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A Malignant Hyperthermia Competency Training for Nurse Anesthesia Trainees: Development, Implementation, and Evaluation

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Abstract

Background: Video simulation is an alternative method of teaching that can play an important role in nurse anesthesia education. Using video simulation for uncommon crisis could prove beneficial.

Objectives: The purpose of this study is to analyze the effects of an educational video simulation regarding malignant hyperthermia (MH) recognition and management on knowledge of nurse anesthesia trainees (NATs).

Methods: A single group pretest-posttest design was used to compare knowledge on recognition and management of malignant hyperthermia. The study included a voluntary convenience sample of junior and senior nurse anesthesia trainees at NorthShore University HealthSystem School of Nurse Anesthesia. Pretest scores were attained and followed by a viewing of pre-recorded video simulation on proper recognition and management of malignant hyperthermia. Posttest scores were obtained immediately after viewing the complete pre-recorded video simulation.

Results: Twenty NATs participated in the single group pretest-posttest design. Ten junior and ten senior NATs participated in total. The comparison of mean scores between the pretest and posttest showed a statistically significant result ($p < 0.05$). The video on MH recognition and treatment significantly improved NAT scores on the posttest when compared to the pretest. The average pretest score including both junior and senior NATs was M=10.75 (SD 1.48235). The average score on the posttest was M=13.9 (SD= .30779). The overall NAT pretest score on average improved 3.15 points (95% confidence interval, 3.799, 2.501) after viewing the video simulation. The paired t-test showed statistically significant improvement between pretest and posttest scores with a p value of 0.00 on the two-tailed paired t-test.

Conclusions: Viewing a video simulation on the recognition and management of malignant hyperthermia increased knowledge of both junior and senior NATs. This pilot study offers preliminary evidence that there is a role for video simulation education in the curriculum of nurse anesthesia programs. There is a need for larger, more rigorous research in order to provide further evidence on the effectiveness of video educational strategy.

Key words: Simulation, video, malignant hyperthermia, nurse anesthesia students, nurse anesthesia

Introduction

Background and Significance

Malignant Hyperthermia (MH) crisis is a rare, anesthesia induced complication with incidence estimated to be 1:15,000 in children and 1:20,000 to 1:50,000 in adults (Redmond, 2001). According to the Malignant Hyperthermia Association of the United States (MHAUS) (2017), MH can be triggered by frequently used anesthetic gases such as sevoflurane, desflurane, and isoflurane and also a frequently used short acting muscle relaxant called succinylcholine. Symptoms of MH crisis include increased blood carbon dioxide level, muscle spasms or rigidity, increased respirations, increased heart rate, and increased temperature. It also causes severe electrolyte shifts causing blood potassium levels to be extremely high and the blood to become acidotic (MHAUS, 2017). This crisis can be difficult to recognize and manage without proper training. It is a time sensitive and critical situation that must be recognized and managed properly to ensure patient survival. Video simulation is a teaching method used to facilitate real life scenarios in a safe learning environment. Video simulation scenarios provide a unique learning experience, since they provide a safe place to learn how to manage uncommon, but serious complications, such as MH. Moreover, video simulation is more accessible and affordable when compared to high fidelity simulation. Nurse Anesthesia Trainees (NATSs) may never see a MH crisis in their clinical training experience, so training in video simulation is necessary to ensure optimal patient outcomes. The goal of this project is to develop and implement a MH video simulation for NATs that improves knowledge regarding management of a MH crisis. The implementation of this video learning session will be evaluated by the participants via a pre-test and post-test to determine if knowledge is gained from the video simulation.

Malignant Hyperthermia is a drug-triggered disease that occurs when predisposed individuals are given certain anesthetics such as inhaled agents or succinylcholine. The crisis occurs most often quickly after the induction of a general anesthetic (Cain, Riess, Gettrust, & Novalija, 2014). In order to prevent death in this emergency, immediate intervention with rapid and specific treatment is needed. Simulation has already been used consistently in high-risk industries such as airlines, nuclear industries, and the military (Cain, Riess, Gettrust, & Novalija, 2014). NATs can also benefit from simulation training in regards to crisis management.

Nurse Anesthesia Trainees are inexperienced clinically and likely will not see a MH crisis in the hospital training. Using video simulation provides an approachable and practical way to prepare NATs for a low volume, high-stress emergency, such as MH. Simulation can better prepare NATs for the extreme challenge of recognizing, intervening, and a caring for an individual experiencing an MH crisis.

Problem Statement

Although the effectiveness of video simulation is well researched, few studies have explored the role of video simulation to improve knowledge of crisis management for NATs. Furthermore, the use of a simulation video regarding malignant hyperthermia recognition and management has not been comprehensively investigated in NATs.

Purpose of the Study

The purpose of the study was to analyze the outcomes of an educational simulation video regarding malignant hyperthermia recognition and management in junior and senior nurse anesthesia trainees using a pretest-posttest design. A simulated video was made to teach the recognition and management of a malignant hyperthermia crisis. This crisis was chosen because it is an anesthesia specific event that NATs will likely not see in their clinical training, but it is

extremely important to recognize and intervene upon. This video was used to educate NATs on an important anesthesia specific crisis.

Clinical Question

Does viewing an instructional video on management of a MH crisis improve knowledge of 2nd and 3rd year nurse anesthesia trainees?

Conceptual Framework

The theoretical approach used for this study is that of the ADDIE model. The ADDIE model stands for Analysis, Design, Develop, Implement, Evaluate (Bichelmeyer, 2005). During each phase, the model gives an opportunity for changes before moving to the next stage

In the initial analysis stage, the model drives research by asking what training is needed? (Bichelmeyer, 2005). In this specific study, the training needed is that of MH crisis management. It is justifiably needed due to the very essence of this type of emergency. Being such a rare emergency, video simulation provides exposure to otherwise untried practitioners. This question ultimately drove the study design.

During the implementation portion, an instructional strategy is chosen, objectives of that strategy are created, and the appropriate media delivery method is chosen (Shelton & Saltsman, 2008). This portion of the theoretical framework played an integral role in determining that a video simulation would potentially have the greatest outreach given this population. High-fidelity simulation is only available in wealthy areas of the world, whereas a video could be used nearly anywhere. In the development portion, the model creates expectations from the design phase. The design of my study did ultimately drive my development as the use of a video simulation changed the original study design substantially. In the fourth stage, the ADDIE model discusses implementation. In this phase, the course is release and delivered to the learners

(Shelton & Saltsman, 2008). This phase also involves the impact. This phase will be measured when the study has officially occurred. Lastly, evaluation is used to determine if the expected results were found. The evaluation portion evaluates the impact of the course via surveys, test, and analytics (Shelton & Saltsman, 2008).

Literature Review

Search Method

Initially, a search of the Cochrane Review database was performed. There was no previous meta-analysis performed regarding the use of video simulation in crisis management for nurse anesthesia trainees. I then searched CINAHL from years 2007 to 2017. I used the subject headings *simulation, training, crisis simulation,* and *crisis training.* This yielded over 30000 results on CINAHL. I then narrowed my search using the terms *malignant hyperthermia*, *trainees*, *students*, and *residents*. This yielded 17 results available in full text on CINAHL and 18 results available in full text on PubMed. After searching through the articles and reading abstracts, the most appropriate articles were included. An additional search of PubMed was performed from years 2000 to 2017. I used the same subject headings of *simulation, training, crisis simulation,* and *crisis training.* This yielded over 15000 results on PubMed. I then narrowed my search using the terms *malignant hyperthermia*, *trainees*, *students*, and *residents*. This yielded 18 results available in full text on PubMed. After looking at all the abstracts, the most relatable articles were included. The emphasis of the article review was to find information on crisis and simulation training in anesthesia with specific regards to malignant hyperthermia. Qualitative, quantitative, and mixed designs were included in the review. In all, 24 papers were read and 11 were selected. A research table was created using the 11 selected articles. The table included the authors, year of publication, study objectives, study design, study variables, study

instruments, relevant statistics, key study findings, and study conclusions. See Table 1: Evidence-based Table/Synthesis on Crisis Simulation in Trainees (listed alphabetically).

Malignant Hyperthermia Simulation in Trainees

Literature to date describes several benefits of MH crisis simulation (Bashaw, 2016; Henrichs, Rule, Grady, & Ellis, 2002; Dirksen, Van Wicklin, Mashman, Neiderer, & Merritt, 2013; Redmond, 2001). Simulation has been shown in previous studies to successfully improve management of MH in student nurses (Bashaw, 2016) and resident physicians (Dirksen et al., 2013). According to Henrichs et al. (2002), "simulation may provide the only way for a nurse anesthesia student to experience a patient with rare but frightening anesthesia complications, such as malignant hyperthermia" (p. 225). MH is such an uncommon situation that simulation is essential to allow NATs to experience as close to a real life crisis as possible.

