Web-Based Versus High-Fidelity Simulation Training for Certified Registered Nurse Anesthetists in the Management of High Risk/Low Occurrence Anesthesia Events

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ABSTRACT

Purpose: The purpose of this project was to compare web-based to high-fidelity simulation training in the management of high risk/low occurrence anesthesia related events, to enhance knowledge acquisition for Certified Registered Nurse Anesthetists (CRNAs). This project was designed to answer the question: Is web-based training as effective as high-fidelity manikin based simulation training, in assisting CRNAs to maintain knowledge for the management of high risk/low occurrence anesthesia related events over a training period of four weeks in a level one trauma facility?

Methods: This was a quantitative study. Institutional Review Board (IRB) approval was obtained from Penn State Hershey Medical Center (PSHMC) and the University of Michigan-Flint (U of M-Flint), before study participants were enrolled. A total of 32 participants were enrolled in the study. Participants were randomly assigned to either group I (web-based training) or group II (high-fidelity simulation training). All enrolled participants completed a written demographic survey and pre-test. After their respective training sessions, participants completed a post knowledge test. Quantitative data analysis was used to process the data.

Results: Average baseline pre-training percentage correct score for the web-based group was 80.67%, with a post-training average score of 87% reflecting an increase of 6.33% p value 0.13 not significantly different from zero. In the high-fidelity simulation group, average baseline pre-training score was 82.33%; average post-training score was 83.66%, p value 0.70 reflecting a non-significant increase of 1.33%. Comparison of average percentage correct improvement between the training groups (6.3 web vs. 1.3 sim) p value 0.34, revealed a non-significant difference in the knowledge gained between the web-based and high-fidelity simulation groups.

Conclusion: Maintaining skills for the management of high risk/low occurrence anesthesia related events can be difficult due to the infrequency of these events occurring during a practitioner’s career. It is important that CRNAs maintain the knowledge and skills to manage these rare events. High fidelity simulation has been shown to be an effective training technique in anesthesia. Some institutions may not have the advantage of offering simulation to employees, due to budget constraints, or the availability of lab time and instructors. Web-based training is easily accessible, and can be conveniently available to learners. It may accommodate diverse learning styles, and offer an opportunity for CRNAs to train at their own pace, to enhance learning. This study showed, web-based training is as effective as high-fidelity simulation for training CRNAs for the management of high risk/low occurrence anesthesia related events at Penn State Hershey Medical Center.

Data Sources: Medscape, PubMed, CINAHL, and Google Scholar.

Keywords: web-based learning, high-fidelity simulation learning, high and low risk anesthesia events.
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INTRODUCTION

High risk/low occurrence anesthesia related events are by definition, adverse anesthesia events which are associated with a high risk to patients, but with a low occurrence rate in an anesthesia provider’s career. Certified Registered Nurse Anesthetists (CRNAs) are initially well trained in the management of these events. Knowledge and skill levels may deteriorate over time, when practitioners are not exposed to critical events on a regular basis.¹ Gaps exist in the training techniques for clinicians in health care domains, such as anesthesia, that have the cognitive profile of complexity and dynamism.²

Rapid response for the management of anesthesia related adverse events is critical to successful patient outcomes. Providing a means of educating practitioners to maintain skills in the management of complex and dynamically changing environments, is an essential element in the provision of safe anesthesia care.³ A review of literature revealed different strategies for educating CRNAs, such as didactic instruction, simulation training, and one-to-one clinical training. Research studies indicate, it is increasingly difficult to justify traditional teaching strategies when applied to technical procedures due to evolving changes in best clinical practices.¹ Nurses assuming roles as faculty trainers are faced with the necessity to investigate teaching strategies that are more effective, more economical, and easier to access.³

Education models used for high-risk industries such as aviation, nuclear power and offshore oil production emphasize the need for training to reduce the risks of error.⁴ Professions such as aviation and engineering, with dynamically changing environments, have regular training sessions to maintain worker’s skills.⁴ These sessions include non-technical skills training on attitudes, teamwork, technical performance and clinical outcome.⁴ Studies in healthcare show
that regular training improves patient safety, and provider attitudes across a range of specialty settings.\textsuperscript{4}

Assisting practitioners to maintain skills for the management of high risk/low occurrence events can be expensive and labor intensive.\textsuperscript{5} Large institutions with simulation equipment may have scheduling issues that affect the ability to afford all staff members an opportunity to utilize the simulation equipment for training. In a bid to minimize these scheduling issues, some colleges, and universities have resorted to increased use of technology-dependent communication for teaching and training.\textsuperscript{6} The motivations for such an increase in the use of technology include accessibility, institutional needs, and economic drive.\textsuperscript{7}

Web-based training instruction can be delivered over the internet, or a corporate intranet to browser-equipped learners,\textsuperscript{6} creating easier employee access. Studies designed to assess the role of technology in academic progress, have shown that technology has a positive effect in teaching complex problem-solving skills.\textsuperscript{6} Web-based training tools are available any time, making it possible for employers to offer staff training without depleting resources. Web training may utilize personalized study materials, and interactive formats, making it an alternative to conventional training methods.\textsuperscript{8}

High-fidelity patient simulation refers to the use of computerized manikins that simulate real-life scenarios.\textsuperscript{9} The teaching strategy provides participants with a controlled, safe learning environment in which to develop and enhance skills, without fear of compromising patient safety.\textsuperscript{10} Participants in simulation are able to rehearse the clinical management of rare, complex or crisis situations, in a valid representation of clinical practice.\textsuperscript{10}
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Gaps in the literature exist in comparing the effectiveness of high-fidelity simulation training to web-based training for the management of high risk/low occurrence anesthesia related events. For the purpose of this study; web-based training may be referred to as online learning, or eLearning. eLearning may eliminate some costs associated with high-fidelity simulation training methods such as, commuter costs for training sessions, classroom and infrastructure rentals, trainer cost per hour, and administrative costs.

The intent of this project was to identify if a less costly and labor intensive web-based training method, is as effective as high-fidelity simulation, for educating practitioners to manage high risk/low occurrence anesthesia related events at Penn State Hershey Medical Center. This project aimed to identify the effectiveness of web-based training when compared to high-fidelity simulation training for enhancing CRNAs knowledge in the management of Malignant Hyperthermia (MH) and Local Anesthesia Systemic Toxicity (LAST).

Today's millennial workforce employees may not practice solely for financial gain, but to continually enhance knowledge and skills. Simulation training environments, may offer a limited number of training opportunities for employees. With web-based instruction, training opportunities can be accessed at the employee's convenience. Modules can be created on a variety of subjects, offering increased opportunities for employees to update skills and enhance knowledge in areas of interest. This may be beneficial to the learner, as well as increase employee satisfaction. Institutions that enable access to valuable eLearning topics to their staff, enjoy better loyalty from employees, who demonstrate a greater sense of accomplishment in the workplace.
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The goal of this study was to identify a more cost effective, easier to access training option for CRNAs, for the management of high risk/low occurrence anesthesia related events. This project was designed to address the question; Is web-based training as effective as high-fidelity manikin based simulation training, in assisting CRNAs to maintain knowledge for the management of high risk/low occurrence anesthesia related events, over a training period of four weeks in a level one trauma facility?

REVIEW OF LITERATURE

In 1999, The Institute of Medicine (IOM) concluded that tens of thousands of Americans die each year, as a result of medical errors, and that even larger numbers suffer temporary or permanent harm.11 In the IOM report, To Err is Human: Building a Safer Health Care System, simulation training is recommended as one strategy that can be used to prevent errors in the clinical setting. The report states that health care organizations should take part in development, and use of simulation for training novice practitioners, problem solving, and crisis management.11

The high incidence of medical errors discussed in the IOM report, has resulted in the investigation of educational practices to reduce, and attempt to prevent patient harm. CRNAs may seldom, if ever encounter high risk/low occurrence anesthesia related events in their practice. Errors are costly in terms of loss of trust in the health care system by patients, and diminished satisfaction by both patients and healthcare professionals.11 Assisting practitioners to maintain knowledge and skills to manage adverse anesthesia related events may be challenging for an institution.

The education of anesthesia providers in crisis resource management has been met with challenges due to the inability to duplicate crisis in clinical practice.12 Assisting practitioners to
maintain skill in the management of complex and dynamically changing environments is an essential element in the provision of safe anesthesia care. It is necessary to establish the most efficient and effective method to educate practitioners toward the management of high risk/low occurrence anesthesia related events.

Simulation as a Training Strategy

Using high-fidelity simulation as a means for novices to maintain the necessary cognitive, affective, and psychomotor skills to develop practice expertise is established in the literature. Literature has cited articles involving the application of manikin-based simulation as a teaching tool. Patient simulators that are manikin-based have been utilized for training across numerous health care professions. The IOM report on nursing work environments recommends simulation as a method to support nurses in the ongoing acquisition of knowledge and skills. Despite recommendations for use of simulation, and growing integration of simulation into education, empirical evidence for the impact of simulation on patient outcomes is still underdeveloped.

High-quality evidence indicates that simulation training is an effective strategy to improve team and interdisciplinary communication, technical and cognitive skills, as well as patient outcomes. More studies are required in the application of high-fidelity simulation-based training in high risk/low occurrence anesthesia related events. Medical-surgical nurses took part in a simulated failure to rescue event in which the patient’s clinical condition deteriorated rapidly. In the results of this project, nursing knowledge and critical thinking improved after the simulation. The study established the effectiveness of simulation as a teaching strategy to address nursing knowledge and critical thinking skills.
A systematic review was conducted\textsuperscript{17} including studies related to nursing education that linked safety dimensions with high-fidelity simulation. Primary sources published since 2007 were included with a conclusion that simulation-enhanced clinical experiences may decrease medication errors. The review\textsuperscript{17} established the need for more comparative studies to support theoretical models of simulation.

The study\textsuperscript{18} describes weekly in situ simulation team training when included in routine clinical practice, for the pediatric medical emergency team. The focus was on recognition of the deteriorating child, teamwork and early consultant review of patients with evolving critical illness. Results of the study indicated that simulation lessons incorporated into routine clinical staff training during regular in situ team training, led to significantly improved recognition and management of deteriorating in-patients with evolving critical illness.\textsuperscript{18} Integration of in situ simulation team training in clinical care may have potential applications, beyond pediatrics, to CRNAs faced with high risk/ low occurrence anesthesia related events.

