steps to take following recognition of an MH crisis have been identified as critical needs at the project site. The purpose of this project is to increase the L&D staffs' knowledge, recognition, and confidence when encountering an MH crisis.

The next steps in the Iowa model are to determine if this topic is a priority, form a team, and conduct research. MH is a priority at this site due to the current lack of systematic training for MH events for new and current staff. A team has been formed consisting of the unit clinical educator, the unit manager, the MH site champion, and a designated L&D nurse, all of whom are in charge of the development, updates, and continued education at the project site. Research was conducted and the current literature was reviewed, assembled, and synthesized to assess how to improve current systems. Sufficient evidence in improving current systems and increasing knowledge and comfort levels of staff has been demonstrated by the use of education and simulation of high acuity, low-frequency events such as MH (Cain et al., 2014).

Designing and piloting the practice change, determining if the change is appropriate, integrating and sustaining the practice change, and disseminating results are the final steps to the Iowa model. Before the implementation of the project a paper copy pre-intervention survey was

administered to the participants to assess baseline knowledge, recognition, and confidence. The survey topic areas included emergency situations such as cardiac arrest, basic airway management, MH symptom recognition, and crisis management. The design of this project engages the staff by providing education and subsequently allowing the staff to utilize the newly acquired knowledge in an interactive hands-on MH simulation drill. An identical post-intervention survey was then administered via an online survey tool approximately three to four weeks post-implementation.

Population

The target population was the L&D nursing staff at a local, urban hospital in Raleigh, NC. A convenience sampling of the L&D nurses was used to obtain participants for the study. A recruitment email was forwarded to the unit clinical educator and was then distributed to the L&D staff. The inclusion criteria for this study were those clinicians working in the L&D unit. Registered nurses that do not work in the L&D unit were excluded from participation in this project.

Setting

The project took place in the Women's Health Center at a local urban hospital in Raleigh, NC. This facility is a private, not-for-profit health care system, containing 665 inpatient beds. Approximately 31,000 procedures are performed at this location annually and services are provided for people of all ages. Operative services and procedures for patients include orthopedic, bariatric, obstetrics and gynecology, general, plastic, podiatry, ophthalmology, urology, heart & vascular, neurology and ear, nose, and throat procedures.

Project Implementation

To obtain the largest sample size possible, two educational sessions were conducted in a classroom setting. These sessions included an educational MH PowerPoint presentation that illustrated clear objectives to participants which had been met by the end of the presentation (Appendix A). The PowerPoint presentation was then followed by a hands-on MH simulation. Prior to the educational session all participants took a pre-evaluation survey. A post-intervention evaluation was then completed approximately three to four weeks after completion of the educational presentation and MH simulation drill.

The MH simulation introduced L&D nurses to a critical event they may have previously read or heard about but had not experienced in clinical practice (Appendix B). According to Bruner's theory, "providers will have a greater understanding of the clinical manifestations of MH and the correct sequence of events that is needed to prevent catastrophic outcomes in this low volume, high acuity event" (Bruner, 1961). Furthermore, when challenged with an MH crisis, early recognition, along with increased confidence and proficiency, will lead to effective management and decreased patient morbidity and mortality.

Instruments

Upon arrival at project implementation, participants were given the Pre-Intervention Evaluation Instrument (Appendix C). The Pre-Evaluation Instrument portion was utilized to evaluate the participants knowledge of MH and comfort of dealing with an MH event. The Pre-Evaluation instrument consisted of five-point Likert items consisting of the following five options: 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree. 1 = (SD) corresponds to lack of knowledge or confidence, while 5 = (SA) corresponds to a great knowledge or confidence.

After three to four weeks post-education and simulation provided by the PI, the participants were given an MH Post-Intervention Instrument (Appendix C). This instrument included the same information provided on the MH Pre-Intervention Instrument.

Timeline and critical milestones

The first session was completed on November 2nd, 2021, for nurses who were leaving their 7a-7p shift. The second session was completed on November 21st, 2021, for nurses who were coming in to work their 7a-7p shift. All post-evaluations were returned by January 10th, 2022.

IRB approval

Prior to the implementation of the project, participants were sent an email discussing the purpose of the project, specific details and risks of participating, objectives to be completed, and the procedures to maintain anonymity (Appendix D). Participant confidentiality was maintained by creating a personal participant identifier using the first letter of their last name and the last four digits of their phone number. Prior to the completion of the IRB application, approval was obtained from the hospital's IRB review board, the anesthesia department, and the L&D unit manager and nurse clinical educator. Once all approvals were obtained, the IRB application was created and submitted for approval through the online application service.

