Adopted BOD October 2005
Revised January 2013

Guideline Statement for Malignant Hyperthermia in the Perioperative Environment

Recognition of Existing Protocol and Treatment Guidelines

The following is not so much a guideline but a brief review of malignant hyperthermia (MH) related to the role of the Certified Surgical Technologist (CST) when dealing with an MH crisis in the perioperative setting. AST recognizes that the definitive protocols for treating MH have been established by the Malignant Hyperthermia Association of the United States (MHAUS) and are viewed as the standard of care for treating the patient in surgery. The information pertaining to recognition of, and treatment of a MH crisis, is taken directly from the MHAUS guidelines.

Pathophysiology, Mortality, and Population

MH was first described in 1962 when Denborough reported recurring anesthetic deaths within a family.[3] MH is defined as a fulminant hypermetabolic crisis triggered by certain types of anesthetic agents, typically succinylcholine, sevoflurane, desflurane, isoflurane and halothane. MH is characterized by an uncontrolled increase in skeletal muscle metabolism. Contrary to common belief, pyrexia is not the first indicator of an MH crisis. The earliest sign and symptom that will present is an increase in end-tidal carbon dioxide. End-tidal CO_2 can occur due to other reasons, but when the anesthesia provider has quickly ruled out all other possibilities, it is recognized that a potential MH crisis may need to be treated.[8]

Other additional early signs include tachycardia, tachypnea, and rigidity of the masseter muscle called trismus. However, trismus often occurs with pediatric patients, in particular when intubating, so this sign must be taken into consideration with all other signs and symptoms. As an MH crisis progresses, other signs and symptoms are unstable blood pressure, cyanosis and/or mottling of the skin, diaphoresis, cardiac dysrhythmia and a dramatic increase in the body temperature. The patient's temperature may elevate as much as 1-2°C every five minutes. The sterile surgical team may confirm that blood on the field is dark in color due to central venous saturation. Table 1 is a listing of laboratory results that will often be seen during an MH crisis.

Table 1: Patient Laboratory Results during an MH Crisis

Lab Test	Results
PCO_2 (partial pressure of carbon dioxide)	Increase
pH level	Decrease
PO_2 (partial pressure of oxygen)	Decrease
Potassium	Increase
Calcium	Increase
Magnesium	Increase
Sodium	Decrease
Lactate	Increase
Pyruvate	Increase
Creatine phosphokinase	Increase

Myoglobin	Increase
Glucose	Increase
Creatinine	Increase
Prothrombin time	Decrease
Platelet count	Decrease

If MH is unrecognized and therefore not treated, mortality is approximately 80%. Current statistics indicate mortality is <10% when an MH crisis is treated; however, experts believe this can be reduced by improved MH preparedness.[4]

Identifying patients who are susceptible to MH can be difficult and only occurs in 1:15,000 patients.[1] The true indication of MH susceptibility (MHS) is unknown because MH is a silent disorder until triggered via commonly used general anesthetics and the muscle relaxant succinylcholine. The presence of a defective gene causing MHS has not yet been identified for any given population.[4] Approximately 50% of patients who experience an MH crisis had previously received a triggering anesthetic agent without showing any signs or symptoms. Male patients are affected more frequently than female patients, and the incidence of MH decreases with patients older than 50 years of age. Additionally, pediatric patients are the most frequently affected age group, in particular those with rheumatoid arthritis.[1]

Several musculoskeletal diseases are correlated to high incidences of MH. Diseases include myotonia, osteogenesis imperfecta, King-Denborough syndrome and Duchenne's muscular dystrophy. Surgical procedures associated with an increased incidence of MH include orthopedics, repair of cleft palate, tonsillectomy and adenoidectomy, repair of ptosis, and strabismus correction.[1] Family history of complications with anesthetic agents can be an indicator, in particular if a family member(s) experienced an MH episode, but it is still not the most reliable indicator.

The most dependable method for confirming a patient with MHS is a muscle biopsy test. A patient is injected with a local anesthetic and a small piece of muscle is excised, most often from the leg. In the laboratory, the muscle is placed in a small bath mixture of caffeine and halothane. A positive muscle contracture provides 95% reliability that the patient is susceptible.[1]

Treatment Protocol

Table 2 is the protocol for treating MH taken directly from MHAUS.[6] Many of these activities take place simultaneously are not presented in any particular order with the exception of the first three treatments – those should be immediately implemented. Prompt treatment involves quickly resolving hyperkalemia, administering Dantrolene, cooling the patient's core temperate to 38° C, and hyperventilating the patient.