Simulation exercises allow for patient-safe clinician training in, an environment where errors do not affect patient safety.\textsuperscript{19} There is heterogeneous evidence across multiple topic areas that demonstrates training with simulation-based exercises, increases technical and procedural performance. Simulation-based exercises can improve team performance and interpersonal dynamics.\textsuperscript{19}

Simulation must not become an end in itself, disconnected from professional practice, which can lead to over-confidence in learners.\textsuperscript{20} Simulation activities must be made to be as realistic as possible. Research shows that in some simulators, novices can out-perform experts. This indicates a lack of correlation with other outcome measures, and questions the validity of a
simulation experience. To realize its full potential as a learning aid, simulation must be used in conjunction with clinical instruction, and linked closely with it.\textsuperscript{20}

Two primary costs have been identified in the literature associated with simulation, the cost of the simulator, and the cost for training materials.\textsuperscript{21} Simulation instructors require training for the use of simulation equipment, and to develop simulation activities.\textsuperscript{22} There is a need for faculty development and experience, to optimize simulation resources and learning opportunities. Integration of simulated experiences should be incorporated into educational programs.\textsuperscript{22} The instructor should have the appropriate skill set. Many simulation centers offer training for instructors in the educational use of simulation.\textsuperscript{22} This is an additional expense to the already capital-intensive simulation equipment.

In order for simulation to be effective as a learning tool, it should be performed within a safe environment, ensuring that recently-acquired skills are packaged within a clear program of study.\textsuperscript{23} Expert tutors should be available; simulations should map onto real-life clinical experiences, and provide a supportive, motivational and learner centered environment, conducive to learning.\textsuperscript{23} Some institutions with simulation equipment may have scheduling issues that affect their ability to offer all staff members a chance to utilize the simulation equipment. This may eliminate simulation as a training option for many practicing CRNAs. Simulation scenarios are flexible and can be applied in a variety of contexts.\textsuperscript{24} However, they are not standardized, and a formalized set of rules and best practices, is not always readily available.\textsuperscript{24}

A randomized control trial\textsuperscript{25} sought to establish the feasibility of scenario-based simulation training versus traditional workshops in Continuing Medical Education (CME). The study compared the effectiveness of interactive didactic lecture, versus online simulation-based
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CME programs directed at improving the diagnostic capabilities of primary care practitioners. Results established that the use of simulation-based training was not associated with benefits in knowledge acquisition, knowledge retention, or comfort in patient assessment. The data indicated that within the context of a CME activity, a significant improvement in diagnostic accuracy can be achieved by using a web-delivered, multimedia-based instructional activity, supplemented by practice opportunities, and feedback delivered by an artificial intelligence-driven simulation/tutor.

A study was performed to determine whether virtual reality simulation training could supplement and/or replace early conventional endoscopy training (apprenticeship model) in diagnostic gastrointestinal endoscopy. There was no conclusive evidence that simulation-based training was superior to conventional patient-based training, although data were limited. There was insufficient evidence to advise for, or against the use of virtual reality simulation-based training as a replacement for apprenticeship model for health professions trainees with limited or no prior endoscopic experience.

Assisting practitioners to maintain skills for the management of high risk/low frequency events can be expensive and labor intensive for an institution. Facilities may not have access to this type of training environment due to costs associated with educating trainers and providing equipment. The lack of faculty, or time and resources necessary for simulation instruction, may be a deterrent. In order for simulation training to be effective, available faculty trained to provide scenarios, and to operate simulation equipment is imperative. Simulation may limit the number of participants that can be taught at any given time; limiting staff access to available instructors and equipment. Inadequate instruction and low quality simulations can translate into wrong or incorrect conclusions, or incorrect information passed on to participants. Information obtained
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during inadequate simulated scenarios may be applied in the real world, and possibly result in patient harm, or lead to false results in a study that is used to compare different modes of training.  

Simulations that are not well designed may not achieve the training they are intended for. Privacy for participants should be ensured to avoid distraction. Simulation may not allow for certain conditions to be assessed, such as sweating, drooling and other physiologic changes that may appear in real life. Some of these changes are important in the management of high risk/low occurrence scenarios. Limitations associated with the use of simulation as a staff training method lead to the necessity to explore alternative means of educating CRNA practitioners. Web-based training may be more practical as an alternative option to simulation.

Web-Based Learning as a Training Strategy

Web-based, or eLearning refers to the use of technology to enhance knowledge. The term eLearning encompasses the use of computers and networks in training, providing online course administration, online course information, and online communication. This type of learning is referred to by terms such as: online learning, computer-assisted learning, or web-based learning using the internet. eLearning can be accomplished by using a stored electronic medium such as a CD or DVD that displays interactive content on the computer independent of an internet connection, i.e. computer-assisted learning. Merits of eLearning include: eLearning allows anyone, anywhere, to study anything. This strategy makes it possible to teach one person or a group of persons, without much adjustment. It makes it possible to teach any topic in different languages thus accommodating everyone.
Web-based learning has made it possible to study nearly any subject from nearly anywhere in the world. Some types of web-based learning allow students to advance at their own pace; with the exclusion of real-time instructions. Web-based learning packages offered in modules, allow participants to work through individually at their own pace. In addition, electronic forums such as Skype® and Face Time®, allow students to meet with instructors on a one-to-one basis and have the personal attention they may need. eLearning provides students the opportunity to work through the teaching content at their own pace unlike, traditional teaching methods.

Web-based training is easily accessible, and can be conveniently available to learners. Graphics, video, and audio can enhance learning, and accommodate diverse learning styles. Training bias resulting from time limitations, geography restrictions or disability, are eliminated. The provision of this type of training may allow CRNAs to undertake continuous learning without making job changes.

The use of technology-dependent communication in higher education, for teaching and learning, is increasing across all faculties, universities, and professions. The motivations for the development of this style of teaching and learning are varied. Increasing accessibility, institutional needs, and economic implications are all cited as drivers for this increasing use of technology in teaching. Web-based training instruction can be delivered over the internet, or a corporate intranet, to browser-equipped learners. eLearners have demonstrated increased retention rates and better utilization of content. Studies designed to assess the role of technology in academic achievement have shown that it has a positive effect in teaching complex problem-solving skills. By using rich multimedia-content, the learner becomes an active participant in the learning.
In the United States (US), an increasing number of institutions use course management software in training anesthesia residents. Most systems are web-based to facilitate anytime, convenient access to learning content and administration. The web-based software can be accessed even when residents are on rotation outside the main hospital. Social tools such as networking and interactions between the learners and the instructor, are essential components of the entire learning experience, additionally, blogs and wikis can be used to augment the learning experience. For optimum results, the tools used should match the outcome desired and the material being taught.

A study describes the use of the internet and its associated technology in education as necessities at the 21st century University. It specifically addressed how the internet is influencing higher education nursing faculty with regard to teaching, research, and service. Using critical event analysis, the study revealed that access to information via the internet resulted in an increase in faculty productivity and connectivity with colleagues and students, locally and around the world.

A meta-analysis of 51 independent effects identified from a systematic review found that, on average, students in online learning situations performed better than those receiving face-to-face cognitive instruction. The ability of the web’s prospective to function as an information storehouse that could enhance richer inquiry experiences for learners, is articulated. The study advocates for a stronger research focus on three topics: using the web for student inquiry, studying student communication via the web, and invoking qualitative research methods to illuminate web-based learning. The article argues for more research that examines student’s inquiry processes with the web and the teacher’s role in guiding and evaluating such processes.
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By emphasizing the need for further research in using the web for educational purposes, an author,\(^3\) highlights the learner’s abilities to communicate with an international audience through the web. It is suggested that, “researchers need to invoke qualitative research methods in order to discover, document, and describe complex changes occurring in the context of web-based teaching and learning”.\(^3\) This review demonstrates that the web could lead to increased preparation and engagement of the learners, especially due to the web’s transformation and penetration of use in everyday lives.\(^3\)

A study\(^5\) examining effects of web-based learning for emergency airway management in anesthesia residency training, showed a significant improvement in knowledge enhancement with the usage of web-based learning in medical education. The study\(^5\) concluded that feasibility studies can help guide the appropriate use of web-based learning. In an interactive web-based educational program developed for hospital nurses, the study\(^6\) showed a significant increase in their knowledge and performances in assessing, managing, and reporting clinical deterioration.

According to the US Bureau of Labor Statistics, there were close to 80 million people born between the years 1976 and 2001, the generation that is often referred as millennials or Generation Y. This generation represented 36% of the US workforce in 2014, and is likely to rise up to 46% by 2020.\(^8\) “The critical distinction between millennials and the older generations is that while high pay was the most important factor for the older workforce, 30% of millennials considered meaningful work, as the most important job factor. Another 25% regarded a sense of accomplishment being critical to their job.\(^8\)

For learning professionals, this is an important indicator towards the evolution in the industry, at Penn State Hershey Medical Center, Department of Anesthesia and Perioperative
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Medicine, > 70% of CRNAs are millennials. As the percentage of the tech-savvy millennials rises in the work force, the reliance on eLearning tools should increase commensurately. Web-based learning may be a feasible option to CRNA population at Penn State Hershey Medical Center, or any environment where CRNAs practice. eLearning materials may be made accessible to CRNAs throughout the day. CRNAs can learn the subject material at their own pace and comfort. eLearning ensures the fast learners may complete their training sooner, and this enhances productivity unlike conventional learning and simulation training. Time zone differences do not affect learning, nor would office hours, because eLearning is available 24/7.

Studies have shown that gamification, the concept of applying game mechanics and game design techniques to engage and motivate people to achieve their goals, enhances learner engagement and improves retention. There is software available to make interactive modules, and to allow eLearning to be enjoyable, with an improved retention rate. Programs such as POLLEVERYWHERE®, CAMTASIA® and PREZI®, are available to make interactive PowerPoints®. With eLearning, it is possible to gain instant access to trainers from all parts of the world. Video conferencing enables people from various locations to collaborate on problem-solving challenges in real-time, these tools offer advantages that can be applied to CRNA training such as instant connectivity to subject matter experts, regardless of location.

“The worldwide eLearning market will show fast and significant growth over the next three years. The worldwide market for Self-Paced eLearning reached $35.6 billion in 2011.”

The eLearning market is expanding on a yearly basis. This expansion has affected all sectors including healthcare, and as such its benefits can be captured for educating CRNAs.
There is shortage for community health care workers (CHW) worldwide and mostly in sub-Saharan Africa alone, where the shortage is approximately one million. CHWs provide vital life-saving services to communities that do not have regular access to health services. According to the study, savings through using a blended eLearning approach in comparison to a traditional didactic method for CHW training are increased by as much as 67%. These results indicate that using a blended eLearning approach is an opportunity for closing the gap in training community health care workers, and demonstrates how technology can improve training and widen its scope.

In a study to identify the power of technology for training, opportunities to train CHWs through technology-enabled multimedia, were identified to be more cost-effective. Training content utilized visuals, videos, and audio. This research highlighted the potential to create open, easily sharable digital content, which could act as a crucial ingredient for new approaches to train and learn in the future.