How data were collected

Following a brief introduction, the participants received a paper information sheet and the pre-intervention questionnaire. Following survey completion, a thirty-minute education session commenced followed by a mock patient scenario simulation. A follow-up anonymous, post-intervention online survey was provided for participants to complete approximately one month after initial education and simulation intervention.

Data collection remained anonymous and posed minimal risks to the participants. Participant information was kept anonymous by linking surveys with participants first initial of their last name followed by the last four digits of their telephone number. This created an arbitrary, systematic approach to identify respondents in order to link pre-and post-survey responses. The quality improvement project results will be shared with the L&D clinical educator and nurse manager. Only the PI and the DNP faculty will have access to the de-identified data. All information in this project will be kept confidential unless disclosure is required by law.

Data Analysis

The data was initially analyzed using descriptive statistics. Data were grouped into two categories. Category A consisted of the entire sample of participants who completed the pre-evaluation survey (n=20) or who completed the post-evaluation survey (n=20). Category B was the sample of all the participants who completed both the pre-intervention evaluation and post-intervention evaluation surveys (n=20).

Category A was subdivided into two separate groups. Category A_1 entailed the responses from the pre-evaluation survey (n=20). These responses were separated by each of the 13 questions on the survey and the percentage of response rates for each Likert-scale category (strongly disagree, disagree, undecided, etc.) was tabulated for each question. The average of these response rates was then calculated. The same was done for Category A_2 which was the number of participants who completed the post-evaluation survey (n=20). Finally, the average response rate for each Likert-scale category (strongly disagree, disagree, undecided, etc.) was compared in both groups (pre- and post-evaluation surveys).

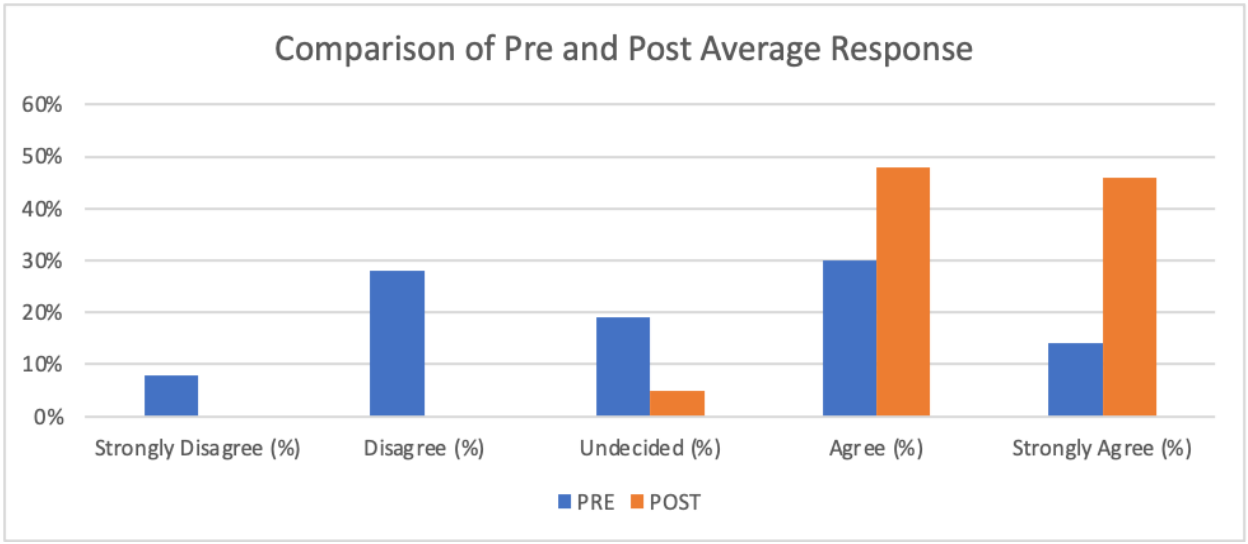
Category B was analyzed using paired t-tests comparing this category's pre-evaluation survey responses to the post-evaluation survey responses. The purpose of this analysis was to focus on the mean results as well as the p-values to determine any statistical significance between the two surveys due to the education and simulation intervention.