In a qualitative study, Cain, Riess, Gettrust, and Novalija (2014) observed that simulation of a MH scenario also improves communication and collaboration between operating room staff. They also found that debriefing allowed for all members of the operating room to voice any concerns regarding the simulation. Furthermore, improved role clarity between nurses, techs, certified registered nurse anesthetists (CRNAs), and physicians were shown during then MH crisis simulation (Cain et al., 2014).

In another qualitative study, Dierksen et al. (2013) evaluated what makes successful and effective drills regarding MH crisis management. The authors found that preparation for medical emergencies like MH "must include not only didactic educational sessions but also regular mock drills and simulation exercises to allow for improvement of cognitive, mechanical, and teamwork skills" (p. 349). The article examined what past studies had used as mock drills and simulations and evaluated what was successful and unsuccessful. They also created a template for evaluating

student success in MH simulation. Lastly, they found that advanced practice nursing educators found that "high-fidelity simulations provide valuable training without risk to patients, particularly for high-risk, low-volume emergencies" (Bashaw, 2016, p. 212).

In a separate quantitative single-blinded study by Henrichs, Avidan, Murray, Boulet, Kras, Krause, and Evers, (2009), the researchers explored performance of 26 certified registered nurse anesthetists and 35 anesthesiologists in a simulation-based skills assessment. They looked at 12 randomly selected and scripted intraoperative events (bronchospasm, anaphylaxis, unstable ventricular tachycardia, MI, right bronchial intubation, tension pneumothorax, MH, blocked ETT, total spine, loss of pipeline O2, hyperkalemia, and acute hemorrhage) and found that certification in either discipline (nurse anesthesia or anesthesiology) did not yield uniform judgment in management of simulated intraoperative emergencies. This study demonstrates that regardless of discipline and years of experience, there is always room for improvement in regards to crisis management simulation.

Sousa, Bispo, Cunha, and Siqueira (2015) evaluated the effectiveness of an educational intervention on malignant hyperthermia with 96 operating room nurses and techs. They found that there was a statistically significant difference after their educational intervention and that there was an increase of the minimum and maximum scores, and an improved growth in the knowledge of professionals when compared to the previous exam. The authors concluded that the educational intervention shows effectiveness of the educational intervention performed with an increase in knowledge gained by the team and also improves a patient safety.

Crisis Management for Nurse Anesthesia Trainees

Henrichs, Rule, Grady, and Ellis (2002) performed a qualitative study evaluating nurse anesthesia students' attitudes and perceptions towards simulations. The authors found that NATs

found advantages of the simulation to include ability to evaluate cogitative skills, psychomotor skills, critical thinking, and management of unusual anesthetic events. Furthermore, Henrichs et al. (2002) found that NATs actually wanted more simulation implemented into their curriculums as early as possible (p. 223). Reading in textbooks provides information regarding management of emergency situations; however, there is a substantial difference in reading and "doing" when it comes to management of a real MH crisis (Henrichs et al., 2002).

Wunder (2016) examined whether an educational intervention on nontechnical skills could improve the performance of nontechnical skills during anesthesia crisis simulation with a group of 32 first year nurse anesthesia students. The authors found that nontechnical skills mean posttest score was greater than pretest scores with the mean gain in scores for standardized nontechnical skills being significantly greater than those for standardized technical skills. The authors thus concluded that nontechnical skills are not acquired through experience, but rather through instruction. The use of simulation training is certainly not limited to technical skills. It can be highly applicable in the teaching and measuring of non-technical skills as well.

Nurse anesthesia students are especially vulnerable to make medical errors as they are transitioning to a new role with much more autonomy and decision making ability (Wunder, 2016). It is widely shown that high-fidelity simulation is beneficial to students from a variety of disciplines (Bashaw, 2016; Henrichs, Rule, Grady, & Ellis, 2002; Dirksen, Van Wicklin, Mashman, Neiderer, & Merritt, 2013; Redmond, 2001), however, there is limited research on the use of video simulation. Unfortunately, high fidelity simulation is not readily available throughout the United States or the world, so development of a video simulation provides a more accessible and convenient way to simulate a MH crisis. The research gap focused on in this project is the potential benefit of video simulation in crisis situations, particularly malignant

hyperthermia. There is lack of research in regards to the use of video simulation and crisis management.

Methods

Design

A single group pretest-posttest design was used to determine the effectiveness of video simulation on improving knowledge of junior and senior NATs at NorthShore University HealthSystem School of Nurse Anesthesia (NSUHSSNA). This project had three phases: (1) development of the simulation video, (2) development of the pre-test and post-test, and (3) evaluation of the video simulation on NAT knowledge via the pre-test and post-test. Since this was not a controlled study, participants were not divided into intervention and control groups. This gave the NATs an equal opportunity to learn through the video simulation.

Sample

The target population for this study was junior and senior NATs. Since NATs are clinically inexperienced and will likely never see a MH crisis in their training, they are ideal candidates for a video simulation learning session. A convenience sample of junior and senior NATs at NSUHSSNA was used. This population has a minimum of two years of previous nursing experience in the intensive care unit setting. They were recruited strictly on a voluntary basis through email and in person at Northshore Seminar Club. A convenience sample was chosen due to the small field of interest and the limited number of students that met the criteria for inclusion. At the time of the study there were a total of 36 junior and senior NATs.

Recruitment Procedure

A recruitment email with detailed information regarding the study was sent via email to junior and senior NATs by faculty member and committee chair Karen Kapanke, DNP, CRNA.

A recruitment letter (Appendix D) and information sheet (Appendix E) was included in the email, which outlined the rights of the participants and the aim of the study. Participation in the study was voluntary and no formal consent was required. Voluntarily participating and showing up at the location of the study implied consent. No monetary or other incentives were offered. All data collected was kept anonymous and the scores on the pre-test and post-test had no effect on grades within NUSHSSNA or DePaul University. The data collection took place on Saturday February 10th, 2018. The collection was held in a conference room at Evanston Hospital after a NUSHSSNA seminar club. NATs who participated were already present at the hospital and no travel time was added or required. All participants were reminded of the voluntary nature of the study prior to distribution of the pre-test. Participation on the pre-test, video, and post-test was considered implied consent and participants were reminded they could leave at any time.

Creation of Malignant Hyperthermia Video

The primary intervention used in this study was a pre-recorded video that was created in order to demonstrate proper recognition and management of malignant hyperthermia. The primary investigator reviewed literature in order to create evidence-based steps for recognizing and treating malignant hyperthermia. These steps were then compared with existing steps from the Malignant Hyperthermia Association of the United States (MHAUS) in order to create the outline for the video simulation, as need in Appendix A. After completion, the video outline was reviewed by a five member expert panel consisting of Pamela Schwartz, DNP, CRNA, Karen Kapanke, DNP, CRNA, Julia Feczko, DNP CRNA, Anne Sauri, DNP, CRNA and Bernadette Roche, EdD, CRNA. Each portion of the outline was assessed for relevance, clarity, simplicity, and consistency. Of these indicators, each portion of the video was scored on a scale from 1-10, with 1 being low and 10 being high. A perfect score of 10 out of 10 on each section was required

from all five members of the expert panel in order to ensure content validity. After multiple revisions, all five members approved the video outline with 100% content validity (Appendix A).

After content validity was completed, the primary investigator was able to proceed with filing the video. A simulation of a malignant hyperthermia crisis was recorded in the Grainger Center for Simulation and Innovation (GSCI) located within NorthShore University HealthSystem (NSUHS, 2017) at Evanston Hospital. The recordings were edited and assembled into one video. The video coincided with the approved outline validated by the expert validity panel. Committee member Karen Kapanke, DNP, CRNA, helped develop the video and was present to ensure the primary investigator followed the approved video outline. The recording took roughly one hour and was completed in a step-wise fashion as the outline reviews (Appendix A).

Pre-test and Post-test Development

3. Gathering resources and ideas from Malignant Hyperthermia Association of the United States (2017), Dirksen, Van Wicklin, Mashman, Neiderer, and Merritt (2013) and Bashaw (2016), allowed formulation of roughly twenty questions, which was later reduced to fourteen questions. After completion of the literature review, no single tool adequately and concisely tested the recognition and treatment of malignant hyperthermia for anesthesia providers. In collaboration with committee members Karen Kapanke, DNP, CRNA and Anne Sauri, DNP, CRNA, a fourteen-question test was created that hit key points of MH recognition and management.

The contents of pre-test and post-test were reviewed by a five member expert panel, consisting Pamela Schwartz DNP, CRNA, Julia Feczko DNP, CRNA, Karen Kapanke DNP, CRNA, Anne Sauri, DNP, CRNA and Bernadette Roche EdD, CRNA. Each question was

assessed for clarity, relevance, simplicity, and consistency and scored on a scale of 1-10, with 1 being the lowest score and 10 being the highest. After four revisions, each question on the pre-test and post-test had a score of 10 in each of the four categories by each member of the expert panel. This established content validity of pre-test and post-test.