Professional silos, static medical curricula, and perceptions of information overload, are some of the issues that have made it difficult for medical training and continued professional development (CPD) to adapt to the changing needs of healthcare professionals, in an increasingly patient centered, collaborative, and/or remote delivery contexts. Increasing numbers of medical education and CPD programs have adopted e-learning approaches, in response to these challenges. eLearning has been shown to provide flexible, low-cost, user-centered, and easily updated learning.

The obstetrics and gynecology residency program at Singhealth, Singapore, aimed to achieve and maintain, excellence in the education and training of obstetricians and gynecologists.
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The goal was to ensure that the program adequately prepared the next generation of obstetrician-gynecologists to become competent and confident specialists, with an interest in lifelong learning, leadership skills, and the ability to adapt to the needs of a changing health care system.\textsuperscript{41} The program identified and adapted new teaching strategies and new competencies not explicitly taught in the prior program.\textsuperscript{41}

Barriers to the effective use of web-based training include issues arising with the use of technology, such as poor access, and slow downloading which can deter learning. Learners may find it frustrating if they cannot access graphics, images, and video clips due to technical issues, lack of skill, or computer expertise. Some learners may have problems with managing complex online learning software, leading to instructors feeling overloaded with learner requests. Though an additional cost, it is important that instructors have inbuilt expert help to deal with technical issues, maintain the program, and manage other issues that may arise, to improve the web-based learning experience for both the learners and the instructor.\textsuperscript{42}

Procrastinators or learners with low motivation may fall behind with web based training strategies. They may have difficulties in organizing their learning, and may need constant reminders.\textsuperscript{43} The lack of contact with the instructor and fellow learners, may result in some learners feeling isolated.\textsuperscript{43} Corporate culture may view access to information as a matter of departmental empowerment, and may wish to maintain centralized control. It may be more difficult for management to allow access to all portions of the corporate intranet.\textsuperscript{43}

Summary

The education of anesthesia providers in crisis resource management has been met with challenges due to the inability to duplicate crisis in clinical practice.\textsuperscript{12} Assisting practitioners to
maintain skill in the management of complex and dynamically changing environments is an essential element in the provision of safe anesthesia care.\textsuperscript{12} It is necessary for individual healthcare institutions to identify the most effective method to educate practitioners in the management of high risk/low occurrence anesthesia related events.

There are gaps in the literature comparing the effectiveness of high-fidelity simulation training to web-based training for the management of high risk/low occurrence anesthesia related events. Many healthcare facilities are not equipped to assist providers in maintaining knowledge regarding these adverse events. This project aimed to determine if web-based training is as effective as simulation training for knowledge enhancement of CRNAs at Penn State Hershey Medical Center.

Studies have shown a significant improvement in knowledge and performance in various contexts with the use of web-based learning, as well as simulation. However, there is little information in the literature that compares web-based learning to high-fidelity simulation learning. By making a comparison of the effectiveness between high-fidelity simulation training and web-based training strategies, the results of this project may offer a viable alternative for assisting CRNAs to maintain the knowledge and skills necessary to manage the high risk/low occurrence events, MH and LAST.

With the rapidly growing volume of medical and scientific information, and the increasing complexity of the healthcare environment, anesthesia providers must adopt new strategies to keep up with the changes. There is a call to bridge the implementation gap, discover, document, and describe complex changes occurring in the context of web-based and simulation learning. CRNAs that are well equipped in handling high risk/low occurrence anesthesia related
events provide safer clinical care. This study aimed to identify a more cost effective, easier to access training option for the management of high risk/low occurrence events, and to answer the research question: Is web-based training as effective as high-fidelity manikin based simulation training, in assisting CRNAs to maintain knowledge for the management of high risk/low occurrence anesthesia related events over a training period of four weeks in a level one trauma facility?

THEORETICAL MODELS

Experimental Model

Applying theories may assist educators to provide learning environments that are most beneficial for anesthesia providers. This study used an experimental design to compare training outcomes between the group I (web–based training), and group II (simulation-based training). An experimental model establishes a cause and effect between the intervention and outcomes.44

Experimental research tests a hypothesis, and establishes causation by using independent and dependent variables, in a controlled environment.44 Manipulation in this study was accomplished via the use of two different training interventions; web-based and simulation. After the training intervention, the determination of the effect of the training on the subject’s knowledge level was assessed via the use of posttests.

Constructivist Learning Theory

Constructivist learning theories emanate from the philosophy of pragmatism, and suggest that learners learn best though interaction with the environment, and reflection on their actions. Constructivism states that learning is an active, contextualized process of constructing
knowledge rather than acquiring it. People learn and construct their own understanding and knowledge of the world based on observation and scientific study. Through experiencing things and reflecting on those experiences, people construct their own understanding and knowledge of things.

Knowledge is constructed based on personal experiences and hypotheses of the environment, and learners continuously test these hypotheses through social negotiation. Individuals have a different interpretation and construction of knowledge process. Each CRNA participating in the study had the opportunity to actively learn through either web-based or simulation training sessions, and construct knowledge. The interactional web-based eModules incorporated videos, animations, and pictures to facilitate learning, as well as achieve learning objectives. Web-based participants performed online testing.

**Bloom’s taxonomy**

Bloom’s taxonomy can be utilized to assess the CRNAs competency, and to identify their level and domain of learning. Bloom’s model consists of six levels, with the three lower levels; (knowledge, comprehension, and application) - being more basic than the higher levels which include; (analysis, synthesis, and evaluation). This taxonomy can be utilized to indicate a progressive path beginning with lower level competencies such as knowledge and comprehension, to higher level competencies such as synthesis and analysis through skill evaluation in the simulation training. CRNAs are encouraged to achieve a higher level of thinking, from one level to another higher level.
Malcolm Knowles Adult Learning Theory

This theory is premised on the belief that adults are self-directed, goal oriented, and motivated to learn in response to real life problems or situations, that require knowledge and/or skills they lack. Adults are oriented to relevancy and practicality in their learning, which is influenced by their life experiences. Adults are seen as being able to structure their learning experiences; they are capable of evaluating achievement against the self-defined criteria.

CRNAs are able to acquire and apply useful information to build on their previous knowledge regarding the management of high risk/low occurrence anesthesia related events and, refine their knowledge through web-based and high-fidelity simulation training with the goal of re-attaining clinical expertise in managing high risk/low occurrence events. Self-paced, on-demand interactive web-based training eModules, support interactive, individual structured learning.

MATERIALS AND METHODS

The study was conducted at Penn State Hershey Medical Center- Department of Anesthesia and Perioperative Services. This facility is a level one trauma center. Collaborative Institutional Training Initiative (CITI®) training that was required by both the anesthesia departmental review and the institutional IRB at Penn State Hershey Medical center was completed. Mandatory Research Electronic Data Capture Application Program (REDCAP®), training was completed, and an account for the Principal Investigator (PI) created by the department, for this study purpose. The Anesthesia and Perioperative Medicine department was in full support of this study.
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Informed consent was obtained from the participants (Appendix A). The project required IRB approval before the study began, in accordance with applicable policies of Penn State Hershey Medical Center (PSHMC) IRB. IRB approval from PSHMC was obtained February, 28th 2017 (Appendix B). IRB approval from University of Michigan-Flint was obtained on March 3, 2017 (Appendix C). There was neither observed or reported harm, nor any adverse event experienced by a participant or other individual in this study. The study population was randomly assigned into two study groups; group I (web–based training) and group II (high-.3 fidelity simulation training), using a randomization list obtained from statistician Tonya King PhD to reduce bias. The sample size provided 80% power to detect a difference of approximately 10 percentage points improvement within each of the training groups, and an 80% power to detect a difference between groups of 15 or more percentage points as statistically significant.

Study Population

All CRNA employees at Penn State Hershey Medical Center (PSHMC) Anesthesiology and Perioperative Department were eligible to be participants in the study. The target enrollment population was the 40 Fulltime CRNAs at PSHMC. Participants were identified using a participant number allocated to each subject in the order in which written consents were obtained, and then randomly assigned to either group I or II. Participants completed a demographic survey and pretest. Pretest and posttest scores were matched with the participant numbers, to compare pretest and posttest scores per individual. Participant anonymity was maintained in administration of the demographic survey, and pre/post test results.
Data Collection

Data was collected from each subject by administration of a demographic survey (Appendix D), a pretest and a posttest (Appendix E). There was no external sponsor associated with this study and no research related injuries were encountered. Audits and inspections were performed as needed, by the Penn State quality assurance program office and IRB.

All participants completed a written demographic survey and pretest, which was administered at the time the written consent was obtained. After completion of the pretest, group I participants were granted access to evidence based online training modules created for this project. The participants had one month after receipt of the online modules to complete the posttest. Online training modules were shared with participants via interdepartmental HersheyMed portal folders with a link to Penn State Hershey Research Electronic Data Capture Application Program (REDCAP ®), for the posttest.

Group II Posttest results were manually entered into REDCAP for evaluation. Marking scheme (Appendix F) was programmed into REDCAP and was used to evaluate the pre and the posttests. Two simulation sessions were held for group II participants; LAST case scenario (Appendix G) and MH case scenario (Appendix H). The online modules (Appendix I and J) used for web-based training, are attached as separate documents due to the file size. The information provided in the online modules regarding the management of the two anesthesia events used in this study, was the same information provided by the facilitators in the simulation scenarios. Consent to perform this study was granted by Penn State Hershey Medical Center IRB (Appendix B). University of Michigan-Flint granted an exempt status for this project (Appendix C).
Group I online test results were password protected and only the Principal Investigator (PI), and authorized study members had access to the data. Hard copy responses were safely stored by the Principal Investigator in a locked cabinet. After completion of the research, data was stored for six months before it was discarded.

After completion of the demographic survey and the pretest, Group II participants performed the simulation session on March 11, 2017. Upon arrival for the simulation training at the Penn State Hershey simulation laboratory, the 15 participants were split into two groups; the first eight participants to arrive were placed in the MH simulation scenario and the last seven participants to arrive were assigned to the LAST simulation scenario. Study participants performed the MH scenario as a group activity with each of the eight individuals having unique roles in the MH simulation session. The other seven participants remotely watched the MH simulation on a screen in separate room. The two groups subsequently switched roles and the seven participants who watched the MH scenario, actively participated as a group in the LAST simulation, each subject had individual roles. The eight participants, who were actively engaged in the MH simulation scenario, remotely watched the LAST simulation scenario.

After both simulations were completed, all 15 participants convened for debriefing. They discussed the possible diagnoses, outcomes and alternate interventions, they then completed a posttest. Simulation and debriefing sessions for each topic took approximately 40 minutes with a written posttest that took approximately 20 minutes to complete. Test scores of individual participants were identified using the unique participant numbers allocated to them to map the differences in pretest and posttest scores.
Study Design

A quantitative research design was employed to analyze data, and establish the relationships between the two training options. Statistical procedures were used to assess the magnitude, reliability and relationship of data collected. Data analysis was done using Statistical Analysis System (SAS®) program, Wilcoxon rank-sum test and t-test application. A conceptual model for this project is illustrated in figure 1.