Results

The results of Category A showed an average response rate of the pre-intervention evaluation survey scores as follows; *Strongly Disagree* (8%), *Disagree* (28%), *Undecided* (19%), *Agree* (30%), and *Strongly Agree* (14%). The average response rates of the post-intervention evaluation survey scores are as follows; *Strongly Disagree* (0%), *Disagree* (0%), *Undecided* (5%), *Agree* (48%), and *Strongly Agree* (46%).

Figure 1

Comparison of Pre-and Post-Intervention Survey Average Responses

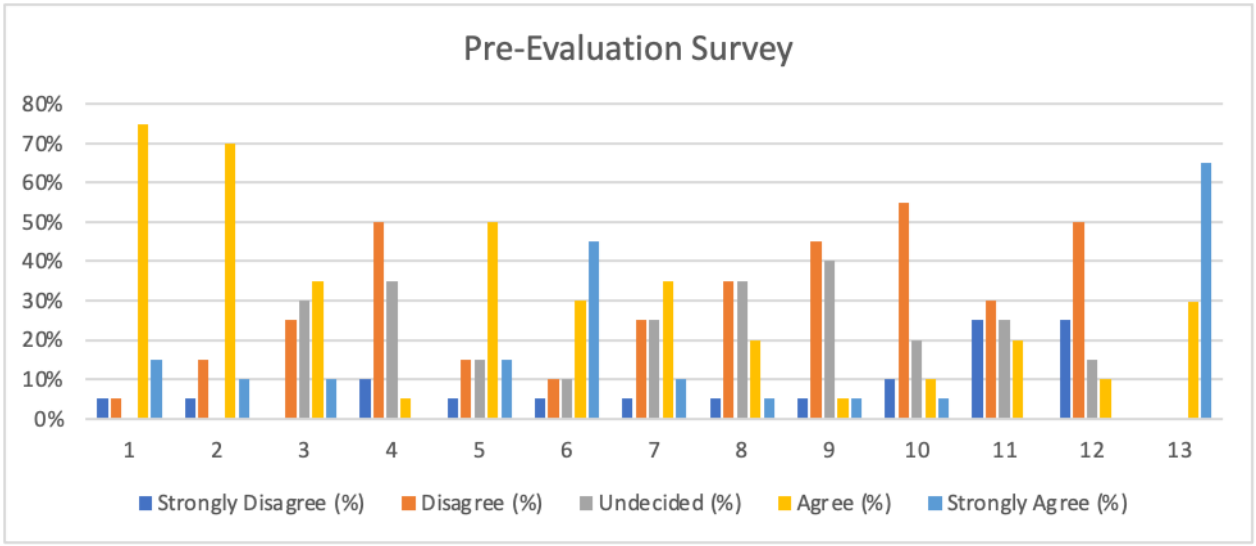


Note. Results comparing the pre-and post-surveys' average response rates of the L&D nurses before and after the intervention are shown in Figure 1.

Category B showed that the average mean scores between pre- and post-evaluation surveys increased for each of the 13 questions. Comparing the average response rates of the pre- and post-evaluation survey scores is as follows; *Strongly Disagree* decreased by (8%), *Disagree* decreased by (28%), *Undecided* decreased by (14%), *Agree* increased by (18%), and *Strongly Agree* increased by (32%). The average response rate for all but one question (question 13) showed p-values that were statistically significant ($p<0.05$). The statistically significant data for each of the 12 questions are as follows: question 1 ($p=0.008$), question 2 ($p=.00003$), question 3 ($p=.00003$), question 4 ($p=3.4595E-9$), question 5 ($p=0.0004$), question 6 ($p=0.014$), question 7 ($p=5.0987E-6$), question 8 ($p=2.2929E-7$), question 9 ($p=1.9983E-8$), question 10 ($p=2.2286E-8$), question 11 ($p=9.4881E-7$), and question 12 ($p=1.6503E-8$).