Human Subjects Protection

Collaborative Institutional Training Initiative (CITI) and Financial Conflict of Interest (FCOI) training was completed prior to sending applications to the institutional review boards (IRB) at NorthShore University HealthSystem and DePaul University. This training confirmed that the primary investigator was educated in research regarding human subjects. The IRB application explained the voluntary nature of the study and that all information collected would be kept confidential. As shown in the recruitment email (Appendix D) and the information sheet (Appendix E), there is a detailed explanation showing the purpose of the study, its voluntary nature, participant protection of privacy, lack of financial incentive, and ability to stop participation in the study at any time.

The only identifier/demographic information is whether the student is a junior or senior NAT (see Appendix B). There will be no questions about race, sex, or any other unique identifiers. The first page of the pre-test (Appendix B) identifying whether the participant is a junior or senior NAT was placed in the manila envelope in prior to completing the pre-test. After completion of the pre-test, this was placed in the same manila envelope. Finally after completion of the post-test, it was placed in the same manila envelope. This allowed comparison of the data based on whether the NAT was a junior or senior, but did not breach any confidentiality, as there were no unique identifiers on the face sheet. All data obtained was kept securely in a locked area.

Prior to beginning the study, the primary investigator reminded the participants of the voluntary nature of the study and reminded them that by being there and filling out the pre and post-test that their consent was implied. Furthermore, an explanation of the voluntary nature of the study was included on the pre-test (Appendix B), the post-test (Appendix C), the recruitment email (Appendix D), and the information sheet (Appendix E). There was no monitory or academic incentive for NATs to participate in the study. The study in no way affected participants standing within NSUHSSNA or DePaul University. The study took place during their normally occurring schedule, so no inconvenient travel time was added by attending the study. All material presented was pertinent to the participants field of study.

Data Collection Procedure

Once approved by NorthShore University HealthSystem and DePaul University IRBs, the data collection date was set. Data collection occurred on Saturday February 10th, 2018. The data collection occurred in a conference room at Evanston Hospital, part of NorthShore University HealthSystem. A convenience sample of 20 NATs arrived and participated in the study. The entire data collection process took approximately 35 minutes. At the beginning of the study, they were reminded that their participation was entirely voluntary and their information would be kept confidential. Furthermore, they were reminded that they could leave the study at any time and that there was no financial incentive for participating. After data collection was completed, the envelopes were placed in a large box and kept for storage in a locked space.

The focus of research for this project was on junior and senior NATs. The first page of the pre-test (Appendix B) is a face sheet that identified whether the participant is a junior or senior NAT. This sheet was placed in the manila envelope in prior to completing the pre-test. The face sheet was placed in an envelope that corresponds with the number on the pre-test and

post-test (i.e. face sheet #1 goes with pre-test #1 and post-test #1). A pre-test printed on white paper was given to NATs to complete prior to any education or training on MH crisis. The test examined knowledge of the NATs regarding proper management of a MH crisis. The pre-test and post-test were the same for consistency. Each test took approximately ten minutes. After completion of the pre-test, the video simulation demonstrating proper recognition and management MH was played and observed. NATs were asked not to take any notes during this time. The video simulation was roughly ten minutes in length. Finally, after the video was completed, the post-test (printed on off-yellow paper) was given to the NATs to complete. The pre-test and post-test results were compared to determine if there was significant knowledge gained after viewing the educational video simulation.

Ethical Considerations

Students are considered a vulnerable population, so caution must be used when involving them in research. The students will be participating on a completely voluntary basis. The competency measure must be proven to be reliable and valid by a panel of experts. The competency test should in no way cause injury, harm, or distress to the students involved in the study. Other than identifying whether they are a junior or senior NAT, no identifiers will be used. Before the study is implemented, IRB approval will be obtained from both NorthShore University HealthSystem IRB and DePaul University IRB.

Collaborative Institutional Training Initiative (CITI) basic course and good clinical practice course and training were completed by the primary researcher of the project. Both these courses were completed on April 7, 2017. It included information on the ethical considerations of research. It provided tools to evaluate, report, and detect ethical issues in research. Furthermore,

the courses involved considerations when involving students in research, potential conflicts of interest, and privacy concerns in healthcare research.

Results

The pre-tests and post-tests were hand graded and checked a second time to ensure there were no errors in grading. Data analyses were performed using International Business Machines (IBM) SPSS Statistics version 23 (IBM, 2017). Descriptive statistics were initially run. Overall 20 students attended the study (**Figure 1**). Of the 20 participants, 10 were senior NATs and 10 were junior NATs (**Figure 1**). A preliminary check of the percentage of individual correct and incorrect responses for each question on the pre-test was conducted and presented (**Table 4**). After running the descriptive statistics, a paired t-test was used between the pre-test and post-test results to determine whether a statistically significant difference exists in the mean scores. The significance level for the paired t-test (α-level) is .05. After looking at descriptive statistics and identifying the questions that were most frequently answered incorrectly, data was compared between the junior and senior nurse anesthesia trainees as shown in **Table 5.**

An analysis of the participant's pre and post-test for each question answers the research question:

- Does viewing an instructional video on management of a MH crisis improve knowledge of 2nd and 3rd year nurse anesthesia trainees?

Because of the pretest-post test style of the study, a paired t-test was run in order to examine if there was a statistically significant difference between the pretest and posttest scores. The comparison of mean scores between the pretest and posttest showed a statistically significant result ($p < 0.05$). The video on MH recognition and treatment significantly improved NAT scores on the posttest when compared to the pretest. The average pretest score including both junior and

senior NATs was *M*=10.75 (SD=1.48235) as shown in **Table 2.** The average score on the posttest was *M*=13.9 (SD= .30779) as seen in **Table 2**. The overall NAT pretest score on average has improved by 3.15 points (95% confidence interval, 3.799, 2.501) after viewing the video simulation (**Table 3)**. The paired t-test showed statistically significant improvement between pretest and posttest scores with a p value of 0.00 on the two-tailed paired t-test (**Table 3)**. It can be concluded that knowledge was gained by the NATs after watching the MH video simulation.

The most frequently missed questions on the pretest were questions 2, 3, 8, and 11 (**Figure 2**). These questions had at least 40% of participants answered incorrectly on the pretest **(Table 4)**. Senior NATs did slightly better than junior NATs on the pretest. Junior NATs scored an average of 10 out of 14 on the pretest and senior NATs scored an average of 11.5 out of 14 **(Table 5)**. When comparing the junior and senior NATs pretest scores, Levene's Test for Equality of Variances showed statistically significant variances for questions 7, 12, and 13 **(Table 5)**. This determined that the seniors scored significantly better than the juniors on questions 7, 12, and 13.

Discussion

Video simulation is a useful educational strategy as shown by previous research. Learning with video simulation as a supplement to foundational knowledge allows students to learn in multiple ways. However, there is a lack of research in regards to nurse anesthesia trainee's use of video simulation. This study investigated the use of video simulation as a way to improve knowledge of nurse anesthesia trainees. Malignant hyperthermia is a complex, anesthesia-induced crisis that requires prompt recognition to ensure patient survival. Video simulation is an invaluable tool for infrequent crisis, such as MH.

Malignant hyperthermia is a drug-triggered event that occurs when genetically predisposed individuals are exposed to certain anesthetic agents (MHAUS, 2017). It occurs after induction of a general anesthetic and can be triggered by frequently used anesthetic gases such as sevoflurane, desflurane, and isoflurane and also depolarizing muscle relaxants such as succinylcholine (MHAUS, 2017). The steps for recognizing and managing the crisis are outlined in **Appendix A**.

The results show NATs that participated in the study gained knowledge regarding the management and treatment of MH. Out of a 14-question pretest, both the junior (average pretest = 10, average posttest= 13.9) and senior (average pretest = 11.5, average posttest = 14) NATs improved their scores after viewing the video simulation. The seniors scored slightly higher on the pretest (11.5), than the juniors (10), suggesting that some advanced clinical experience and education on anesthetic crises provided them with a slight advantage going into the study. Furthermore, Levene's Test for Equality of Variances showed statistically significant variances for questions 7, 12, and 13. These questions were regarding Dantrolene dosage (question 7), fluid management (question 12), and disease states associated with MH or that increase the incidence of MH (question 13). This knowledge could help educators in the future identify knowledge gaps for the junior NATs. Lastly, the paired t-test showed strong statistical significance ($p < 0.05$) that the intervention made a difference in the posttest results.

The target population for this study was junior and senior NATs at NSUHSSNA. All participants had a Bachelor's Degree in Nursing and 2 or more years of ICU experience. The junior NAT participants began clinical education just two months prior to the study. The senior NAT participants had fourteen months of clinical experience. Participants included 20 NATs. Of

the 20 participants, 10 were juniors and 10 were seniors. Demographic information was not collected, so no data can be inferred based off of demographic characteristics.