**Figure 1.** Comparing Web-Based to High-Fidelity Simulation Training for Certified Registered Nurse Anesthetists for High Risk/Low Occurrence Anesthesia Events.
Study Participants

All Full-time CRNAs working at PSHMC on the date the study begun were eligible to take part in this study. Exclusion criteria included CRNAs who were not full-time, CRNAs on Family Medical Leave of Absence (FMLA) or Leave of Absence (LOA) at the beginning of the study. CRNAs who did not consent to take part in the study were excluded. All subjects were aware of the specific topics of the study content being investigated.

Study Members

An experimental design was utilized for this study. The study team members’ included;

- **Principal Investigator**: Judy Kimemia, CRNA, MS is the holder of the PSHMC IRB approval permit.
- **Advisor**: Sonia Vaida, MD, was a source of advice when needed.
- **Simulation Manager**: David Rodgers, PhD was in-charge of ensuring that all simulation equipment needed for the study was available and in good working condition.
- **Debriefer**: Erica Elliott, CRNA held the debriefing session after the simulation teaching was conducted (by involving an independent debriefer, bias was reduced).
- **Research Assistant**: Mathew Pendergrass, assisted with technical issues that arose and with printing the poster.
- **Statistician**: Tonya King, PhD provided guidance and assistance with data management, statistical analysis, and provided the randomization list used for the study.
**WEB–BASED VERSUS SIMULATION TRAINING**

*Timeline*

The study begun March 11, 2017 after written consent was obtained from all willing participants. The web-based group received interactive online modules at the scheduled time. The study began and was completed as per the study timeline.

*Ethics*

Minimal risk is the magnitude of physical or psychological harm that is normally encountered in daily lives. This study was not anticipated to cause any harm greater than minimal risk to the participants. Personal emails which constituted as Protected Health Information (PHI) were used for communication during the study, with a possible disclosure to research members involved in this study.

**RESULTS**

Data was analyzed using two-sample and paired data t-tests, Wilcoxon rank sum tests for the continuous outcomes, and chi-square tests for the categorical outcomes, all procedures performed using SAS®. Homogeneity between the simulation and web-based groups, in regards to baseline knowledge, was evaluated using the two-sample t-test, as percentages were approximately normally distributed despite the small sample size. Pretest results were compared to posttest results for each individual participant, to determine the level of learning achieved within each group separately using paired t-tests, since the difference scores had an approximately normal distribution.

These difference scores were compared between the two training groups using a two-sample t-test to determine if there was any cognitive knowledge difference between the two
groups based on the training received. The items on the demographic survey were compared between the two training groups using chi-square and Wilcoxon rank sum tests, due to the nature of the survey questions. Results were summarized and a conclusion drawn to determine which mode of training was more effective. This study aimed to determine whether web-based training was a more efficient training option for knowledge acquisition on high risk/ low occurrence anesthesia related events, compared to high-fidelity simulation training sessions.

Thirty-two CRNAs enrolled in this study, completed the pretest and demographic survey. Sixteen participants were randomly assigned to each study group. There was attrition of one subject assigned to the high-fidelity simulation group due to sudden illness of a family member on the day the simulation study was being conducted. One web-based participant did not complete the study due to personal family issues. The final n of participants who completed the training was 30. Fifteen in the web-based group and 15 in the high-fidelity manikin-based simulation study group.

Pretest Results

A pretest was administered to all study participants to determine the baseline knowledge of the two groups prior to the start of the study. For group I participants, the pretest had a mean score of 16.13 correct answers, out of a possible 20 points (SD 2.67). The high-fidelity simulation group had a mean score of 16.47 correct answers, out of a possible 20 points (SD 2.20) on their pretest. The pretest % correct scores (80.7% web vs. 82.3% sim) indicated there was no significant difference in the subjects’ baseline knowledge between the two groups prior to the study. Two group t-test p=0.71 (Graph 1).
Graph 1. Distribution and Probability Plot for Pretest Percentage Correct Scores
Web-based Study:

The web-based study was open for a period of one month after the pretest was conducted. For approximately 50% of the group, the study was marked by numerous technical issues, which ranged from ‘freezing’ modules to PowerPoint® programs not responding. Computer compatibility issues attributed to some online links not opening on several home computers, error messages such as ‘not a valid link’ were received from three participants in the study. Two participants experienced problems accessing the posttest. Issues were reported to the Principal Investigator via email and were resolved in a timely fashion. The Information Technology (IT) department provided written instructions that gave all CRNAs the ability to access Hershey Medical Center files from both personal home computers and work computers. Fifteen participants of the web-based group were able to complete the study and take the online posttest, with the exception of one participant who had personal issues that kept her from completing the study.

High-fidelity Simulation Study:

Group II’s simulation session was held on Saturday March 11, 2017 at the simulation laboratory at PSHMC. In attendance to run the high-fidelity simulation was the simulation laboratory director, Rodgers David, PhD and the debriefer, Erica Elliott, CRNA. Vaida Sonia, MD was also present during the sessions to offer assistance if needed. Participants arrived in a timely fashion and the simulation began and ended on the scheduled time. All participants who had consented for the simulation study were able to attend except one individual who did not come due to an acute illness of a family member.
The first eight participants to arrive for the simulation session were placed in the MH simulation; all participants actively participated in assigned different roles during the simulation. The rest of the seven participants observed the simulation at the debriefing room through televised screens. The seven participants, who observed the MH simulation from the debriefing room, actively participated in the LAST simulation while those who actively participated in the MH simulation watched the LAST simulation via televised screens in the debriefing room. Debriefing was done with all 15 participants in attendance; participants completed the written posttest after debriefing.

Simulation Debriefing

Participants discussed the strong points and the deficits that occurred in each simulation session. They discussed matters that would have been done better or differently. Simulator sound quality was poor in the MH simulation, there was too much chatter and participant roles were not well defined. These issues were corrected during the LAST simulation. The LAST high-fidelity simulation session was marked by a technical default in the mannequin when the seizure button failed to exhibit seizure activity. The participants were still able to identify the diagnosis and to treat the condition effectively. Both MH and LAST simulation sessions were marked with closed loop communication and clear leadership roles.

Compared Posttest-Pretest Results

Average baseline pre-training percentage correct score for the web-based group was 80.67%, with average post-training score of 87% reflecting an increase of 6.33%, p=0.13 not significantly different from zero. In the high-fidelity simulation group, average baseline pre-training score was 82.33%, average post-training score was 83.66%, p=0.70, reflecting a non-
significant difference of 1.33%. The average pre-post training change in scores within the web-based group was 1.27 (SD 3.01) raw points or 6.33 percentage points (p=0.13), and the average increase within the sim group was 0.27 (SD 2.63) raw points or 1.33 percentage points (p=0.70). These results indicate that the average pre-post change within each group was not significantly different from zero. The difference in raw scores (or percentage correct scores) was not significantly different between the two groups: two-group t-test p=0.34. (Graph 2).

**Graph 2.** Post-Pretest Difference in Scores Between Web-Based and Simulation Groups

The sample size provided 80% power to detect a difference of approximately 10 percentage points improvement within each of the training groups. Comparison of percentage correct pretest and posttest scores, within each training group; (6.3 web vs. 1.3 sim), revealed an improvement score less than 10 percentage points in both groups. There was no significant difference in the knowledge gained by either the web-based and high-fidelity simulation groups.

Comparison of average percent correct improvement, between the training groups revealed a difference of 5 percentage points. (6.3 web less 1.3 sim) p=0.34. According to the
small sample size, we had 80% power to detect a difference between groups of 15 or more percentage points as statistically significant. There was no significant difference in the knowledge gained by either the web-based and high-fidelity simulation groups.

Descriptive Data

Descriptive data was obtained from the demographic survey form. This was completed by the subjects at the beginning of the study. The demographic survey was self-administered.

Age

The total population constituted 32 participants; 18 participants (56.3%) age 18-40 years, 14 participants (43.8%) between 41 and 64 years old. All participants were below 65 years of age. For the web-based training group, 8 participants were 18-40 years of age the other 50% of the web-based group was 41-64 years of age. For the high-fidelity simulation group, 10 (62.5%) participants were 18-40 years of age and 6 participants, (37.5%) were 41-64 years of age. There was not a significant difference between the two groups with respect to age group, 50% of the web group and 38% of the sim group were in the age 41-64 age group (chi-square p=0.48).
WEB–BASED VERSUS SIMULATION TRAINING

**Gender**

There were 12 males (37.5%) and 20 females (62.5%) in the entire population of the study participants. For the web-based group, there were four males (0.25%) and 12 females (75%). The high-fidelity simulation group was evenly distributed in gender; 50% of the participants were male and 50% were female. There was not a significant difference between the two groups with respect to gender (chi-square p=0.14).

![Gender Distribution Graph]

**Prior Experience in Malignant Hyperthermia (MH) Case Numbers**

For the entire sample group, 25 (78.1%) indicated no prior experience with MH case numbers. Fourteen of the participants who had no prior experience with MH case numbers, were randomly placed in the web-based group (56%) and 11 (44%) of the participants with no prior MH experience, were placed in the high-fidelity simulation group. Of those participants who indicated prior MH experience, six participants had one MH case experience (18.8%). Of those...
WEB–BASED VERSUS SIMULATION TRAINING

six participants, two were randomly assigned to the web-based training group and four were randomly assigned to the high-fidelity simulation training group. Only one participant had greater than one MH case experience (3.1%), and he was randomly assigned to the high-fidelity simulation group. There was not a significant difference between the two groups with respect to MH experience (p=0.39).

Experience in Case Numbers with Local Anesthesia Systemic Toxicity (LAST)

For the entire sample group, 27 participants (84.4%) had no prior experience in LAST. Thirteen participants (0.48%) with no experience in LAST were assigned to the web-based group while 14 participants (0.52%) were randomly placed in the high-fidelity simulation training group. Five participants (15.6%) had an experience with one LAST case. Three of the participants (0.6%) who had an experience with a LAST case were placed in the web-based training group and two of the participants (0.4%) were placed in the high-fidelity simulation group. There was no participant in the study who had more than one LAST case number.
experience. There was not a significant difference between the web-based and high-fidelity simulation group with respect to LAST experience (p=1.00) based on Fisher’s exact test.

**ICU Work/ CRNA Experience**

The overall mean number of years of ICU work experience was 8.25 (SD= 7.59), with a range from two years to 35 years. The mean number of years of CRNA work experience was 4.85 (SD= 5.14), with a range from two months to 29 years. There was not a significant difference between the two groups with respect to work experience (median 4.5 for web, vs. 5.5 for sim, p=0.64, nor with respect to CRNA experience (median 5.0 for web vs. 3.0 for sim, p=0.29).
DISCUSSION

The goal of this study was to compare knowledge gained from web-based training to that gained during high-fidelity simulation training for CRNAs for the management of high risk/low occurrence anesthesia related events. This project was designed to answer the research question; Is web-based training as effective as high-fidelity manikin based simulation training, in assisting CRNAs to maintain knowledge for the management of high risk/low occurrence anesthesia related events over a training period of four weeks in a level one trauma facility?

