Published in final edited form as:

AORN J. 2014 February ; 99(2): 301–311. doi:10.1016/j.aorn.2013.06.012.

Malignant Hyperthermia Crisis: Optimizing Patient Outcomes through Simulation and Interdisciplinary Collaboration

Cindy L. Cain, RN, CNOR¹, Matthias L. Riess, MD, PhD², Gettrust Lynn, MSN, RN, ACNS-BC³, and Jutta Novalija, MD, PhD²

Cindy L. Cain: cindy.cain@va.gov; Matthias L. Riess: matthias.riess@va.gov; Gettrust Lynn: lynn.gettrust@va.gov; Jutta Novalija: jutta.novalija@va.gov

¹Staff Nurse Operating Room

²Staff Anesthesiologist and Associate Professor

³Perioperative Clinical Nurse Specialist

Abstract

Background—Malignant Hyperthermia (MH) is a rare, life-threatening event and many clinicians may be unprepared for management should a crisis occur. Simulation is a recognized teaching method to facilitate learning in a safe environment, and scenarios can be developed to resemble real life experiences. Our aim was to provide education to operating room (OR) staff in its early recognition, treatment, and management.

Methods—We formed an interdisciplinary perioperative team and developed an MH education plan for OR staff. An educational presentation by an anesthesiologist was followed by role playing scenarios using high-fidelity simulation in the OR suite.

Results and Clinical Implications—OR staff responded very favorably to the lecture and the simulation exercise. Outcomes achieved included role clarity, improved anticipatory response and overall team cohesion and interaction. As an immediate consequence, the MH cart was updated and reorganized and an institutional MH policy implemented.

Keywords

Malignant Hyperthermia; MH; Simulation; Interdisciplinary; Crisis

Introduction

Malignant Hyperthermia (MH) is a pharmacogenetic disease process that occurs when predisposed individuals are exposed to volatile anesthetics and/or succinylcholine. It is a medical emergency, with most episodes occurring shortly after induction of general anesthesia or during the intra-operative period.⁴ Immediate intervention with rapid, specific

Correspondence to: Cindy L. Cain, Clement J. Zablocki VA Medical Center, 5000 W. National Ave, Milwaukee, WI 53295; Tel. 414-384-2000 ext 41705; cindy.cain@va.gov.

Contact information for all authors: Clement J. Zablocki VA Medical Center, 5000 W. National Ave, Milwaukee, WI 53295, Tel. 414-384-2000 ext 41705

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treatment is needed to prevent death. Anesthesiologists and Certified Registered Nurse Anesthetists (CRNA) are well trained to manage patients with known susceptibility to MH by using non-triggering anesthetic agents. However, when the susceptibility is unknown a true medical emergency occurs and it takes an interdisciplinary team effort to save the patient.

MH was identified in 1961 when a reported string of anesthetic related deaths occurred.⁸ It came to be known as Malignant Hyperthermia because a rapid rise in temperature is a common feature. The number of reported MH cases has increased over the last 20 years with variations in occurrences from country to country and state to state, presumably due to variations in the genetic pool.⁴ It is more common in men than women and it is familial.⁸ MH occurs due to a defect in the ryanodine receptor (RYR1) which is found in all skeletal muscle and responsible for calcium release. In an MH crisis, exposure to triggering agents causes excessive intercellular calcium release, resulting in sustained skeletal muscle contractions and rigidity.⁴ An increase in O₂ consumption occurs and leads to a hypermetabolic state which in turn leads to hypercarbia, respiratory and metabolic acidosis, hyperkalemia, arrhythmias, and a rapid rise in temperature.⁸ Perioperative staff can be better prepared for the challenge of caring for a patient in a MH crisis through a simulation exercise. Simulation is a recognized teaching method to facilitate learning in a safe environment, and scenarios can be created to resemble real life experiences. In high risk industries, including the military, space flight and nuclear power simulation is a well known technique.²

Simulators are run via a computer program. Vital signs are displayed on a monitor, and changes in vital signs or physical assessment findings can be made during the scenario. The simulator can also be used to practice CPR, intubation and several other emergency procedures in the real environment (so call in-situ simulation).⁹ Life-like mannequins that breathe, talk, blink, have heart and bowel sounds, combined with a high level of clinical scenario interactivity and realism allow learners to suspend disbelief.³ Since anesthesiologists were early champions and have been using simulation routinely since 1994 to enhance their procedural skills.¹⁰ they were a crucial part of the simulation learning exercise. Also, in a real life MH crisis anesthesiologists are in charge.

Problem

The need for a quality improvement project for MH treatment management was identified by staff nurses in the OR of our hospital, a recognized academic teaching facility affiliated with a nearby medical school. Staff knowledge of MH and its treatment was limited. Yearly education of MH crisis was missing. The MH treatment cart was not up-to-date and a policy and procedure for management of MH did not exist. The project involved four specific processes to obtain best practice: staff education by the anesthesia staff, simulation with multidisciplinary teams, revision of the MH cart, and creation of an OR specific policy and procedure for MH.

Setting

An academic medical facility in the Midwest with 8 OR suites. The staff in the OR includes 19 registered nurses and 10 surgical technicians. All surgical specialties are practiced in the OR and the staff is trained to cover all specialties.

Goal

The goal of the Quality Improvement project was to increase staff knowledge through implementation of evidence based criteria for the treatment of MH. In the event of a MH crisis, staff would be prepared to follow an evidence based protocol to provide optimal patient care.