Implementation of a video simulation on recognition and treatment of malignant hyperthermia had a positive effect on the knowledge of nurse anesthesia trainees. The statically significant results of the paired t-test ($p < 0.05$) showed that the intervention had a strong effect on NAT knowledge. Implicating video simulation in the curriculum of NATs could have significant benefits for nurse anesthesia educators. This study can help educators focus efforts on knowledge gaps pointed out in the study. Furthermore, this pilot study shows that there is some baseline deficit of knowledge regarding malignant hyperthermia for both junior and senior nurse anesthesia trainees. Video simulation may prove to be more useful as technology becomes a larger part of education. This pilot study supports the use of video simulation in the nurse anesthesia trainee population.

Limitations

One limitation of this study was the small sample size of twenty students. Since the convenience sample target population was only those nurse anesthesia trainees in their second or third year at Northshore University HealthSystem School of Nurse Anesthesia, the number amount of potential volunteer participants was restricted. Furthermore, the sample size was nonrandom and was a convenience sample. This could ultimately have led to selection bias.

Another potential limitation was possibly developing a pre-test that was too simple to be reliable from the Kuder-Richardson Formula Test perspective. The KR-20 value of 0.031 suggests that the pre-test may have been made too simple to appropriately discern internal reliability. The small sample size of twenty students also skews the results of the KR-20 towards such a low value of reliability. Overall, the pre-test could have been made more difficult to

ensure reliability. Demographic information was not collected in this study, however, future research that associates demographic information with the participants pre-test and post-test scores would provide great insight to educators that could help tailor individual students learning needs.

Future Recommendations

High-fidelity simulation has been widely shown to be a useful tool in healthcare education. Further research regarding the use of instructional video simulation sessions are needed in order to determine the usefulness of videos as a tool for learning crisis. The goal of this project was to create an instructional video simulation for NATs that is practical, useful, accessible, and ultimately improves clinical performance should a MH crisis occur.

The impact of this study is to teach NATs how to properly manage a MH crisis in their professional practice. Another impact of the study is that NATs that receive MH simulation training will feel more comfortable managing MH crisis than those without training. Furthermore, the study will facilitate the NATs to implement a culture of safety into their practice, which will ultimately be beneficial going under anesthesia. The strength of this study is that it helps NATs learn how to properly manage a MH crisis in a safe and approachable environment. With MH being such a rare, but life threatening complication, it is unlikely that many NATs will see it in their practicum. Teaching a video simulation will ultimately help the NATs properly manage this crisis if it occurs later in their practice. This benefits public health by ensuring that those providing anesthesia have training in crisis scenarios and know how to manage a MH crisis.

The results of this pilot study show that video simulation is useful in improving knowledge of NATs regarding MH recognition and treatment. A long-term goal is to create a

library of videos at Northshore University HealthSystem School of Nurse Anesthesia. Past Doctorate of Nursing Practice (DNP) studies have been performed regarding skills and clinical scenarios. Eventually, a large library of technical skills, non-technical skills, and crises management could be developed. This library could then be shared to other programs throughout the country and also to impoverished areas throughout the world that may not have high-fidelity simulation sites readily available. If video simulation proves to be a useful learning tool, the potential outreach is boundless.

Conclusion

The use of technology is useful in enhancing traditional learning methods. The findings of this study show that viewing a video simulation on the proper management of malignant hyperthermia increased knowledge in both second and third year nurse anesthesia trainees. The results of this anesthesia crisis study were consistent with previous literature that demonstrated the positive effects of video simulation in medical and nursing education. The strong results of this pilot study conclude that there is a significant role for video simulation in the curriculum of nurse anesthesia programs. Further research is needed to explore this new and exciting educational strategy.

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Figure 1: Sample Distribution