Results from the study indicate that there is no significant difference in the knowledge obtained between the web-based and high-fidelity simulation groups. Based on pretest and posttest scores, paired t-test p=0.13 for web improvement of 6.3, and simulation improvement of 1.3 (p=0.70). The difference in percentage correct scores (6.3 web vs. 1.3 sim) are not significantly different between the two groups. However, they are clinically relevant.

The results of this study demonstrate findings that suggest that web-based training is as effective as high-fidelity simulation sessions, in providing the knowledge necessary to manage the high risk/low occurrence events of MH and LAST. A review of literature revealed merits and demerits of both training modalities. Hence it would benefit organizations to consider a hybrid of web-based training and high-fidelity simulation to capture the benefits of both for CRNA training.

Strengths of the Study

The study was well supported by the department and CRNAs as evidenced by a CRNA participation of 80%. The study received full support from the Anesthesia and Perioperative Services department at PSHMC. The IT department was prompt and efficient at ensuring that
technical issues that arose during the study were resolved in a timely fashion. Timelines were maintained throughout the study. There were no adverse effects that occurred during the study.

**Weaknesses of the Study**

The sample size was small. This study compared knowledge testing, omitting both technical and non-technical skills testing. Incorporating technical skills testing may provide greater insight to the comparison of web-based training to high-fidelity simulation based training, actual skill performance assessments were not measured based on the study design. The study targeted CRNAs, disregarding anesthesiologists, residents and anesthesia assistants. Articles and studies with information involving non-CRNA anesthesia providers were excluded. By taking the pretest, both groups most likely did better on the post regardless of interventions based on their pre-exposure to the information.

**CONCLUSION**

Maintaining skills for the management of high risk/low occurrence events can be difficult related to the infrequency of these events occurring during a practitioner’s career. It is important that CRNAs maintain the knowledge to manage these rare events. High fidelity simulation has been shown to be an effective training technique in anesthesia. Some institutions may not have the advantage of offering simulation to their employees, due to budget constraints, or the availability of lab time and instructors.

Participants in this study had a mean number of 4.85 years of CRNA work experience. It is conceivable that this population may not require the extent of training in technical or non-technical skills based on experiences encountered and skills gained, during their practice. Therefore, simulation training may not be necessary with this population. Web-based learning is
easily accessible, is less costly to create, and can be conveniently available to learners. This study demonstrated web-based training is as effective as high-fidelity simulation for training CRNAs for the management of MH and LAST at Penn State Hershey medical Center.

This project demonstrated that problems can occur with both training methods. Creating web-based eModules was time consuming. Making the eModules interactive required extra computer training for the PI, meeting with various IT programmers to learn how to incorporate features such as Poll Everywhere® into the eModules. Special audio recording was done by the PI at the Penn State One-Touch Studio (OTS). It required coordinating recording sessions which had to be scheduled amidst many other projects that were ongoing at the OTS. Despite eModules being tested on various computers before their roll-out, technical issues ranging from ‘freezing’ modules to PowerPoint® programs not responding arose during the actual use of the eModules.

Scheduling simulation sessions was labor intensive and time consuming. The study members were required to attend multiple meetings with the five-member simulation committee group to identify a day convenient to hold the simulation training, and resources needed to run the high-fidelity simulation training. It was difficult to co-ordinate meetings with simulation committee members due to differing schedules. The simulation training session could only be held on a date that the anesthesia residents were not using the simulation laboratory for scheduled simulation sessions. It was only plausible to hold the high-fidelity simulation training session for this study on a weekend. Simulation staff were not available on the weekends, thereby requiring the PI and debriefer to attend training sessions on how to operate the simulation equipment before the actual simulation training day. Three, two-hour training sessions were held for the training to use the simulation equipment.
WEB–BASED VERSUS SIMULATION TRAINING

By comparing CRNA knowledge acquisition between web-based training sessions, and high-fidelity simulation training strategies, this project sought to demonstrate a training alternative for educating CRNAs. The project was aimed at improving CRNA overall knowledge acquisition in the management of Malignant Hyperthermia (MH) and Local Anesthetic Systemic Toxicity (LAST) emergencies. Researching this topic provided an alternative training method to assist CRNAs to maintain knowledge in the management of high risk/low occurrence anesthesia related events. The advantages of e-learning may be applied to CRNA continued education, and may allow for safer and higher quality patient care during high risk/low occurrence anesthesia related events.

**Recommendation for Future Research**

More research is required to identify if a web-based teaching strategy is beneficial for the CRNA population. Performing a comparison of high-fidelity mannequin based simulation training, and web-based training, was necessary to determine which forms of technology are appropriate to assist CRNAs to maintain the skills for the management of high risk/low occurrence anesthesia related events.

Future studies may aim to compare other training modalities such as comparison of traditional lecture to web-based or simulation training in high risk/low occurrence anesthesia related events. Studies that utilize different performance scoring for actual simulation performance to capture time taken to complete tasks such as time to diagnosis and time to treat, may provide greater insight in comparing training modalities. Research that compares high-fidelity simulation following a lecture may help determine if the lecture would reinforce the important points for the diagnosis and management of high risk/low occurrence anesthesia
related events such as MH and LAST. Other considerations to investigate may include identifying learner style and preferences. Some people are visual learners and prefer the use of technology, while others are more hands-on. Tech-savvy visual learners may prefer the convenience that web-based training offers. People who prefer human interaction or those who are hands-on learners may prefer high-fidelity simulation training.

It was assumed by this researcher that this population had the necessary training to manage MH and LAST during their anesthesia education. This research demonstrated that the majority of the practitioners participating in this study, had not encountered these events during their careers. 84.4% had no prior experience in LAST case numbers and 78.1% indicated no prior experience with MH case numbers. These findings align with the research that knowledge for the management of these events may decline over time. It is beneficial for practitioners to have a means for maintaining knowledge to manage low occurrence events in a safe fashion. This research study has shown that web-based training is as effective as high-fidelity manikin based simulation training, in assisting CRNAs to maintain knowledge for the management of high risk/low occurrence anesthesia related events.

DISSEMINATION

The study results were presented at Pennsylvania Association of Nurse Anesthetists (PANA) 2017 annual meeting held in May 7, 2017 at the Hershey Hotel, Hershey, Pennsylvania. The presentation included a PowerPoint presentation summary of the study; interactive modules used during web-based training, MH and LAST high-fidelity simulation case scenarios and results from the study.
A poster and PowerPoint presentation of the study was accomplished at the Department of Anesthesia and Perioperative Services departmental meeting in June, 2017. Interactive modules used during web-based training, MH and LAST high-fidelity simulation case scenarios were presented.
SUMMARY EXPLANATION OF RESEARCH

Penn State College of Medicine
The Milton S. Hershey Medical Center

Title of Project: Comparing web-based to high-fidelity simulation training learning sessions in the management of high risk/low occurrence anesthesia related events, to improve knowledge acquisition for Certified Registered Nurse Anesthetists.

Principal Investigator: Judy, Kimemia, CRNA, MS

Address: Penn State College of Medicine, Department of Anesthesiology, Mail Code H187
500 University Drive, Hershey, PA 17033-0850

Telephone Numbers: Weekdays: 8:00 a.m. to 5:00 p.m. (717) 531-0003 Ext. 311354

Dear CRNA;

You are being invited to volunteer for participation in a research study. This summary explains information about this research. You are urged to ask questions about anything that is unclear to you.

The purpose of this research is to compare web-based learning to high-fidelity simulation learning sessions on high risk/low occurrence anesthesia related events, to improve knowledge acquisition for CRNAs at Penn State Hershey Medical Center.

Inclusion criteria are every full-time CRNA. Exclusion criteria are CRNAs on FMLA or Leave of absence (LOA), CRNAs on probation at the beginning of the study or CRNAs who do not wish to participate.

If you agree to participate in the research, you will be randomly assigned to either a web-based group or to the simulation group. This means that whichever study treatment you receive will be determined purely by chance. You will have an equal chance of being assigned to either group.

You will first complete a quiz to measure your current knowledge about Malignant Hyperthermia, and Local Anesthetic Systemic Toxicity (LAST) before you attend either the web-based training or participate in the high-fidelity simulation session described below:

Web-based training – Participants will use interactional online training modules which will be followed by a posttest to be completed within a month after the receipt of the modules.
WEB–BASED VERSUS SIMULATION TRAINING

• Simulation Session – There will be one high-fidelity simulation session. During this visit, participants from this group will participate in the two different simulation scenarios (MH and LAST). Each scenario will have different subjects while the other subjects watch remotely in a separate room. Following each scenario, all subjects will join together to discuss the possible diagnoses, outcomes and alternate interventions followed by a posttest. Each of the two simulation and debriefing sessions will each take approximately 40 minutes and the posttest will take about 20 minutes to complete.

Individual participant identifiers will be used to associate pretest and posttest scores with the individual Subject. Subject confidentiality will be maintained.

Your participation or lack of participation will have no impact on your employment at Penn State Hershey Medical Center (PSHMC).

Potential benefits from participating in this research are the investigation of a more effective training program for CRNAs at PSHMC that may be used to educate practitioners to manage high risk/low occurrence anesthesia related events. There is also a potential benefit of improved understanding and insight by CRNAs’ on management of critical anesthesia related events, which may facilitate personal and departmental growth. Instructors may also benefit from availability of better, more effective training tools for improved staff instruction.

There are no costs associated with participating in this study, nor compensation for your participation. The investigators have no financial relationships or conflict of interest related to this study.

The research records for this study will be kept online. Written test scores will be locked up in the Principal Investigator’s’ office. Access of results will be password protected and only accessible to study members. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. Absolute confidentiality cannot be guaranteed; there is a risk of loss of confidentiality if your information or your identity is obtained by someone other than the investigators, but precautions will be taken to prevent this from happening. The confidentiality of your electronic data created by you or by the researchers will be maintained to the degree permitted by the technology used.

You have the right to ask any questions you may have about this research. If you have questions, complaints or concerns or believe you may have been harmed from participating in this research, you should contact Judy Kimemia at 717-531-0003 Ext 311354. If you have questions regarding your rights as a research subject or concerns regarding your privacy, you may contact the research protection advocate in the HMC Human Subjects Protection Office at 717-531-5687. You may call this number to discuss any problems, concerns or questions; get information or offer input.
You do not have to participate in this research. Taking part in the research study is voluntary. Your decision to participate or to decline will not result in any penalty or loss of benefits to which you are entitled. Please respond via email to jkimemia@hmc.psu.edu indicating whether you plan to participate or not. You can stop participating at any time. If you stop, there will be no penalty.