Figure 2

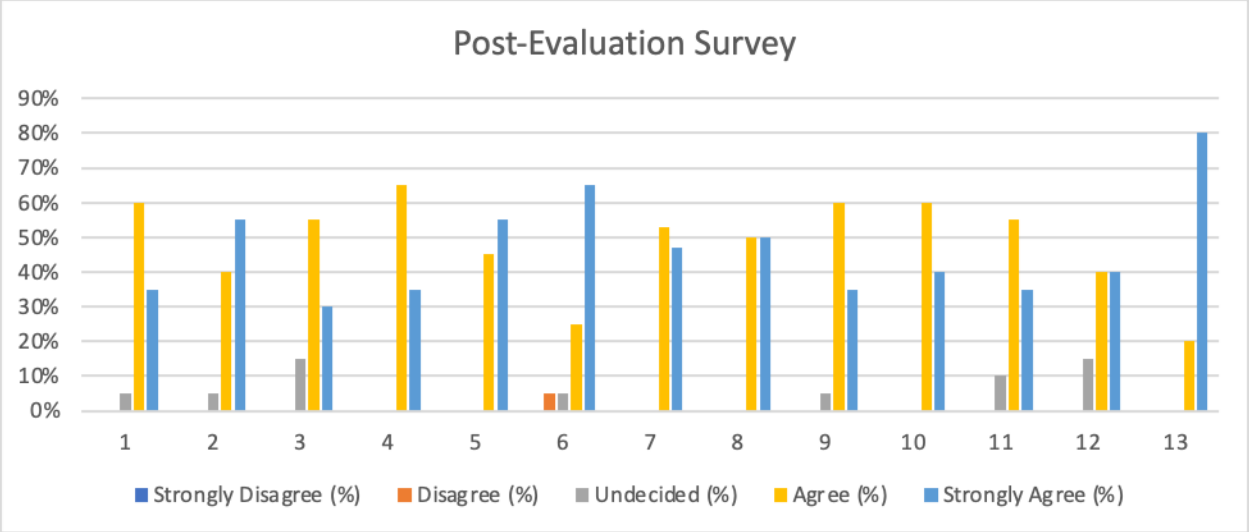
Pre-Intervention Survey Responses



Note. Results of the pre-survey response rates of the L&D nurses before the intervention are shown in Figure 2.

Figure 3

Post-Intervention Survey Responses



Note. Results of the post-intervention survey response rates of the L&D nurses 4-weeks after the intervention are shown in Figure 3.

With regard to readiness to manage an MH event, the L&D RNs felt more prepared to manage MH as a result of the educational experience and the hands-on simulation. Lastly, there is overwhelming support for the project. The majority of participants agree that vigilance has improved in patients who are receiving general anesthesia. The Labor and Delivery clinical educator felt that this training exercise was extremely beneficial for all participants in the L&D unit. The L&D clinical educator is integrating this educational experience exercise into the staff orientation program and the unit's annual competency training.

Discussion

Multiple studies have shown that incorporating education and simulation involving critical events improves knowledge, confidence, and team dynamics. The same holds true for crisis events such as MH. With improved knowledge and confidence comes a decreased number

of adverse patient outcomes when healthcare workers encounter a crisis they have managed through simulation.

When evaluating the results of this quality improvement project, one must first appreciate that the participants involved are trained healthcare professionals, not novice learners. However, L&D nurses are not PACU nurses, and their knowledge of MH was very limited. Because of this, there is a large gap in the mean difference between pre-and post-evaluation responses from participants.

When examining all categories of data, there was a distinct and significant increase in positive responses. When comparing pre-and post-intervention average responses (Category A), there are is a 50% increase in positive responses (Agree or Strongly Agree). These results are indicative of a meaningful intervention at the project facility. Increased positive responses can directly be linked to increased knowledge and confidence about an MH crisis. L&D registered nurses participating in this quality improvement project demonstrated that their knowledge and confidence had increased. As a result, the patients at this facility are provided with healthcare workers in the perioperative and postoperative areas that are more prepared to efficiently intervene during an MH crisis.

When evaluating question 13, the only non-statistically significant result from the 13 questions provided on both pre-and post-surveys, all participants agreed that an MH educational briefing and mock scenario demonstration is effective at increasing confidence and competence in the management of an MH crisis. Even though there was a 65% response rate for strongly agree, the response rate for strongly agree increased to 80% in the post-survey.

MH training facilitators included the clinical education coordinator on the L&D unit as well as the hospital and operating room MH leader. The director of anesthesia education and

chief nurse anesthetist provided guidance, educational material, and helped to maintain the project followed the guidelines and policies of the facility.

Limitations

Because of an exceptionally busy clinical schedule, staffing conflicts and unit emergencies were identified as limitations to this project. Another limitation was the attitude and willingness of staff. Staff may have felt that because an MH crisis is rare, the need to participate was unnecessary. Additionally, according to Miller (1956), if the staff feels the simulation is stressful, they may not absorb the information.