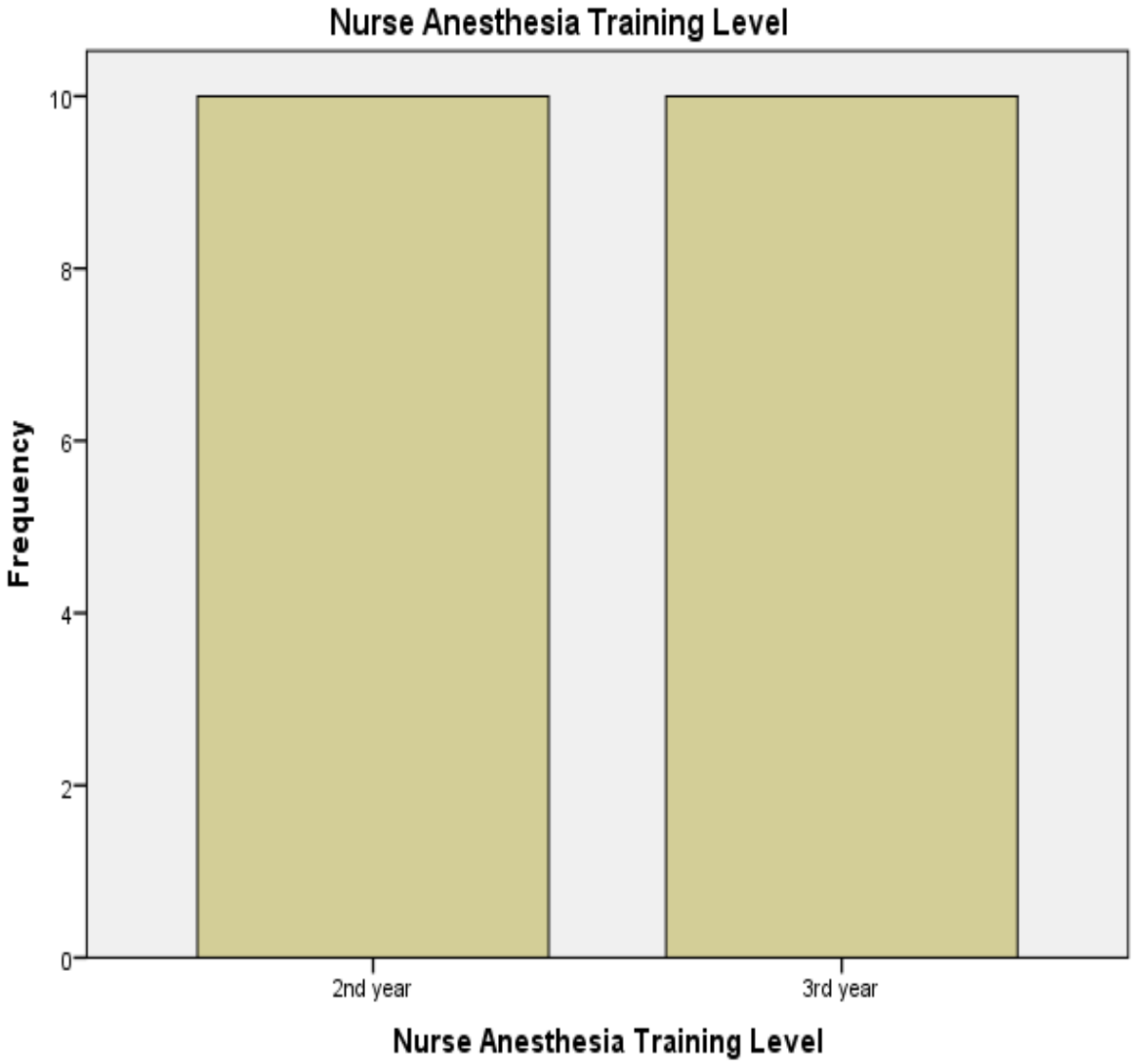

Figure 2: Pretest - Challenging Questions

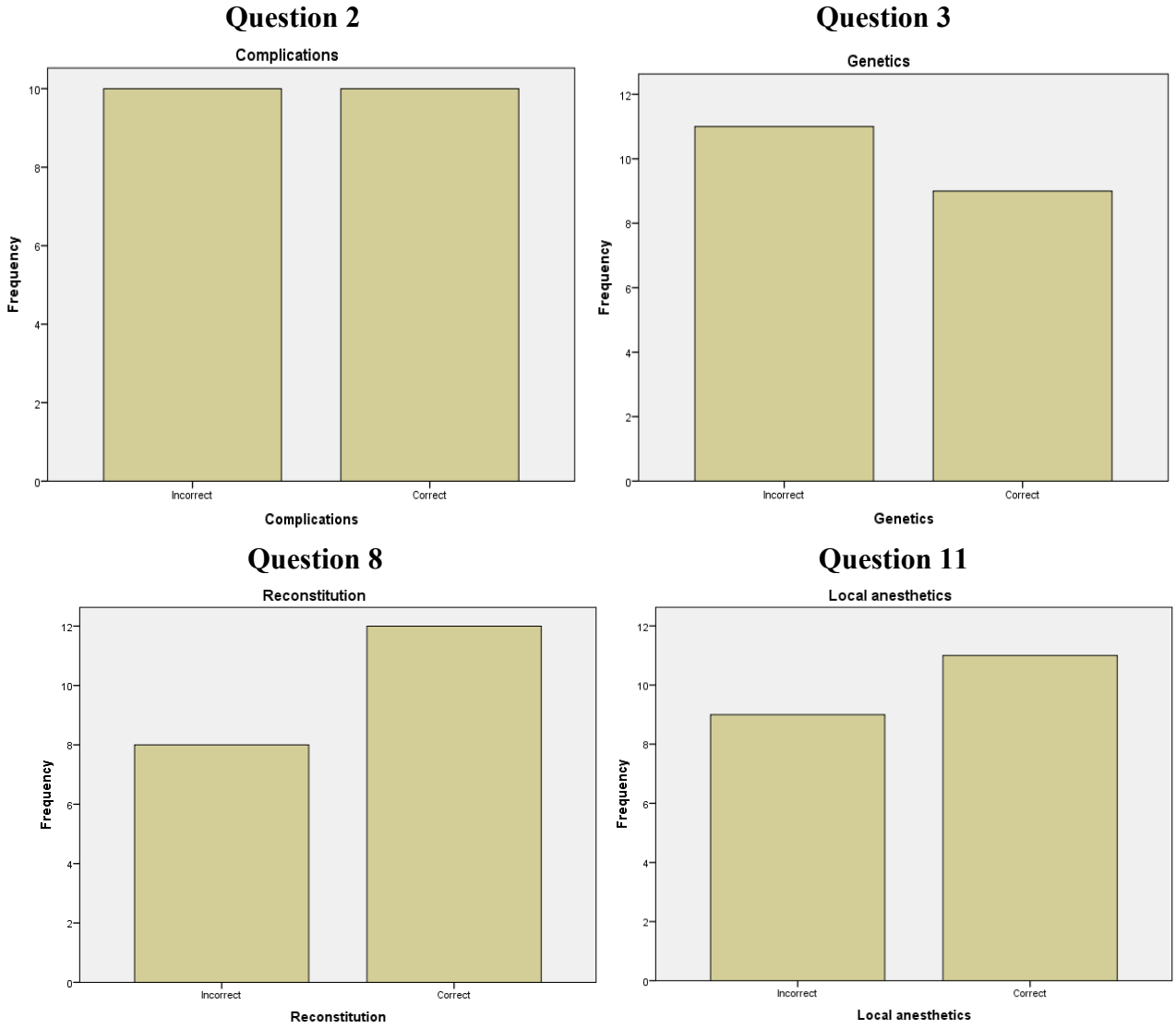

Table 1: Crisis Simulation Evidence-Based Research Table

Study Author & Year	Study Objectives	Methods (Design, sample size, setting, human subject issues)	Study variables or constructs measured or variables controlled by researchers	Instruments used to measure the constructs	Statistics Used	Findings	Conclusions
Bashaw (2016)	Incorporate a high-fidelity simulation of MH into an undergraduate nursing program's elective course	Qualitative observational Convenience sampling - 9 undergraduate nursing students Yes – students as a vulnerable population – IRB approval not specified	No direct variables being looked at – observational study	Qualitative debriefing session	No statistics used	High-fidelity simulation allow allows nursing faculty to assess a student's ability to manage MH, debriefings found that MH simulation was a positive experience	Student nurses and nursing school faculty voiced that having the MH crisis simulation allowed them to improve student performance without risking harm to actual patients
Cain, Riess, Gettrust, and Novalija (2014)	Discuss high-fidelity simulation for MH training purposes and explain how a quality improvement project improved response to MH crisis	Qualitative descriptive Convenience sampling - 19 RNs and 10 surgical techs divided into two groups on two separate days Human subject issues – No	Variables were not controlled as the study was descriptive in nature and did not perform an actual intervention	Qualitative debriefing session	No statistics used	Two-part MH simulation provided improved role clarity, anticipatory response, and team cohesion Increased knowledge and confidence managing a MH crisis	All personal at the given institution are required to participate yearly in MH team training
Dirksen, Van Wicklin, Mashman, Neiderer, and Merritt (2013)	Develop a successful MH drill, response plan, and evaluation	Qualitative descriptive Explained failures of MH crisis management in case study and developed tools/lists to help improve future episodes No given sample size No human subject issues	Suggested responsibilities by role during MH drill or event MH Mock Drill Evaluation Tool Suggested components of MH emergency treatment cart No actual performances of mock drill performed, just suggested components of above lists	10 question multiple choice competency test regarding MH crisis management	No statistics used	Hospitals are often unprepared to properly respond to MH crisis. In case study example identifying tachycardia, taking too much time to mix dantrolene, taking too much time to retrieve ice, and difficulty reading the MH hotline number were problems that could have been prevented if MH mock drill and response plan was in place Preparation for emergencies	An evaluation tool can be designed to help identify MH management problems Conducting mock drills on a regular basis would help prevent problems during MH management

						like MH must not only include didactic educational sessions, but also regular mock drills and simulation exercises to allow for improvement of cognitive, mechanical, and teamwork skills	
Henrichs et al. (2009)	Explore performance of certified registered nurse anesthetists and anesthesiologists in a simulation-based skills assessment	Quantitative experimental – single blinded Convenience sampling - 26 CRNAs and 35 anesthesiologists 61 specialists each managed 8 of 12 randomly selected, scripted, intraoperative simulation exercises IRB approval obtained – noted in methods section	12 randomly selected, scripted, intraoperative simulated events were developed to measure essential skills in intraoperative acute care management Bronchospasm, anaphylaxis, unstable ventricular tachycardia, MI, right bronchial intubation, tension pneumothorax, MH, blocked ETT, total spine, loss of pipeline O2, hyperkalemia, acute hemorrhage	Two primary raters scored 488 simulation exercises (61 participants x 8 encounters)	The two-way ANOVA yielded a significant group effect (F1 7.8, P 0.01) The significant group effect indicates that, averaged over their eight encounters, the anesthesiologists (mean 66.6% 11.7; range 41.7%–86.7%) received higher overall scores than the CRNAs (59.9% 10.2; range 38.3%–80.4%)	Anesthesiologists achieved a modestly higher mean overall score than CRNAs (66.6% 11.7 [range 41.7%–86.7%] vs 59.9% 10.2 [range 38.3%–80.4%] P 0.01) There were no significant differences in performance between groups on individual encounters. The raters were consistent in their identification of key actions. The reliability of the eight-scenario assessment, with two raters for each scenario, was 0.80.	The wide range suggests that certification in either discipline may not yield uniform acumen in management of simulated intraoperative emergencies In both groups, there were practitioners who failed to diagnose and treat simulated emergencies. Simulation-based assessment provides a tool to determine the ability of practitioners to respond appropriately to clinical emergencies If all practitioners could effectively manage these critical events, the standard of patient care and ultimately patient safety could be improved
Henrichs, Rule, Grady, and Ellis (2002)	Explore nurse anesthesia students perceptions of using simulation training in their education	Qualitative observational Convenience sampling - 12 nurse anesthesia students	Students perceived advantages of the simulation training Students perceived	Observation by primary investigator, journal entries by nurse anesthesia students, and	Modified version by Moustakas of the Stevick-Colaizzi-Keen Method of Analysis of Phenomenological Data and	Advantages identified included the ability to evaluate cognitive and psychomotor skills, the	Simulation sessions may be the only way for a nurse anesthesia student to experience a patient with

		4 simulation sessions – 1) introduction to simulation lab before OR experience, 2) anesthetic induction before OR experience, 3) 5 weeks after being in OR and managing cases, and 4) 10 weeks after being in OR and managing cases Human subject issue – yes – students as a vulnerable population – IRB approval not deliberately specified	disadvantages of simulation training	focus group interviews with the students	merging it with Creswell's Data Analysis Procedures – observation notes, journals, and interview tapes were analyzed	development of critical thinking and decision-making skills along with crisis management skills, and the management of rare or unusual anesthetic events increased confidence and development of leadership skills Disadvantages identified by the students included the lack of reality of the simulator, the lack of knowledge regarding crisis event management, the potential for making fixation errors, and the anxiety that the sessions caused	rare but frightening anesthetic complications such as MH Students had mixed feelings regarding the use of simulation
Redmond (2001)	Review MH and discuss perianesthesia recognition, treatment, and care of a patient with MH crisis	Qualitative descriptive Explained pathophysiology of MH crisis management, reviewed essential MH cart supplies, overviewed roles of various OR staff, and discussed staff preparedness No given sample size – descriptive study No human subject issues	No constructs measured	N/A	No statistics used	One method of preparing for MH crisis management is to conduct a mock MH crisis drill to familiarize staff with resources, responsibilities, and crisis plan	By reviewing the pathophysiology and treatment interventions of MH, perianesthesia nurses, perioperative nurses, and anesthesia providers are better prepared to recognize the crisis, intervene effectively, and participate in the management of these patients
Sousa, Bispo, Cunha, and Siqueira (2015)	To evaluate the effectiveness of an educational intervention on malignant hyperthermia with operating room nurses	Quantitative quasi-experimental pretest posttest Convenience sampling - 96 nursing techs and nurses IRB approval was obtained as mentioned in	Pre-intervention tests and post-intervention tests were applied, which consisted of a lecture followed by simulation The test	The existence of a protocol for crisis assistance, assistance notification procedures and the professionals that act during malignant hyperthermia	Collected data was entered into Microsoft Excel spread- sheet in, using double entry technique for analysis in the Statistical Package for Social Sciences, version 20.0 (SPSS)	There was a statistically significant difference ($p<0.00$) after the educational intervention There was an increase of the minimum and maximum scores, and	The educational intervention strategy favors the concept of the content developed by everyone involved and qualifies professionals to work safely