Sincerely,

Judy Kimemia, CRNA, MS
Dept. of Anesthesiology & Perioperative Medicine
Mail code H187
Penn State College of Medicine
500 University Dr.
Hershey, PA 17033
(717) 531-0003 Ext. 311354
jkimemia@hmc.psu.edu
pager: 5722
Appendix B: IRB Approval Letter - Penn State Hershey Medical Center

EXEMPTION DETERMINATION

Date: March 1, 2017
From: Connie Manchester, Manager, HSPO
To: Judy Kimemia

Type of Submission: Initial Study
Title of Study: Comparing web-based learning to high-fidelity simulation educational training sessions on high risk/low occurrence events, to improve knowledge acquisition for Certified Registered Nurse Anesthetists.
Principal Investigator: Judy Kimemia
Study ID: STUDY00006372
Submission ID: STUDY00006372
Funding: Not Applicable
Documents Approved: • Consent form (v4), Category: Consent Form
• DEMOGRAPHIC SURVEY (0.01), Category: Data Collection Instrument
• E mail explanation (v 4), Category: Consent Form
• HRP 591 (V4), Category: IRB Protocol
• HRP 598 (4.01), Category: IRB Protocol
• LAST SIMULATION CASE SCENARIO (0.02), Category: Other
• LAST WEB MODULE (0.01), Category: Other
• MH MODULE (0.02), Category: Other
• MH SIMULATION CASE SCENARIO (0.02), Category: Other
• POST TEST (0.01), Category: Data Collection Instrument
• PRE TEST (0.01), Category: Data Collection Instrument

The Human Subjects Protection Office determined that the proposed activity, as described in the above-referenced submission, does not require formal IRB review because the research met the criteria for exempt research according to the policies of this institution and the provisions of applicable federal regulations.

Continuing Progress Reports are not required for exempt research. Record of this research determined to be exempt will be maintained for five years from the date of this notification. If your research will continue beyond five years, please contact the Human Subjects Protection Office closer to the determination end date.

Changes to exempt research only need to be submitted to the Human Subjects Protection Office in limited circumstances described in the below-referenced Investigator Manual. If changes are being considered and there are questions about whether IRB review is needed, please contact the Human Subjects Protection Office.
Penn State researchers are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within CATS IRB (http://irb.psu.edu). This correspondence should be maintained with your records.
To: Judy Kimemia

From: Marianne McGrath

Subject: Notice of Exemption for [HUM00127689]

SUBMISSION INFORMATION:
Title: Web-based versus Simulation Learning.
Full Study Title (if applicable): Comparing web-based learning to high-fidelity simulation educational training sessions on high risk/low occurrence events, to improve knowledge acquisition for Certified Registered Nurse Anesthetists at Penn State Hershey Medical Center.
Study eResearch ID: HUM00127689
Date of this Notification from IRB: 3/3/2017
Date of IRB Exempt Determination: 3/3/2017
UM Federalwide Assurance: FWA00004969 (For the current FWA expiration date, please visit the UM HRPP Webpage)
OHRP IRB Registration Number(s): IRB00000248

IRB EXEMPTION STATUS:
The IRB Flint has reviewed the study referenced above and determined that, as currently described, it is exempt from ongoing IRB review, per the following federal exemption category:

EXEMPTION #1 of the 45 CFR 46.101.(b):
Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the
comparison among instructional techniques, curricula, or classroom management methods.

Note that the study is considered exempt as long as any changes to the use of human subjects (including their data) remain within the scope of the exemption category above. Any proposed changes that may exceed the scope of this category, or the approval conditions of any other non-IRB reviewing committees, must be submitted as an amendment through eResearch.

Although an exemption determination eliminates the need for ongoing IRB review and approval, you still have an obligation to understand and abide by generally accepted principles of responsible and ethical conduct of research. Examples of these principles can be found in the Belmont Report as well as in guidance from professional societies and scientific organizations.

**SUBMITTING AMENDMENTS VIA eRESEARCH:**
You can access the online forms for amendments in the eResearch workspace for this exempt study, referenced above.

**ACCESSING EXEMPT STUDIES IN eRESEARCH:**
Click the "Exempt and Not Regulated" tab in your eResearch home workspace to access this exempt study.

Marianne McGrath  
Chair, IRB Flint
Appendix D: Demographic Survey

Q.1 Age: What is your age?
Q. 2 What is your sex?
Q. 3 What is your experience in case numbers with Malignant Hyperthermia?
Q. 4 What is your experience in case numbers with Local Anesthesia Systemic Toxicity?
Q. 5 How many years did you practice as an ICU/ Critical Care Nurse?
Q. 6 How many years have you been working as a CRNA?
Q. 7 What is your preferred learning method?
   a) Web-based learning
   b) Simulation learning
   c) Hybrid combination of web-based and simulation learning
Appendix E: Pre/Posttest  www.projectredcap.org.

Confidential

Please complete the survey below. Thank you!
Please enter your Participant ID (or your name, if you do not know your ID)________________________

1. Malignant Hyperthermia (MH) is a hypermetabolic state that results in a rapid rise in body temperature and severe muscle contraction and can possibly result in death if untreated. Which of the following is FALSE regarding Malignant Hyperthermia?
   a) It is an autosomal dominant disorder
   b) It is caused by a dopamine receptor blockade
   c) It is caused by an increase in skeletal muscle metabolism
   d) It can be triggered by exercise and exposure to hot environment
   e) MHAUS recommends storing 36 vials of dantrolene in a MH cart

2. Emmanuel, CRNA is providing care for thirteen year-old M. K. who is 55kg and is undergoing a repair of a clavicle fracture under general anesthesia with an Endotracheal tube. M. K. has no significant medical or surgical history. Emmanuel suddenly notices muscle rigidity, tachypnea and tachycardia. The patient’s EtCO2 has suddenly increased from 32 to 53 and his temperature is steadily rising. Emmanuel starts preparation for managing suspected MH. Emmanuel knows that in managing MH, the recommended dose of dantrolene administration will be:
   a) 1 mg/kg
   b) 1.5 mg/kg
   c) 2 mg/kg
   d) 2.5 mg/kg
   e) 3 mg/kg

3. When providing care for a patient who is susceptible to Malignant Hyperthermia, which of the following test inhaled anesthetic agents is safe to use?
   a) Nitrous Oxide
   b) Halothane
   c) Desflurane
   d) Sevoflurane
   e) Isoflurane

4. The CRNA is providing care of nine year-old John, who is undergoing tonsillectomy. Anesthesia is induced with sevoflurane and nitrous oxide in oxygen. Rocuronium is used for the endotracheal intubation. Forty minutes after administration of sevoflurane his temperature rises to 43.7 degrees C from a baseline of 37 degrees C. Heart rate is 183 bpm (baseline 112 bpm) and Spo2 94%(baseline 98%). Muscle rigidity of legs ensues. All the following will be considered as signs or symptoms of Malignant Hyperthermia EXCEPT?
   a) Muscle rigidity
   b) Metabolic acidosis
   c) Hypertension
   d) Hyperthermia
e) Hyperkalemia

5. Maya is a 16 kg, five-year-old girl, undergoing Anterior Cruciate Ligament (ACL) repair. Anesthesia was induced and maintained with sevoflurane and nitrous oxide in oxygen. Endotracheal intubation was done without the use of muscle relaxant. Thirty minutes after the induction of anesthesia, EtCO2 was over 60 mmHg despite hyperventilation. Muscle rigidity of legs and the rise in temperature were noted. What would be the first step for the CRNA to take after Immediately suspecting Malignant Hyperthermia?
   a) Mix dantrolene with 30 ml of sterile water
   b) Follow ETCO2 levels
   c) Cool the patient to 38C
   d) Discontinue all volatile agents
   e) Follow serial serum myoglobin levels

6. A CRNA is providing care of a 10 year old for strabismus repair. The CRNA knows that the most common trigger for Malignant Hyperthermia is:
   a) Narcotics
   b) Succinylcholine
   c) Nitrous oxide
   d) Propofol

7. Seven year-old Juma is scheduled for same day surgery for repair of strabismus under general anesthesia. He has a family history of Malignant Hyperthermia. Previous anesthetic history included an uneventful sevoflurane and nitrous oxide anesthesia for bilateral myringotomy. Which patient data points are important for a CRNA provider to address in the event of Malignant Hyperthermia occurrence?
   a) Stage of dantrolene administration
   b) Stabilizing heart rate/rhythm
   c) Normalization of end tidal CO2
   d) Muscle tone status
   e) All of the above

8. True/False? During acute phase management of Malignant Hyperthermia, diuresis is induced to maintain urine output to >1 ml/kg/hr to avoid myoglobinuria-induced renal failure.
   a) True
   b) False

9. While providing care for an otherwise healthy 9 year-old who has is susceptible to developing Malignant Hyperthermia, The CRNA knows the following to be treatment modalities for hyperkalemia EXCEPT?
   a) Treat with hyperventilation
   b) Bicarbonate,
   c) Glucose/insulin
   d) Potassium
10. Dysrhythmias usually respond to treatment of acidosis and hyperkalemia. In the presence of Malignant Hyperthermia crisis, all of the following medications can be used to address dysrhythmias, EXCEPT?
   a) Lidocaine
   b) Diltiazem
   c) Metoprolol
   d) Amiodorone

11. In the patient with suspected local anesthetic toxicity, the initial step is stabilization of potential threats to life. If the signs and symptoms develop during administration of the local anesthetic, stop the injection immediately and prepare to treat the reaction. The CRNA realizes that the earliest sign of local anesthesia toxicity is?
   a) Drowsiness
   b) Slurred speech
   c) Circumoral numbness
   d) Tongue paresthesia

12. In the patient with suspected local anesthetic toxicity, the initial step is stabilization of potential threats to life. If the signs and symptoms develop during administration of the local anesthetic, stop the injection immediately and prepare to treat the reaction. Which of the following is not an initial treatment for local anesthesia toxicity?
   a) Hyperventilation to decrease cerebral blood flow
   b) Benzodiazepines
   c) Increase oxygenation
   d) Epinephrine bolus

13. Sam, a ten year-old boy had a small melanoma resected from his back with the use of lidocaine for local anesthesia. He is now experiencing hypoxemia and metabolic acidosis. The CRNA realizes that this may quickly escalate to cardiovascular toxicity. The CRNA knows the following statements below to be true in the management of this situation EXCEPT which one?
   a) Cardiac arrest due to local anesthetic toxicity is a rare but may occur in cases of inadvertent intravascular injection of local anesthetic
   b) Use of sodium bicarbonate may be considered to treat severe acidosis
   c) Aggressive airway management to treat hypoxemia and acidosis may prevent cardiac arrest.
   d) Hypoxemia and metabolic acidosis do not potentiate the cardiovascular toxicity of lidocaine and other local anesthetics

14. After the initial bolus of lipid emulsion at 1.5 ml/kg over one minute is administered, at what rate should the CRNA managing a case of local anesthesia toxicity maintain the continuous infusion of lipid emulsion?
   a) 0.25 ml/kg/min over ten minutes
   b) 0.25 ml/kg/min over fifteen minutes
   c) 0.5 ml/kg/min over ten minutes
   d) 0.5 ml/kg/min over fifteen minutes
15. Joy, CRNA is taking care of a patient who suffered from Local anesthesia systemic toxicity after a procedure. The patient received lipid emulsion treatment with inadequate response. Which final treatment modality is Joy now preparing for?
   a) CPR for at least 90 minutes
   b) Epinephrine drip
   c) Re-bolus lipid emulsion
   d) Cardiopulmonary bypass

16. An 18 year-old male has just had a resection of multiple skin lesions on his arm at a surgical center. The procedure is done with light sedation and local anesthetic. Patient complains of ringing in his ears and metallic taste in his mouth and begins having seizures. What is the initial step of action the CRNA needs to take?
   a) Get report from RN who cared for the patient intraoperatively
   b) Administer intralipid therapy
   c) Pre-oxygenate patient with 100 % O2 and secure the airway
   d) Ask the patient if he is okay.