Recommendations for Future Study

This quality improvement DNP project has shown positive results related to the improvement of knowledge preparedness, and confidence of L&D RNs. However, there is always room for improvement when preparing healthcare providers for crisis events.

According to the pre-survey results, most L&D nurses are not adequately prepared for an MH crisis event. Data collected after L&D nurses participated in the educational presentation and training session scenario illustrated that there was a statistically significant increase in L&D nurses' recognition, preparedness, and knowledge of MH crisis management. Based on the data, recommendations to include L&D nurses in MH training and drill simulations will benefit patients and improve response to an MH crisis. MH training including hands-on, scenario-based training drills and education needs to be utilized in all locations where MH triggering agents are used, including L&D units. By conducting a well-organized annual training session and simulation drill, along with an education PowerPoint module, the management of MH can improve patient care and safety.

An additional recommendation is to allot more time to disseminate the presentation information over a greater number of sessions, allowing for a larger sample size. Increasing the sample size would yield more promising data creating a more favorable statistical analysis.

Finally, MH simulation drills for L&D nurses can and should be implemented at other institutions where annual MH training is not a priority. Evidence of post-survey scores directly correlates to improved preparedness of healthcare providers for high acuity, low-frequency events when they practice rescue measures needed for MH management. Utilizing Benner's Novice to Expert theory (Benner, 1984) can help meet the growing demand for emergency preparedness and nursing excellence.

Conclusion

In conclusion, MH is a rare event where patient safety is reliant on the knowledge and confidence of the L&D team. Reaction and recognition of initial signs and symptoms of MH followed by prompt treatment promote the provision of effective, life-saving treatments. The confidence of L&D RNs in recognizing the onset of an MH crisis is influenced by the infrequency of this critical event. Providing L&D RNs with evidence-based education and a simulated MH exercise was shown to improve knowledge, recognition, preparedness, and confidence in MH crisis management.

The purpose of this DNP project is to provide education, increase awareness, and increase proficiency in early recognition and management of an MH crisis, specifically relating to L&D nurses. The results have shown improvement in all areas previously stated. Also, these findings may provide grounds for practice change for all healthcare providers staffing L&D units. Ultimately, such training could provide staff with the means to manage an MH event and save a life.

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Appendix A: Educational MH PowerPoint Presentation

Malignant Hyperthermia Crisis: Improving Knowledge, Recognition, and Preparedness of the Labor and Delivery Registered Nurse Through the Use of an Educational PowerPoint Presentation & Hands-On Simulation

JOHN GARLAND
UNIVERSITY OF NORTH CAROLINA GREENSBORO

PRIMARY GOALS OF PROGRAM

- Participants will learn the causes, signs and symptoms, and treatment for Malignant Hyperthermia (MH)
- Participants will learn location of MH cart and the MH cart contents
- Participants will learn the correct dosing of Ryanodex and Renovo (Dantrolene) and how to properly reconstitute the medication
- Participants will know how and where to obtain bags of ice
- Participants will learn the various tasks completed by the medical personnel when responding to an MH crisis

WHAT IS MALIGNANT HYPERTHERMIA?

- Malignant Hyperthermia (MH) is a rare but potentially deadly hyper-metabolic crisis that typically occurs as a complication of general anesthesia
- ONSET: The signs may arise at any time during anesthesia
  - Can occur up to 12-18 hours post general anesthetic
- MH has occurred in patients who had previously been exposed to the same anesthetic agents without incident
- 50% of all MH cases occur in patients who previously had an uncomplicated general anesthetic

MALIGNANT HYPERTHERMIA

- MH can be triggered by exposure to volatile inhalational anesthetic agents
  - (Isoflurane, Sevoflurane, & Desflurane)
- MH can be triggered by exposure to Succinylcholine
  - (Only Depolarizing Neuromuscular Blocking Drug)
- Recent evidence suggests that some individuals can develop an MH crisis with heavy exercise and/or exposure to hot environments

MH PATHOPHYSIOLOGY

- Patients who are susceptible to MH have a defective calcium channel on the sarcoplasmic reticulum of skeletal muscle cells
- Various mutations of gene coding for the ryanodine receptor leads to excess calcium release during muscle contraction
- Calcium release causes contraction of muscle, increased metabolism, & excessive heat production from hypermetabolism in skeletal muscle

INCIDENCE AND GENETICS

- This defect is inherited as an autosomal dominant trait
  - Only one gene with MH trait needs to be inherited from either parent
- About 1:2,000 patients harbor a genetic change that makes them susceptible to MH
- The gold standard for determining susceptibility to MH is the *Caffeine-Halothane Contracture Test*
  - Requires a biopsy of skeletal muscle
- Incidence: Adults 1:100,000
  Pediatrics 1:30,000

GENETIC PREDISPOSITION

It has been noted by orthopedists and anesthesiologists who have been practicing many years in NC that the Lumbee tribe have higher than normal incidence of congenital musculoskeletal anomalies, which might be linked to a higher incidence of MH.