		the methods portion of the paper	comprised knowledge of pathology definitions, diagnosis, treatment, and side effects of medication Cronbach's Alpha coefficient of the questionnaire was 1.0	crisis A point was awarded for each correct answer Total score of the knowledge test corresponded to the sum of all correct answers Knowledge on the subject was considered for scores similar or higher than 70%	For statistical analysis, the Wilcoxon test was used to compare mean before and after (significance level was set at $p<0.05$)	average growth of 2.64 points in the knowledge of professionals when compared to the previous step	The results show effectiveness of the educational intervention performed with an increase in knowledge gained by the team
Tofil et al. (2014)	Evaluate time to recognize and treat ventricular fibrillation in a pediatric prone patient and to expose learners to the difficulties of managing emergencies in prone patients	Quantitative – Quasi-experimental Convenience sampling - 24 anesthesia residents with 13 groups Standardized simulation sessions were conducted monthly for 13 months with groups of 1–2 residents in each simulation Ventricular fibrillation occurred three minutes into the case Sessions were viewed by simulation staff, and time to events was recorded A scripted debriefing followed each case Evaluations were completed by each participants Human subjects issue –	Time to: Announce rhythm Turn patient Ask for blood gas Call for crash cart Start chest compressions Ask for defibrillator Call for help Recognize hyperkalemia Give medications Warm patient	Measured via scorer: Times to critical events were recorded on a data recording form and entered into a spreadsheet.	Descriptive statistics were calculated using Microsoft Excel	The average time to start chest compressions was 77 s, and the average time in recognizing ventricular fibrillation was 76 s. No group performed chest compressions while prone Only one group defibrillated in the prone position Participants average time to request defibrillation was 108 s While nine of 13 groups (69%) ordered an arterial blood gas, only five recognized hyperkalemia, and only four groups gave calcium	Anesthesia residents need additional training in recognizing and treating operative ventricular fibrillation, especially in prone patients Training in the treatment of uncommon pediatric emergencies should be a focal point in anesthesia residency programs

		IRB approval from university review board stated in ethical consideration section					
Wunder (2016)	Determine whether an educational intervention on nontechnical skills could improve the performance of nontechnical skills during anesthesia crisis simulation with a group of first-year student registered nurse anesthetists	Quantitative Quasi-experimental pretest-posttest Convenience sampling - 32 first year nurse anesthesia students Each student was videotaped and rated as they performed 6 simulated crisis scenarios: 3 scenarios before the intervention and 3 after the intervention. Human subjects issue – students as a vulnerable population – IRB approval obtained as stated in methods section	Anesthetists' Non-Technical Skills system (ANTS) by four raters Measured: 1) Task management 2) Teamwork 3) Situational awareness, 4) Decision making A 4-point scoring system (1-4) was used, with 1 indicating poor and 4 indicating good (minimum score of 1 and maximum score of 16 for the 4 categories). If an element was not observed, it was documented "not observed"	All measured by 4 raters with 5+ years as CRNAs Task management – Planning and preparing, prioritizing, providing and maintaining standards, identifying and utilizing resources Teamwork - Coordinating activities with team, exchanging information, assessing capabilities, and supporting others Situational awareness – gathering information, recognizing and understanding, and anticipating Decision making – identifying options, balancing risks and selecting options, reevaluating	A 1-tailed, paired-samples *t* test was conducted to evaluate the hypothesis that mean posttest scores for nontechnical skills scores will be greater than mean pretest nontechnical skills scores. The test for nontechnical skills scores was significant: t (df = 31) = 1.99, P = .028. Mean scores on the posttest (13.3, SD = 1.73) were higher than the mean scores on the pretest (12.7, SD = 2.12) The standardized difference in means, d = 0.28, indicated a small effect size. The η2 index indicated that 2% of the variance in scored nontechnical skills was attributed to the educational intervention	Nontechnical skills mean posttest score was greater than pretest scores: t (df = 31) = 1.99, P = .028. The mean gain in scores for standardized nontechnical skills were significantly greater than those for standardized technical skills: t (df = 30) = 1.81, P = .04	A 3-hour educational intervention on nontechnical skills resulted in significant improvement of first year nurse anesthesia students Nontechnical skills are not acquired through experience, but rather through instruction An educational intervention using the Anaesthetists' Non- Technical Skills system is a valuable tool in the measurement of nontechnical skills assessment of first-year nurse anesthesia students
Yiasemidou, Glassman, Tomlinson, Song, and Gough (2017)	Assess expert opinion on the current and future role of simulation in surgical education	Mixed qualitative, quantitative cross-sectional study Questionnaire sent to 27 surgical programs (21 responded)	Questionnaire: 1) Simulation is a good training tool 2) simulation can re-enact stressful situations 3) simulation is most appropriate	Expert opinion was sought through an externally validated questionnaire that was disseminated electronically	The regional response rate was 78% (21 questionnaires received/27 questionnaires sent) with replies from 9/11 specialties (cardiothoracic surgery, general surgery, maxillo-	Simulation was considered a good training tool The concept that simulation is useful mostly to novices and for basic skills acquisition was rejected	The use of simulation for the acquirement of both technical and nontechnical skills is strongly supported while views on other

		The methodology consists of 4 stages: (1) development of questionnaire, (2) external validation of questionnaire, (3) regional dissemination, and (4) national dissemination	for novices 4) simulation is mostly useful for basic skills Written portion was also available for additional comments		facial surgery, neurosurgery, trauma and orthopedics, Ear, Nose, Throat surgery, pediatric surgery, urology, and vascular surgery) Pie graphs used to depict survey results	Simulation is considered suitable for teaching nontechnical skills and re-enacting stressful situations Most respondents also felt that education centers should be formally and that consultant mentors should be appointed by every trust There were mixed views on its use for trainee assessment	applications (e.g., assessment) are conflicting The need for center accreditation and supervised, consultant-led teaching is highlighted

Table 2: Paired Samples Statistics and Correlations

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Mean Scores Pre Test	**10.7500**	20	1.48235	.33146
	Mean Scores Post Test	**13.9000**	20	.30779	.06882

Paired Samples Correlations

		N	Correlation	**Sig.**
Pair 1	Mean Scores Pre Test & Mean Scores Post Test	20	.404	**.078**

Table 3: Paired Samples Test

Paired Samples Test

		Paired Differences				
					95% Confidence Interval of the Difference	
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper
Pair 1	Mean Scores Pre Test - Mean Scores Post Test	**-3.15000**	1.38697	.31014	-3.79912	-2.50088

		t	df	**Sig. (2-tailed)**
Pair 1	Mean Scores Pre Test - Mean Scores Post Test	-10.157	19	**.000**

Table 4: Descriptive Statistics by Question

	1 - General MH Question	**2**- Complications	**3**- Genetics	**4**- Presentation	**5**- First Step	**6**- Drugs	**7**- Dantrolene
Mean	1.00	.50	.45	.90	1.00	1.00	.85
Median	1.00	.50	.00	1.00	1.00	1.00	1.00
Std. Deviation	.000	.513	.510	.308	.000	.000	.366
Variance	.000	.263	.261	.095	.000	.000	.134
Skewness	N/A	.000	.218	-2.888	N/A	N/A	-2.123
Std. Error of Skewness	.512	.512	.512	.512	.512	.512	.512
Sum	20	10	9	18	20	20	17

	8 - Reconstitution	**9** - Timing	**10**- Pharmacology	**11**- Local Anesthetics	**12**- Fluid Management	**13**- Diseases	**14**- Treatment
Mean	.60	.70	.75	.55	.90	.70	.85
Median	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Std. Deviation	.503	.470	.444	.510	.308	.470	.366
Variance	.253	.221	.197	.261	.095	.221	.134
Skewness	-.442	-.945	-1.251	-.218	-2.888	-.945	-2.123
Std. Error of Skewness	.512	.512	.512	.512	.512	.512	.512
Sum	12	14	15	11	18	14	17

Table 5: Results - Juniors vs. Seniors

Group Statistics

	Nurse Anesthesia Training Level	N	**Mean**	Std. Deviation	Std. Error Mean
Mean Scores Pre Test	2nd year	10	**10.0000**	1.24722	.39441
	3rd year	10	**11.5000**	1.35401	.42817
Mean Scores Post Test	2nd year	10	**13.8000**	.42164	.13333
	3rd year	10	**14.0000**	.00000	.00000