Evidence

AORN developed a Malignant Hyperthermia Guideline (2006) focused on the perioperative care of patients known to have or considered susceptible to MH. The guideline outlines the assessment and treatment of MH and provides resources and tools for OR nurses and health care provider education.¹ The AORN guideline is based on current available best evidence and incorporates information from the Malignant Hyperthermia Association of the United States (MHAUS). The protocol developed by MHAUS was developed based on scientific research, and is viewed as the national guideline for care of the MH patient. MHAUS suggests that perioperative teams initiate mock MH drills to improve staff efficiency in managing a crisis.⁶

Methods

The Quality Improvement project at our institution had two components. First, a staff anesthesiologist (MLR) provided a power point presentation on MH which was attended by all nursing and surgical technician staff in our OR. This didactic portion provided MH education and created an underlying understanding of the disease process and crisis. Second, a MH scenario using high fidelity simulation was held in an OR suite (Fig 1). A wireless high-fidelity full body mannequin⁹ (SimMan 3G, Laerdal Medical Corporation, Wappingers Falls, NY) served as the patient and allowed the scenario to unfold in real time from diagnosis to treatment. In order to engage the OR staff in the simulated MH crisis, 19 RNs and 10 surgical technicians were divided into two groups for participation in simulation on two separate days. The simulation was developed by a staff anesthesiologist (JN) who utilizes simulation as a teaching method with medical students. Each exercise began with a brief explanation by the anesthesiologist of the simulation scenario. The scenario involved a patient undergoing a routine surgical procedure complicated by a MH crisis. An anesthesiologist, anesthesia resident, anesthesia tech and CRNA filled the roles of surgeon and anesthesia staff. The OR nurses and surgical technicians filled their specific roles and during the crisis, additional staff in the room were delegated duties (i.e. reconstitution of Dantrolene, obtain basin of ice, documentation). The simulation scenario lasted approximately 15 minutes followed by a debriefing. During the debriefing, staff had the opportunity to identify what went well and how the process could be improved. For example, the participants realized the challenges in drawing up and injecting Dantrolene and

the time involved with gathering ice and setting up various cooling measures. The goal of the simulation experience was to teach effective responses to a complex, high risk low volume situation by working together as an interdisciplinary team. Effective and powerful teams are composed of members who are aware of other team members' roles and responsibilities and believe in the importance of team work.³ In the OR, clear communication saves lives.⁴

Implementation

The OR did not have a policy for the treatment and management of MH. The first step in the process involved identifying the key stakeholders involved in the process and forming an interdisciplinary team to provide staff education. This was a new process and staff seemed eager to learn. Our interdisciplinary team worked collaboratively on the development of staff education, the simulation exercise, and updating of the MH cart to current standards. The educational power point was provided by the staff anesthesiologist four weeks prior to the simulation scenarios. Simulation was done on two meeting dates during the same week. The MH cart revision was completed over a period of a month, and the MH Policy and Procedure took approximately two months to complete.

Outcomes

Outcomes achieved from this simulation activity included role clarity, improved anticipatory response, and overall team cohesion and interaction. During the debriefing process, a focused discussion allowed all team members to use their critical thinking skills to pinpoint where the team performed well and where improvements needed to be made. Nurses and surgical technicians expressed that this exercise increased their knowledge and confidence related to roles and responsibilities in the event of an actual MH crisis. Every discipline involved in a surgical procedure contributes significantly to the achievement of optimal patient care. Successful surgical outcomes are the result of a coordinated team effort.

In preparation for a potential MH crisis the contents of the MH cart kept in the OR were reviewed. The *Malignant Hyperthermia Association of the United States* (MHAUS) provided a list of supplies to be included in a MH cart.⁶ This list serviced as a reference for cart reorganization. For ease of staff use, compartment bins were clearly labeled. Our Biomedical Engineer and Clinical Nurse Specialist (LG) worked closely in obtaining current MH treatment guidelines from MHAUS to be placed on the side of the cart (Fig 1 and 2). In addition, we collaborated with the pharmacy to obtain necessary medications. Finally, an MH policy was written and instituted for the OR following treatment guidelines established by MHAUS. Due to the high risk, low volume nature of MH, simulation experiences will now occur on a yearly basis to keep staff prepared to provide optimal patient care in the event an MH crisis would occur.

Discussion

A simulated clinical experience with sufficient realism is a recognized teaching method created to provide learning in a safe environment.⁵ Learning exercises that closely mimic real life situations use high-fidelity simulation devices and evidence based simulation

scenarios. Simulation provides a pathway between formal education and professional practice for rare but potentially fatal experiences such as MH that are essential to know during a crisis in the operating room.⁵ While both the airline and nuclear industry, as well as the military³ have long used simulation to train and respond to crises with potentially serious consequences that may result from human error, the nursing community is now integrating simulation into its curricula as a new method of educating nurses. For example, a new \$4 million clinical simulation center combining the expertise of a nursing faculty and a healthcare facility will be the first clinical simulation center partnership in the state of Wisconsin. According to the Dean of Marquette University's College of Nursing in Milwaukee, WI, the hope is to "create a national standard that can be replicated in communities across the nation to address critical health care issues of nursing shortages and patient safety".⁷ Simulation labs are particularly valuable in preparing for infrequent, high-risk situations such as MH⁶ and increase collaboration across disciplines with interdisciplinary team training.

Conclusions

Since MH is a rare, life-threatening event, many clinicians may be unprepared for management should a crisis occur. Simulation is a recognized teaching method to facilitate learning in a safe environment, and scenarios can be created to resemble real life experiences. Simulation was used to identify areas where improvement was needed. We realized the importance of role assignment to decrease chaos in an MH crisis. We determined that visual aides such as role cards would be helpful in clearly identifying each team member's role. We will initiate yearly MH simulation training for OR staff, with the goal of twice yearly training.

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Fig. 1. Staff anesthesiologist and staff nurse prepare for an MH simulation exercise with multidisciplinary team members. Please note the MH treatment plan by MHAUS on the side of the MH cart.

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