- BARNES
- BROOKS
- CHAVERS
- CHAVIS
- CUMMINGS
- HAMMONDS
- HUNT
- LOCKLEAR
- LOWRY
- OXENDINE
- REVELS
- STRICKLAND

COMMON LUMBEE TRIBE LAST NAMES

MALIGNANT HYPERTHERMIA CRISIS SIGNS, SYMPTOMS, & COMPLICATIONS

Early S/Sx's	Late S/Sx's	Severe Complications
Tachycardia	Hyperthermia (Temp may exceed 110° F = 43.3° C)	Brain Damage
Muscle Rigidity	ECG Changes	Cardiac Arrest
Hypercarbia	Hyperkalemia	Multi-System Organ Failure

EMERGENCY TREATMENT

- **GET HELP!!!!!!**
- GET DANTROLENE (RYANODEX)
- Notify Anesthesiologist and Surgeon
- GET MH Cart & Crash Cart
- Hyperventilate with 100% oxygen at 10L/min
- Immediately begin cooling the patient
  - Cooling blanket
  - Decrease room temperature
  - Bags of ice
  - OGT lavage

GOALS OF EMERGENCY TREATMENT

- Initiate close monitoring
- Core temp goal < 38°C = 100.4°F
- Urine output goal > 1ml/kg/hr
- Arterial Line
- CVP monitoring as warranted by severity of the patient
- Large Bore IV (≥18g)

RYANODEX (DANTROLENE)

RYANODEX (DANTROLENE)

- A new formulation of Ryanodex (Dantrolene) provides 250mg in 5ml of Sterile Water once drug has been mixed
- Allows for faster mixing and administration of initial Dantrolene dose
- 4 vials kept on each MH cart
  - 2 additional vials kept in OB mother pyxis
- **Used for initial dose**, then *switch* to **Revonto**

RYANODEX (DANTROLENE)

- **Initial Ryanodex Dose = 2.5 mg/kg**
  - May repeat as frequently as needed
  - Up to 10mg/kg
- Response to treatment is indicated by:
  - ↓ EtCO2
  - ↓ Muscle Rigidity
  - ↓ Heart Rate
- If no response at 10mg/kg consider alternate diagnosis

REVONTO (DANTROLENE)

REVONTO (DANTROLENE)

Revonto® will only be used after the initial crisis management with Ryanodex®

- **REVONTO (DANTROLENE):**
  - 60ml sterile water for each 20mg vial to be used
- **REVONTO (DANTROLENE) DOSE**:
  - **1mg/kg Q 4-6 hours IV** x 24 hours to prevent reoccurrence
  - Up to 10% may have reoccurrence in first 8 hours of symptom onset

REVONTO (DANTROLENE)

- Revonto requires 60ml sterile water for each 20mg vial
- Revonto will be mixed by pharmacy and hand delivered to the OR
- **Important: RN calls pharmacy ASAP to initiate mixing and delivery of Revonto to unit**

DANTROLENE

- Both Ryanodex and Revonto are formulations of Dantrolene
- Dosage is the same for Ryanodex and Revonto
  - Volumes are different based on concentration of the drug
- **Ryanodex = 250mg in 5ml Sterile Water**
- **Revonto = 20mg in 60ml Sterile Water**

RELAPSE SIGNS

- Recurrent S/Sx's
  - Monitor for recurrence of symptoms
- Watch for relapse
  - Reevaluate q4h for the first 36 hours following acute phase of event
- 25% of patients having an MH crisis relapse
  - Can be fatal if not treated immediately

- Increased muscle rigidity in the absence of shivering
- Inappropriate hypercarbia with respiratory acidosis
- Metabolic acidosis without other cause
- Inappropriate temperature rise

POST-OP CARE

- Patient must be continuously monitored for 24-48 hours
- Monitor
  - HR
  - RR
  - EtCO2
  - Temp
  - O2 saturation
  - Muscle tone
- Monitor labs & ABGs as ordered by provider