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
7 - Dantrolene	Equal variances assumed	47.250	**.000**	-1.964	18
	Equal variances not assumed			-1.964	9.000
12 - Fluid management	Equal variances assumed	16.000	**.001**	-1.500	18
	Equal variances not assumed			-1.500	9.000
13 - Diseases	Equal variances assumed	16.000	**.001**	-2.058	18
	Equal variances not assumed			-2.058	14.737
9 - Timing	Equal variances assumed	3.429	.081	-.949	18
	Equal variances not assumed			-.949	17.308

Appendix A

Instructional Video Script (MH Preparedness)

	VIDEO CONTENT AND SCRIPT
Screen 1: Introduction/Title Screen	Malignant Hyperthermia Video Simulation
Screen 2:	Teaching Objectives: 1. To improve nurse anesthesia trainees' knowledge of malignant hyperthermia recognition 2. To provide an educational video for nurse anesthesia trainees 3. To improve knowledge of management of malignant hyperthermia
Screen 3:	History/Background of Malignant Hyperthermia: *Script:* *"Malignant Hyperthermia (MH) is a rare, anesthesia induced complication with estimated incidence of 1:15,000 in children and 1:20,000 to 1:50,000 in adults"* *"It is a drug-triggered event that occurs when genetically predisposed individuals are exposed to certain anesthetic agents"* *"It occurs most often within one hour after the induction of a general anesthetic"* *"It can be triggered by frequently used anesthetic gases such as sevoflurane, desflurane, and isoflurane and also depolarizing muscle relaxants such as succinylcholine"* *"MH is an inherited autosomal dominant disease carried by the RYR1 gene. Simply put, if one parent has the trait for MH, each child will have a 50% chance of inheriting the same trait"* *"This crisis can be difficult to recognize and manage without proper training. It is a life threatening and time sensitive situation that must be recognized promptly and managed properly to ensure patient survival."*
Screen 4:	Recognition: **Early signs and symptoms:** 1. Increased ETCO2 2. Tachycardia 3. Tachypnea

	4. Mixed Acidosis (ABG) 5. Masseter spasm/trismus 6. Sudden cardiac arrest in young person due to hyperkalemia **Late signs and symptoms:** 1. Hyperthermia 2. Muscle rigidity 3. Myoglobinuria 4. Arrhythmias 5. Cardiac Arrest *Script: (List will be read as they appear on the video)* *The listed symptoms are the most common symptoms of malignant hyperthermia. Please note that hyperthermia is actually a late symptom of MH. A sudden severe increase in ETCO2 is the most common initial symptom.* (visual of a patient care screen during a real MH scenario)
Screen 6:	Initial Steps: 1. Call for help 2. Call for MH cart 3. Inform surgical team – halt procedure if possible. If emergent, discontinue use of volatile agent and continue with non-triggering anesthetic. 4. Start preparing Dantrolene *Script: (List will be read as they appear on the screen)* *It is always important to initially call for help and ask for the MH cart. The only definitive treatment of MH is Dantrolene, so as soon as it is available, it is imperative to begin the preparation. We will demonstrate how to prepare Dantrolene in a later slide.*
Screen 7:	Treatment after above steps 1. Discontinue anesthetic triggers (volatiles and succinylcholine) - do NOT change machine or circuit. 2. Increase oxygen to 100% O2 with high flows (10 L/min) 3. Increase minute ventilation (but avoid air trapping)

	Script: (List will be read as they appear on the screen)
Screen 8:	Reconstitution of Dantrolene Assign two people to reconstitute 2.5 mg/kg IV Dantrolene (Ryanodex) bolus: Dilute each 20 mg Dantrolene vial in 60 mL preservative-free sterile water Ex: for 70 kg person give 175 mg so prepare 9 vials of 20 mg Dantrolene Rapidly administer Dantrolene and continue giving until patient stable (may need >10 mg/kg) *Script: (List above will be read as they appear on the screen)* *Preparation of Dantrolene can be cumbersome and difficult in a stressful situation. Designating 2 or more people to prepare the Dantrolene is very helpful (show example of mixing Dantrolene vials with sterile water)*
Screen 9:	Treatment of Hyperkalemia • Calcium chloride 10 mg/kg IV • D50 1 Amp IV (25g/50 ml Dextrose) + Regular Insulin 10 units IV (monitor glucose) • Sodium Bicarbonate 1-2 mEq/kg *Script: (List above will be read as they appear on the screen)* *Arrhythmias are usually secondary to hyperkalemia. Treat hyperkalemia as needed. DO NOT use calcium channel blockers such as Verapamil, Diltiazem, and Nifedipine. Use ACLS protocol for sustained arrhythmias and instability.*
Screen 10:	Actively cool patient with ice packs, lavage if open abdomen. Stop cooling at core temp of 38°C *Script: (List above will be read as they appear on the screen)* *Pack groin, neck, and axilla with ice packs. Closely monitor temperature and stop cooling once the patient has reached 38* °C.
Screen 11:	Further steps:

	Send labs: ABG, BMP, CKMB, lactate, coagulation studies. Place Foley and monitor UOP to 1-2 ml/kg/hr Fluid Management: Administer NS to maintain a urine output of at least 2 ml/kg/hr Arrange ICU bed Continue Dantrolene 1 mg/kg every 4-6 hours or 0.25 mg/kg/hr infusion for at least 24 hours (25 % of MH events relapse) Observe patient in ICU for at least 24 hours *Script: (List above will be read as they appear on the screen)* *"It is imperative to continue Dantrolene for at least 24 hours even after the acute crisis has stopped"*
Screen 12:	Signs of successful dantrolene treatment: • Decreased serum ionized calcium • Normalization of PaCO2 • Temperature stabilized < 38 degrees centigrade Complications: • Hyperkalemia • Respiratory and metabolic acidosis • Hypocalcemia • Rhabdomyolysis • DIC *Script: (List above will be read as they appear on the screen)* *"A decrease in serum ionized calcium and normalization of CO2 levels are signs of successful treatment with Dantrolene"*

Screen 13	Management of a patient with known MH or family history: *"All local anesthetics are acceptable to use in patients that have a history of or are susceptible to MH"* *"If patient must have general anesthesia, avoid any triggering agents, such as volatile agents and succinylcholine. Total intravenous anesthesia (TIVA) is the preferred approach for those susceptible to MH needing general anesthesia"* Susceptible patient populations: • Unexpected exertional rhabdomyolysis • Central core diseases • King Denborough Syndrome • Multiminicore disease *(List above will be read as they appear on the screen)* *"It is imperative that these patient populations have thorough preoperative assessments and that they are recognized as high risk for MH crisis."*

Appendix B

Pre-Test and Trainee Level Identifier

Please check the box that applies to you:

NAT 2 _____ **NAT 3 _____**

Participation in this study is entirely voluntary and confidential. If at any time during the study you wish to no longer participate, simply let the primary investigator know. Once this page is complete, please place it in the manila envelope provided to you. Ensure that the number on the manila envelope corresponds to this identifier sheet as well as the pre-test and post-test.

MH Competency Pre-Test

Malignant Hyperthermia is a rare, anesthesia induced pathophysiological process that is deadly if not treated accurately and quickly. Please answer the following questions regarding management of a MH crisis. This test should take approximately 10 minutes. Once completed, place the test in the manila envelope provided and ensure that the number on the envelope corresponds to the number on the top of this test.

1) Malignant Hyperthermia **(CHOOSE 2)**

a) Is a life-threatening situation

b) Requires rapid recognition to ensure patient survival

c) Occurs equally in children than adults

d) Occurs primarily in cancer patients

e) Is triggered by propofol

2) Complications if MH is not quickly caught include **(CHOOSE 2)**:

a) Hypothermia

b) Ketoacidosis

c) Diabetes insipidus

d) Hyperkalemia

e) Hypophosphatemia

3) A patient has a parent with malignant hyperthermia, what is the chance that the patient carries the gene for MH?

a) 33%

b) 25%

c) 50%

d) 100%

4) The earliest sign of MH presentation is:

a) Unexplained increase in ETCO2

b) Hyperthermia

c) Muscle rigidity

d) Arrhythmia

5) When MH is suspected, of the following options, the **first thing** an anesthetist should do is:

a) Discontinue use of all volatile agents

b) Draw labs

c) Hyperventilate the patient with 50% O2

d) Give succinylcholine

e) Change the anesthesia machine out for a new machine

6) Which of the following anesthetic drugs could trigger a MH episode? **(CHOOSE 2)**

a) Sevoflurane

b) Rocuronium

c) Succinylcholine

d) Nitrous Oxide

e) Thiopental

7) Dantrolene sodium is initially administered in doses of:

a) 2.5 mg/kg

b) 3.5 mg/kg

c) 5 mg/kg

d) 3.5 mg/kg

e) 20 mg/kg

8) How is dantrolene reconstituted?

a) With 0.9% saline

b) With Sterile Water

c) With D5W

9) At what dose and how long should Dantrolene be continued after a MH crisis has stopped?