17. Which LA has been frequently associated with the development of methemoglobinemia?
   a) Benzocaine
   b) Tetracaine
   c) Bupivacaine
   d) Lidocaine

18. Katwe, a 19 year-old soccer player had tooth number 11, 20, and 24 extracted. Prilocaine was used for the procedure. His dad calls 3 hours following the procedure stating that his son appears cyanotic and sluggish. His nail beds look dark blue. The CRNA realizes that this condition is MOST likely:
   a) Aytypical plasma cholinesterase
   b) Methemoglobinemia
   c) Malignant hyperthermia
   d) Local anesthetic overdose
   e) Local anesthetic allergy

19. ASRA guidelines recommend considering the use of lipid emulsion therapy at the first signs of systemic toxicity from local anesthetics, after airway management. The CRNA should know that lipid therapy is contraindicated in all of the following cases:
   a) In patients with disturbances of normal fat metabolism such as pathologic hyperlipemia and lipoid nephrosis.
   b) Hypersensitivity to soy eggs and possible cross reactivity with peanut.
   c) Acute pancreatitis if accompanied by hyperlipidemia
   d) All of the above

20. The American Society of Regional Anesthesia and Pain Control (ASRA) recommends benzodiazepines as first-line treatment of local anesthetic-induced seizures, because these drugs have limited potential for causing cardiac depression. True or False?
   a) True
   b) False
Appendix F: ANSWER KEY

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B</td>
<td>11</td>
<td>C</td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>12</td>
<td>D</td>
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<tr>
<td>3</td>
<td>A</td>
<td>13</td>
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<td>4</td>
<td>C</td>
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<td>D</td>
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<td>6</td>
<td>E</td>
<td>16</td>
<td>C</td>
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<td>9</td>
<td>D</td>
<td>19</td>
<td>D</td>
</tr>
<tr>
<td>10</td>
<td>B</td>
<td>20</td>
<td>A</td>
</tr>
</tbody>
</table>
Appendix G: LAST Case Scenario

Today’s Date: 3/11/2017
Coordinators: Judy Kimemia, CRNA, David Rodgers, PhD
Faculty Present: Sonia Vaida, MD
Department: Anesthesiology
Session Name: Local Anesthetic Toxicity
Curriculum/Program: Web-based vs Simulation Learning

Simulation Room Setup

<table>
<thead>
<tr>
<th>Manikin / M. K.</th>
<th>M. K. male in the simulation room stretcher in patient gown.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dressings on back that are intact (six or seven 4x4 Gauze with fake blood, clear tape and cloth tape should be available for the SP), no drainage.</td>
</tr>
<tr>
<td></td>
<td>M.K. in lateral position.</td>
</tr>
<tr>
<td></td>
<td>Functioning PIV for M. K. attached to the IV tubing from the IV bag/pump.</td>
</tr>
<tr>
<td></td>
<td>Attach ECG electrodes to patient. Hook up the ECG leads to the electrodes and have them go behind the monitor.</td>
</tr>
<tr>
<td></td>
<td>Put SPO2 on patient’s finger and have it go behind the monitor.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitoring.</th>
<th>ECG, NBP, Pulse oximetry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CRNA at bedside.</td>
</tr>
<tr>
<td></td>
<td>Use iSimulate as the monitoring system with image projected to monitor screen.</td>
</tr>
<tr>
<td></td>
<td>Timer for outside of the room to keep track of the scenario.</td>
</tr>
<tr>
<td></td>
<td>Dr. Angel Sanchez is the debriefer.</td>
</tr>
<tr>
<td></td>
<td>Other CRNAs are in the observation room during the scenario.</td>
</tr>
</tbody>
</table>

| Diagnostics / Results | None needed |

<table>
<thead>
<tr>
<th>Patient Equipment / Medication.</th>
<th>New ambu bag and mask available.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>New nasal cannula/face mask and new nonrebreather mask available but not on patient</td>
</tr>
<tr>
<td></td>
<td>IV pump w/2 ears: 1L NS/LR at 100cc/hr</td>
</tr>
<tr>
<td></td>
<td>Put O2 tank in room</td>
</tr>
<tr>
<td></td>
<td>EKG electrodes</td>
</tr>
<tr>
<td></td>
<td>Training AED only available-not real defibrillator.</td>
</tr>
<tr>
<td></td>
<td>Pyxis machine with syringes of propofol, succinylcholine, midazolam, fentanyl, Ephedrine, Naloxone, Phenylephrine, Lorazepam, Vasopressin, Flumazenil, Epinephrine, Esmolol, Benadryl, Lidocaine, Calcium Chloride, Amiodarone, Adenosine.</td>
</tr>
<tr>
<td></td>
<td>Bag of intralipid, primary tubing, 60cc syringe and needle.</td>
</tr>
</tbody>
</table>
### Scenario Flow

#### Prestart Information:
- Mr. M. K. is an 18yo male who presents for resection of multiple skin lesions on his back at a surgical center where the CRNA participant works. Procedure was done with light sedation and local anesthetic.
- No significant PMH, favorable airway exam. Pt. is 70 kg with a BMI of 30.
- Received sedation from CRNA under supervision of attending anesthesiologist who is now beginning his other room.
- NKA
- No prior anesthesia complications.
- Intraoperative position is left lateral.
- Medications given are Midazolam 2 mg and fentanyl 100 mcg at the start of the case
- Vitals were stable, he was awake, and he was transported to the recovery area to get dressed for discharge. (The recovery area is now the simulation laboratory.)

#### Patients’ Presentation:
- The attending anesthesiologist is asked to come to the simulation area because the patient is now confused and exhibits inappropriate behavior.
- Patient is on ECG, BP and pulse oximetry but no oxygen.
- Vitals are: HR 100 RR 22 BP 12/71 oxygen saturation is >94% on room air and airway does not appear obstructed.
- He is trying to get out of bed and pulling at all lines and cables. Oriented to person only and quickly returns to agitated state after questioning.
- Exam: On his body he has 7 areas of dressings intact with no bleeding, no swelling or other drainage noted.
- During the first 3 minutes there are some PVC’s on the ECG (Begin with 25 PVC’s/min in sinus).

<table>
<thead>
<tr>
<th>Additional Information / equipment</th>
<th>None</th>
</tr>
</thead>
</table>
| AV / Archiving, communication      | - headset for instructor, moles x2 (PACU nurse and patient)  
                                   | - viewer ready for instructor in control area  
                                   | - 5 microphones (1 for coordinator, 1 for attending, 1 for M.K., 1 for RN, 1 for CRNA) |
Nurse should report that the patient seemed fine when he first came out but has actually become more confused and agitated and now he is having a lot of PVC’s.

<table>
<thead>
<tr>
<th>1st change</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>At 3 minutes:</td>
<td>- <strong>If coordinator</strong> asks about if anything of note was reported about this case: RN says: “No he is a healthy guy”&lt;br&gt;- <strong>If coordinator</strong> asks what was given during the case, CRNA hands them the anesthesia record. “He got some local and sedation. Here is the anesthesia record.” (The record states that 2 mls midazolam and 2 mls of fentanyl were given at the beginning of the case.)&lt;br&gt;- <strong>If coordinator</strong> asks for more specific information, you can call the procedure RN who cared for the patient intraoperatively. RN reports that there was no ectopy during the case. Normal sinus the whole time; some bupivacaine was given before the procedure and more was given at the end “for pain control” There were no problems noted during the case—it was all very routine.&lt;br&gt;- <strong>If coordinator</strong> asks persistently for specific drugs that were administered, CRNA will call again and ask: The report is that about 30 ml of 2% lidocaine with 30 ml of 0.5% bupivacaine was administered at the beginning. 40 ml of 0.5% bupivacaine was administered at the end of the 40 min procedure. CRNA is under the direction of the anesthesiologist (Team leader).&lt;br&gt;- CRNA administers 2 LPM NC on pt.&lt;br&gt;- <strong>After 3 minutes/initial report from nurse:</strong>&lt;br&gt;  - M.K. starts to twitch in one extremity.&lt;br&gt;  - M. K. starts to complain of dizziness. Grabbing the bed, and saying “I don’t feel so good” “I gotta get out of here” “Everything feels far away” “I feel dizzy” “Is everything okay doc?” “What’s happening to me?”&lt;br&gt;  - Vitals are: HR 100, RR 29, BP 90/50, O₂ sat 92%, 30 PVC’s/min in sinus. %, breathing more labored and patient appears distressed&lt;br&gt;  - M.K. May be complaining of ringing in his ears or metallic taste in his mouth. <strong>NURSE</strong> at bedside is getting more frantic and pointing out every PVC she sees.&lt;br&gt;  - M.K. is in ventricular tachycardia, HR 111, BP 90/51, O₂ sat 90%</td>
</tr>
</tbody>
</table>
| 2\textsuperscript{nd} change | - CRNA pre-oxygenates M.K. on 100 % O\textsubscript{2} and M.K. is intubated.  
- **M.K:** The arm or leg can be twitching away.  
- Eventually, the leg or other arm should join in, full seizure.  
- **If CRNA** gives midazolam to treat jerking movements/ agitation/ seizures:  
Seizure stops, but ventricular ectopy will continue  
- **If CRNA** gives reversal of opiates or benzodiazepines: there is worsening of seizure activity.  
- **M. K.** Progresses into seizures no matter what the earlier interventions were.  
(Seizure lasts 30 seconds).  
- **Vitals during seizure:** 160/100 HR 120 RR 20’s, O2 sat 90 % short-run PVCs continue.  