POST ACUTE PHASE

- Send the patient to a biopsy center
- Muscle biopsy for ***Caffeine Halothane Contracture Test*** **(CHCT)**
  - Performed at Wake Forest University by Dr. Joseph Tobin, M.D.
- Genetic testing can be performed via mail
- Talk to family about the genetic linkage for this disorder and encourage testing

RN ROLES IN THE OR/RECOVERY AREA/UNIT

- Bring in MH cart and crash cart
- Call pharmacy ASAP to mix Revonto
- Delegate tasks to others: ice packs, cool room, cold saline
- Place ice packs, place foley, Call MHAUS, call ICU
- Lab tubes and labels ready, order labs under MH order set

DOCUMENTATION OF MH EVENT

Documentation in the form of progress note to include:	
Time of trigger removed	Types of cooling measures used
Notification of anesthesia/CRT RN/Intensivist	Labs/EKG performed/Cardiac monitoring
Time of call for MH cart	Time and type of medications given
Contact information of MHAUS	Vital signs
Oxygen administration 100% FiO2	Urine output
Time Ryanodex® administered	Transfer to critical care

MH FORMS & DOCUMENTATION

All MH forms are located on the UNC REX intranet:

Forms → Patient Care Services → PCS Forms → Malignant Hyperthermia

CONTACT MALIGNANT HYPERTHERMIA ASSOCIATION OF THE U.S. (MHAUS) FOR INFORMATION/REFERRAL

- Submit forms to MH Registry of MHAUS: www.mhreg.org

LOCATIONS OF MH CARTS

OR West – Anesthesia Workroom

OR East – Anesthesia Workroom
(MSICU, Endoscopy, BCOR, 2Womens, & 3Womens will use the OR East cart)

HV Hospital – Anesthesia Workroom

Emergency Department

Wakefield Surgical

Pharmacy
(All main tower units will use cart from Pharmacy)

MH CART SAME DAY SURGERY (SDS) OR WEST

MH CART MAIN OR (OR EAST)

MAIN OR (OR EAST) ICE MACHINE BY OR 5

ICE MACHINE SAME DAY SURGERY OR WEST: PACU AND SPRU

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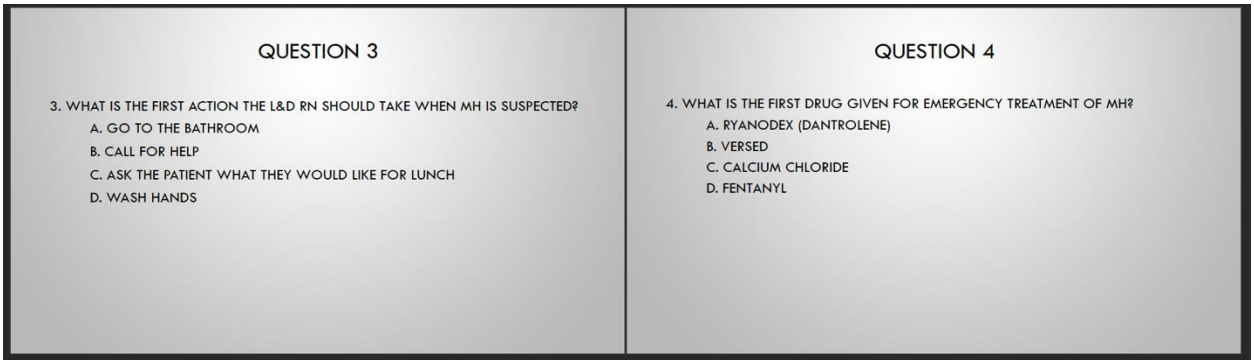
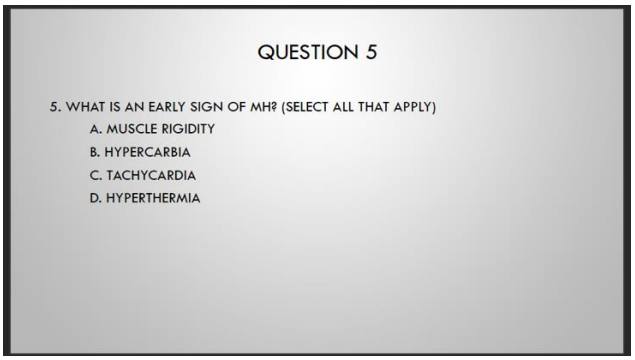
QUESTION 1