a) 0.25 mg/kg/hr infusion for at least 24 hour

b) 1 mg/kg every 8 hours

c) 3 mg/kg every 6 hours

d) It can be stopped immediately after the crisis has stopped

10) If Dantrolene is used to treat a MH crisis, which drug CANNOT be used?

a) Amiodarone

b) Diltiazem

c) Lidocaine

d) Glucose/Insulin

11) Which type local anesthetic is safe to administer in a patient with a suspected history of malignant hyperthermia?

a) Esters

b) Amides

c) Both

d) Neither

12) Describe the fluid management in a patient with malignant hyperthermia:

a) Restrict fluids to 1 ml/kg/hr

b) Administer hypertonic saline at 1 ml/kg/hr

c) Administer LR at 2 mg/kg/hr

d) Administer NS to maintain a urine output of at least 2 ml/kg/hr

13) Patients with which of the following conditions should not receive volatile anesthetics that trigger MH **(CHOOSE 2)**:

a) Central core disease

b) Multiple sclerosis

c) Duchenne muscular dystrophy

d) Paralysis after a stroke

14) Which of the following are signs of a successful dantrolene treatment of a malignant hyperthermia episode **(CHOOSE 2)**:

a) Increase in serum K+ concentration

b) Decrease in serum ionized calcium

c) An increase in skeletal muscle rigidity

d) Normalization of PaCO2

Appendix C

Post Test and Key

MH Competency Post-Test

Malignant Hyperthermia is a rare, anesthesia induced pathophysiological process that is deadly if not treated accurately and quickly. Please answer the following questions regarding management of a MH crisis. This test should take approximately 10 minutes. Once completed, place the test in the manila envelope provided and ensure that the number on the envelope corresponds to the number on the top of this test.

1) Malignant Hyperthermia **(CHOOSE 2)**

a) Is a life-threatening situation

b) Requires rapid recognition to ensure patient survival

c) Occurs equally in children than adults

d) Occurs primarily in cancer patients

e) Is triggered by propofol

2) Complications if MH is not quickly caught include **(CHOOSE 2)**:

a) Hypothermia

b) Ketoacidosis

c) Diabetes insipidus

d) Hyperkalemia

e) Hypophosphatemia

3) A patient has a parent with malignant hyperthermia, what is the chance that the patient carries the gene for MH?

a) 33%

b) 25%

c) 50%

d) 100%

4) The earliest sign of MH presentation is:

a) Unexplained increase in ETCO2

b) Hyperthermia

c) Muscle rigidity

d) Arrhythmia

5) When MH is suspected, of the following options, the **first thing** an anesthetist should do is:

a) Discontinue use of all volatile agents

b) Draw labs

c) Hyperventilate the patient with 50% O2

d) Give succinylcholine

e) Change the anesthesia machine out for a new machine

6) Which of the following anesthetic drugs could trigger a MH episode? **(CHOOSE 2)**

a) Sevoflurane

b) Rocuronium

c) Succinylcholine

d) Nitrous Oxide

e) Thiopental

7) Dantrolene sodium is administered in doses of:

a) 2.5 mg/kg

b) 3.5 mg/kg

c) 5 mg/kg

d) 3.5 mg/kg

e) 20 mg/kg

8) How is dantrolene reconstituted?

a) With 0.9% saline

b) With Sterile Water

c) With D5W

9) At what dose and how long should Dantrolene be continued after a MH crisis has stopped?

a) 0.25 mg/kg/hr infusion for at least 24 hour

b) 1 mg/kg every 8 hours

c) 3 mg/kg every 6 hours

d) It can be stopped immediately after the crisis has stopped

10) If Dantrolene is used to treat a MH crisis, which drug CANNOT be used?

a) Amiodarone

b) Diltiazem

c) Lidocaine

d) Glucose/Insulin

11) Which type local anesthetic is safe to administer in a patient with a suspected history of malignant hyperthermia?

a) Esters

b) Amides

c) Both

d) Neither

12) Describe the fluid management in a patient with malignant hyperthermia:

a) Restrict fluids to 1 ml/kg/hr

b) Administer hypertonic saline at 1 ml/kg/hr

c) Administer LR at 2 mg/kg/hr

d) Administer NS to maintain a urine output of at least 2 ml/kg/hr

13) Patients with which of the following conditions should not receive volatile anesthetics that trigger MH **(CHOOSE 2)**:

a) Central core disease

b) Multiple sclerosis

c) Duchenne muscular dystrophy

d) Paralysis after a stroke

14) Which of the following are signs of a successful dantrolene treatment of a malignant hyperthermia episode **(CHOOSE 2)**:

a) Increase in serum K+ concentration

b) Decrease in serum ionized calcium

c) An increase in skeletal muscle rigidity

d) Normalization of PaCO2

KEY

1) A, B
2) B, D
3) C
4) A
5) A
6) A, C
7) A
8) B
9) A
10) B
11) C
12) D
13) A, C
14) B, D

Appendix D

Recruitment Email

Student Learning Opportunity

"A Malignant Hyperthermia Competency Training for Nurse Anesthesia Trainees: Development, Implementation, and Evaluation"

Andrew Christ, RN, BSN

NorthShore University HealthSystem School of Nurse Anesthesia and DePaul University

Karen Kapanke, CRNA, DNP

Faculty, NorthShore University HealthSystem School of Nurse Anesthesia

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Subject: Malignant Hyperthermia Competency Training

Junior and senior NATs,

My name is Andrew Christ and I am a senior NAT conducting my doctoral research with NorthShore University HealthSystem School of Nurse Anesthesia and DePaul University.

My research study involves the development and implementation of a malignant hyperthermia (MH) competency training for junior and senior NATs. This training involves a simulation video of a properly managed MH crisis along with important knowledge and concepts surrounding MH crisis. The goal of this project is to improve NATs knowledge in regards to MH recognition, management, and intervention of a MH crisis. Each NAT willing to participate will be tested via a pre-test and post-test format. The test will consist of 15 multiple-choice questions and each test should last roughly 15 minutes. After completing the pre-test, a training video lasting 15-20 minutes will be shown. After completion of the video, another 15 question post-test will be administered. The entire competency training should last no more than 1 hour.

Participation in this program is voluntary and the test responses will be confidential. Participants can discontinue involvement at any time without penalty. Participation will not influence your grades and will not have any effect on your standing within NorthShore University HealthSystem School of Nurse Anesthesia or DePaul University. Attached to this email you will find an information sheet outlining this research project. By participating in the program, you will be agreeing to the NorthShore and DePaul Academic Code of Conduct.

This study will take place after your regularly scheduled seminar club on February 10th. If you chose to participate, simply show up to Frank Auditorium on February 10th at 11:30 AM.

If you are junior or senior NAT interested in participating in this educational experience, simply arrive at the time and location listed above. By arriving at the study location, you are providing your consent to partake in the research.

Thanks for your consideration and I look forward to this learning experience.

Andrew Christ, RN, BSN
NorthShore University HealthSystem School of Nurse Anesthesia
Primary Investigator
andrewmichaelchrist@gmail.com

Appendix E

Information Sheet

Student Learning Opportunity

"A Malignant Hyperthermia Competency Training for Nurse Anesthesia Trainees: Development, Implementation, and Evaluation"

Primary Investigator: Andrew Christ, RN, BSN
NorthShore University HealthSystem School of Nurse Anesthesia and DePaul University

Faculty Chair: Karen Kapanke, CRNA, DNP
Faculty, NorthShore University HealthSystem School of Nurse Anesthesia

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Who: Andrew Christ, Senior NAT conducting doctoral research with NorthShore University HealthSystem School of Nurse Anesthesia and DePaul University.

What: My research study involves the development and implementation of a malignant hyperthermia (MH) competency training for junior and senior NATs. This training involves a simulation video of a properly managed MH crisis along with important knowledge and concepts surrounding MH crisis. The goal of this project is to improve NATs knowledge in regards to MH recognition, management, and intervention of a MH crisis. Each NAT willing to participate will be tested via a pre-test and post-test format. The test will consist of 15 multiple-choice questions and each test should last roughly 15 minutes. After completing the pre-test, a training video lasting 15-20 minutes will be shown. After completion of the video, another 15 question post-test will be administered. The entire competency training should last no more than 1 hour.

When: Following seminar club on February 10th at 11:30 AM

Where: Northshore University Hospital

How: If you are junior or senior NAT interested in participating in this educational experience, simply show up to the above location. By arriving to the study location, you are providing your consent to partake in the research.

Further information and disclaimers: Participation in this program is voluntary and the test responses will be confidential. Participants can discontinue involvement at any time without penalty. Participation will not influence your grades and will not have any effect on your standing within NorthShore University HealthSystem School of Nurse Anesthesia or DePaul University. Attached to this email you will find an information sheet outlining this research project. By participating in the program, you will be agreeing to the NorthShore and DePaul Academic Code of Conduct.

Thanks for your consideration and I look forward to this learning experience.