**IF CRNA** asks for code cart or defibrillator, obtain simulated AED.  
If not already in place, nurse should obtain the AED and/or place the AED on the patient because of the ectopy. Should say, “I’m afraid he might arrest. I think we should put the AED on him.”  

If the local anesthetic toxicity idea hasn’t been brought up the nurse should say” Do you think this could be from the injections at the end of the case?” or if LA toxicity was considered but not treated, ” Do you want me to get intralipid? “  
- **IF CRNA** asks for intralipid: Get intralipid, CRNA must specify the dosage, the route and rate of administration of the intralipid.  
- **Vitals 1 minute after intralipid** has been given: sinus, HR 91, RR16, BP 110/82.  

-**M. K.** achieves post-ictal status after the intralipid therapy. O2 saturations are above 94%. PVCs more frequent  

| Important point: | Consider Cardio Pulmonary Bypass (CPB) facility once LA toxicity is established.  

| Post Scenario Debrief | Talk about teamwork concepts and best use of a checklist:  
- Team leader stays team leader and delegates properly.  


– Once the local anesthetic toxicity is brought up, consider CPB facility and start mobilizing or at least considering the logistics.
– Do others in your facility (surgeons, other procedural lists use local when you are not present? Do they know about how to use intralipid for LA toxicity?

Specific points related to lipid/local anesthetic toxicity:
– Discuss dose 1.5 ml/kg over 1 minute as bolus (while continuing CPR) must circulate medication.
– Infusion 0.25/ml/kg/min immediately
– Repeat bolus every 3-5 min up to 3ml/kg as maximum.
– Continue infusion until patient is hemodynamically stable.
– Can increase to 0.5/mcg/kg/min if BP declines.
– Discuss the application of intralipid in non ACLS situations
– Risks of giving intralipid.
– Hypersensitivity to soy eggs and possible cross reactivity with peanut.
– Lipemia has been reported with lipid therapy (typically in neonates).
  Consider other adverse case scenarios.

SMART performance improvement plans.

**Learning Objectives:**

1) Recognize symptoms of Local Anesthetic Systemic Toxicity (LAST)
2) Appropriate treatment of LAST
3) Consider early treatment of LAST (prior to cardiopulmonary collapse)
Appendix H: MH Case Scenario

<table>
<thead>
<tr>
<th>Room setup</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manikin / pt. (position, bed, clothes, location)</strong></td>
<td>In hospital gown, supine position on OR bed (Located in the simulation lab)</td>
</tr>
<tr>
<td><strong>Monitoring</strong></td>
<td>Nothing hooked up: CRNA will hook up</td>
</tr>
<tr>
<td></td>
<td>EKG, Pulse Ox, BP</td>
</tr>
<tr>
<td></td>
<td>Will need ETCO2 monitoring</td>
</tr>
<tr>
<td><strong>Diagnostics / results</strong></td>
<td>CBC, BMP, Coag studies</td>
</tr>
<tr>
<td><strong>Pt equipment / meds (Concentrations, sizes, etc.)</strong></td>
<td>Airway equipment: MAC 2,3 and 4 blade, ETT (size 5-8)</td>
</tr>
<tr>
<td></td>
<td>Meds: Etomidate, Methohexital, Propofol, Succinylcholine, rocuronium, esmolol, labetalol, lidocaine, phenylephrine, glycopyrrolate, ephedrine</td>
</tr>
<tr>
<td></td>
<td>Anesthesia machine: circuit should not be hooked up to patient</td>
</tr>
<tr>
<td></td>
<td>Will need PIV hooked up to pt. with IV fluid hanging, also have an extra IV set up.</td>
</tr>
<tr>
<td><strong>Additional info / equipment (Demo equip, white boards, timers, etc.)</strong></td>
<td>MH Red cart with dantrolene present</td>
</tr>
<tr>
<td><strong>AV / archiving, communication (Record, live feed, VTC, etc.)</strong></td>
<td>Headset for instructor, moles x2 (PACU nurse and patient)</td>
</tr>
<tr>
<td></td>
<td>Viewer ready for instructor in control area</td>
</tr>
<tr>
<td></td>
<td>5 microphones (1 for coordinator, 1 for attending, 1 for M.K., 1 for RN, 1 for CRNA)</td>
</tr>
</tbody>
</table>
First Scenario flow (In the OR)

<table>
<thead>
<tr>
<th>Case Scenario</th>
<th>Patient is an eight year old boy who presents for strabismus correction. No PMH has a history of an anesthetic-related death in the family.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt presents: (Including triggers, timing, etc.)</td>
<td>– CRNA under Anesthesiologist supervision hooks patient up to monitor and induces anesthesia. The patient is intubated with succinylcholine and anesthesia maintained with sevoflurane on anesthesia machine ventilator.</td>
</tr>
<tr>
<td></td>
<td>– Starting vitals: BP 110/70, HR 90s, Sat 100% Twenty minutes into the procedure, the patient develops increasing tachycardia with ventricular premature beats and mottled skin.</td>
</tr>
<tr>
<td></td>
<td>– HR steadily increases to 150s (the earliest sign)</td>
</tr>
<tr>
<td>3rd Change</td>
<td>– ETCO2 steadily increases from 32 to 69 despite constant ventilation (the most sensitive sign)</td>
</tr>
<tr>
<td></td>
<td>– Profuse sweating</td>
</tr>
<tr>
<td></td>
<td>– cyanosis</td>
</tr>
<tr>
<td>4th change</td>
<td>– Muscle rigidity ensues</td>
</tr>
<tr>
<td></td>
<td>– Urine output significantly diminishes</td>
</tr>
<tr>
<td>5th change</td>
<td>– Pts’ core temperature increases to 42.9 °C</td>
</tr>
</tbody>
</table>

Second Scenario flow (change names to accurately reflect states)

<table>
<thead>
<tr>
<th>Actions</th>
<th>CRNA should be able to recognize this as a MH scenario and call for help right away.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interventions by CRNA</td>
<td>i. Stop all anesthetics and surgery.</td>
</tr>
<tr>
<td></td>
<td>ii. Hyperventilate the patient with 100% oxygen and a vapor-free anesthesia machine, fresh circuit, reservoir bag, and soda lime. Flush machine with 10 L oxygen for 10 minutes.</td>
</tr>
<tr>
<td></td>
<td>iii. Start dantrolene sodium early while muscle perfusion is still present. An initial intravenous dose of 2.5 mg/kg should be followed by repeated doses of 1 to 2 mg/kg to a total of 10 mg/kg depending on the patient’s response.</td>
</tr>
<tr>
<td></td>
<td>iv. Initiate aggressive cooling immediately for rapidly increasing temperatures and for those higher than 40°C—Methods for</td>
</tr>
</tbody>
</table>
cooling include the following: surface cooling with the patient on a cooling blanket and packed in ice; gastric, rectal, or peritoneal lavage with iced saline; and iced intravenous fluids (saline). Cooling should be stopped when the patient's temperature falls to lower than 38°C, to prevent inadvertent hypothermia.

v. Treat acidosis with sodium bicarbonate (2 mEq/kg initial dose and titrate as necessary).

vi. Treat hyperkalemia with sodium bicarbonate, insulin, and 50% dextrose.

vii. Treat arrhythmias with standard antiarrhythmics, and avoid calcium channel blockers if dantrolene has been given.

viii. Establish lines—a wide-bore cannula for central venous pressure, arterial line (if not already in place), Foley catheter, and nasogastric tube.

ix. Maintain urine output with mannitol or furosemide.

x. Provide cardiorespiratory support.

| CRNA Monitors Closely | • Pulse oximetry  
|                       | • ECG  
|                       | • Temperature  
|                       | • Arterial blood pressure  
|                       | • Urine output  
|                       | • Central venous pressure  
|                       | • Draws arterial blood gases/electrolytes/coagulation  
|                       | • Capnography  

| Post acute phase | – A. Observe the patient in an ICU for at least 24 hours, due to the risk of recrudescence.  
|                 | – B. Dantrolene 1 mg/kg q 4-6 hours or 0.25 mg/kg/hr by infusion for at least 24 hours. Further doses may be indicated.  
|                 | – C. Follow vitals and labs as above  
|                 | – Frequent ABG checks.  
|                 | – CK every 6 hours  

| Post op management | Pts’ family should be warned of the dangerous nature of this syndrome and should be advised to carry an identification band at all times.  
|                   | The MHAUS should be contacted on their hotline: 1-800-MH-HYPER  

MH debriefing:

1. Listen to participants to understand what they think and how they think the simulation session went. Questions to be asked:

   a) How do you think the simulation went?
   b) What were your favorite and least favorite aspects of simulation?
   c) What were you successes? Your failures?
   d) How did you perform as a team?
   e) Debriefer summarizes comments or statements
   f) Participants identify positive aspects of team or individual behaviors
   g) Participants identify areas of team or individual behaviors that require change or connection.

2. Analyze: Facilitate participants’ reflection and analysis of actions.

   a) Review accurate record of events.
   b) Report observations (correct and incorrect steps)
   c) Ask a series of questions to thoroughly examine their performance during the simulation and their perceptions during the debriefing.

3. Direct/indirect participants during the debriefing to assure continuous focus on session objectives

   a) How familiar were you with the patient’s condition/treatments/complications prior to the simulation? How might you improve next time? Give me specific examples of where not knowing this information might have hindered optimal performance.
b) What additional cues to problems, complications, or needs became apparent during the simulation? Were these recognized and acted upon promptly?

c) How would you describe communication among the team? Was important information shared clearly among team members?

d) Were there any techniques or interventions or conditions with which you were unfamiliar? How would you describe your competence? Did you recognize any technical mistakes?

4. Summarize: Facilitate identification and review of lessons learned on MH.

i. What preoperative evaluation and preparation should be done?

ii. What are the clinical features of the syndrome?

iii. What are the laboratory findings during an acute crisis of malignant hyperthermia?

iv. What is the incidence of this syndrome?

v. What is the mode of inheritance of the disease?

vi. What genetic disorder results in malignant hyperthermia susceptibility?

vii. What is the pathophysiology of the syndrome?

viii. What laboratory tests can further substantiate the susceptibility of the patient to malignant hyperthermia?

ix. What agents will you recommend if local anesthesia was elected instead of General anesthesia?

x. What is the recommended Post-operative management of MH case scenario?
Learning Objectives:

a) Recognize early signs of MH and need for urgent assistance.

b) State differential diagnosis for hyperthermia, tachypnea and tachycardia.

c) Identify key concepts of preparing dantrolene.

d) MHAUS checklist for the recognition and treatment of MH emergencies.

References


2. Malignant Hyperthermia Association of the United States (MHAUS)
Appendix I and J:

Interactive PowerPoint modules for LAST (Appendix I)

Interactive PowerPoint modules for MH (Appendix J).
REFERENCES