1. WHAT IS MH? (SELECT ALL THAT APPLY)
   - A. OVERDOSE OF ANESTHESIA
   - B. A COMPLICATION RELATED TO THE USE OF VOLATILE INHALATIONAL GASES
   - C. HYPERMETABOLIC STATE WITH EXCESSIVE CALCIUM RELEASE
   - D. AUTOSOMAL DOMINANT GENETIC TRANSMISSION

QUESTION 2

2. WHICH OF THE FOLLOWING IS NOT A TRIGGER FOR MALIGNANT HYPERTHERMIA?
   - A. SUCCINYLCHOLINE
   - B. ISOFLURANE
   - C. SEVOFLURANE
   - D. KETAMINE


QUESTION 3
3. WHAT IS THE FIRST ACTION THE L&D RN SHOULD TAKE WHEN MH IS SUSPECTED?
A. GO TO THE BATHROOM
B. CALL FOR HELP
C. ASK THE PATIENT WHAT THEY WOULD LIKE FOR LUNCH
D. WASH HANDS
QUESTION 4
4. WHAT IS THE FIRST DRUG GIVEN FOR EMERGENCY TREATMENT OF MH?
A. RYANODEX (DANTROLENE)
B. VERSED
C. CALCIUM CHLORIDE
D. FENTANYL


QUESTION 5
5. WHAT IS AN EARLY SIGN OF MH? (SELECT ALL THAT APPLY)
A. MUSCLE RIGIDITY
B. HYPERCARBIA
C. TACHYCARDIA
D. HYPERTHERMIA

Appendix B: MH Crisis Demonstration Scenario

MH Scenario: Chloe Ellis is a healthy 32-year-old G2 P1 and is 34 weeks' gestation. She had been admitted to L&D 12 hours ago for Preterm Premature Rupture of Membranes (PPROM).

She weighs 176 lbs. (80 kg), has no past surgical history, and her first child was born vaginally with no complications. There is no other significant health history to report and no familial history of anesthesia complications.

Chloe has NKDA.

Chloe wanted to wait for labor to start naturally and avoid Pitocin if at all possible. At this time, Chloe is still not contracting on her own, and was started on a Pitocin infusion. Chloe baby does not tolerate the Pitocin infusion & begins having late decelerations. The RN stops the Pitocin, gives a bolus of IV fluid, repositions her patient & calls the attending physician to the bedside. The late decelerations continue despite intrauterine resuscitation measures. The baby's heart rate suddenly drops into the 70s with minimal variability & does not improved with intrauterine resuscitation measures. Chloe's cervical is dilated 4 cm, so she is remote from delivery. The attending physician calls an emergency C-section.

Chloe is put to sleep by anesthesia and successfully makes it through surgery with no complications.

Chloe is extubated and is now being monitored in the recovery unit.

Chloe states that she is beginning to feel lightheaded and that her muscles are tensing up. Her heart rate and respiratory rate are beginning to increase, and she is feeling increasingly anxious and restless. At this time Chole's oral temperature is 39° C. When the L&D nurse asks Chloe if she is feeling any better, Chloe is unable to respond because her jaw and mouth have become 'locked' shut.

What do we do now?

Appendix C: Malignant Hyperthermia Pre-and Post-Educational Questionnaire

What is the FIRST initial of your LAST NAME and LAST 4-digits of cellphone? (*To be used for survey identification purposes only*) _____

SD: (strongly disagree); D: (disagree); UN: (undecided): A: (agree); SA: (strongly agree)

Questions	**SD**	**D**	**UN**	**A**	**SA**
1. I feel confident in my skills during a crisis involving direct patient care.					
2. I feel confident in my role during a cardiac arrest.					
3. I feel confident in my role during an airway emergency (e.g., cannot ventilate or intubate).					
4. I feel confident in my role during the management in an MH crisis.					
5. I know the location of the MH cart.					
6. I know the location of the ice machines.					
7. I know the initial interventions in MH management.					
8. I know my role and responsibilities during an MH crisis.					
9. I am confident in my ability to recognize initial MH signs and symptoms.					
10. I am confident in my ability to recognize late MH signs and symptoms.					
11. I feel confident in my ability to reconstitute Ryanodex (Dantrolene) and Revonto (Dantrolene).					
12. I feel confident in dosing Ryanodex (Dantrolene) during an MH crisis.					
13. An MH educational briefing and demonstration is beneficial to increase confidence and competence in the management of an MH crisis.					