Table 2: Treatment Protocol for MH Crisis

Treatment	Dosage or Action
1. Immediately discontinue anesthesia, including succinylcholine.	Life-threatening surgery will be continued, but with the use of a different anesthetic agent and machine to prevent residual inhalation agent from triggering a second episode.[8]
2. Hyperventilate	100% oxygen at a high flow rate of 10L/min. to treat effects of hypercapnia, metabolic acidosis, and increased oxygen consumption.
3. Dantrolene	2.5mg/kg IV as soon as possible; given every five minutes until symptoms subside.[1]
4. Change ventilator tubing and soda lime canister.	Some anesthesia providers may still perform this action, but research has shown that it is not necessary to change the breathing circuit and anesthesia machine since the oxygen delivery rapidly clears the machine of the anesthetic gases.[8]
5. Sodium bicarbonate	1-2 mEq/kg IV to combat metabolic acidosis due to increase of lactate in the circulatory system.
6. Ice packs	Apply to groin area, axillary regions, and sides of neck – where major arteries are located; also apply to wrists and ankles/feet.
7. Iced lavage	Lavage the stomach and rectum with cold fluids to lower temperature. It is recommended not to lavage the bladder since the fluids can alter the true amount of urine being excreted by the patient and alter measurement of output. Avoid causing hypothermia; cooling should be discontinued when the core body temperature reaches 38º C.
8. Mannitol or furosemide	Muscle cells are destroyed during an MH crisis and the myoglobin that is released accumulates in the kidneys, obstructing urinary flow, referred to as myoglobinuria. Diuretics are given IV to promote and maintain urinary flow in order prevent renal damage. Mannitol 0.25g/kg IV; furosemide 1mg/kg IV; up to four doses each. Urinary output of 2ml/kg/hr or higher must be maintained to prevent renal failure.[8]
9. Procainamide	200 mg IV to treat arrhythmias secondary to electrolyte imbalances.

Treatment	Dosage or Action
10. Dextrose and insulin	Treat hyperkalemia due to the release of potassium into the circulatory system as muscle cells are destroyed. Dextrose 25-50g IV; regular insulin 10 units in 50ml of 50% dextrose in water given IV.
11. Monitor urine output	Insert Foley catheter if one is not in place
12. Monitor electrolyte levels	Blood samples taken every 10 minutes to measure sodium, potassium, chlorides, calcium, phosphate, and magnesium levels.
13. Perform clotting studies	
14. ABG	Every five to 10 minutes
15. Arterial blood pressure	Insert line if one is not in place
16. Central venous pressure	Insert line if one is not in place
17. Capnograph	Instrument used to produce a capnogram, a tracing that measures the proportion of carbon dioxide in exhaled air.

Dantrolene is a skeletal muscle relaxant that was developed specifically for the treatment of MH and must be administered through an IV. Dantrolene is freeze-dried and packaged in vials of 20mg and must be reconstituted with 60mL of sterile water. The sterile water is injected into the vial, and the vial will require vigorous shaking to mix. The mixture will be a yellow-orange color indicating it is fully mixed. The standard for measuring the needed dose is based on an adult that weighs 70 kg; thirty-six 20 mg. vials of Dantrolene will be needed to stabilize the patient.[1] Rarely does the total required dosage of Dantrolene exceed 10mg/kg.[6] Dantrolene should be administered every six to eight hours for 24-72 hours after the initial episode to prevent a recurrence; the dosage is 1mg/kg.[1] It is recommended the patient should remain in the PACU for a minimum of four hours and transported to the ICU for observation for 24-48 hours.

Dantrolene is a relatively safe drug in which very few complications have been reported. The most serious complication/side-effect following large dose administration is generalized muscle weakness that can contribute to postoperative aspiration pneumonia or respiratory insufficiency. Additionally, dantrolene can cause phlebitis in small peripheral veins, therefore, it is recommended the drug is administered through a central venous line.[1] Prior to administering dantrolene, the IV line should be flushed with sterile water to prevent precipitation, if other IV solutions were previously running through the line. Ringer's Lactate solution should not be administered, since it will increase the acidosis.

When patients are identified as MHS prior to the surgical intervention, an MH crisis can be avoided by utilizing identified non-triggering anesthetic agents. The following agents have been identified as the safest to use on MHS patients:

- Thiopental sodium and pancuronium: These seem to be protective agents, since they raise the triggering threshold for MH.[1]
- Droperidol
- Benzodiazepines
- Ester-type local anesthetics

Nitrous oxide and ketamine hydrochloride are categorized as weak-triggering agents and therefore, are considered safe for use. The prophylactic IV administration of Dantrolene prior to the surgical procedure is not considered necessary as long as safe anesthetics are used.

Recommended Supplies for the MH Cart

It is recommended each HCF, including out-patient surgery centers and physician's offices where surgical procedures are performed, maintain an MH cart containing the supplies and drugs that are immediately needed to treat an MH crisis.

Supplies and Equipment

- 60 mL syringes x 5
- 16G, 18G, 20G IV catheters, 2-inch x 4 each
- 22G IV catheter, 1 inch x 4
- 24G IV catheter, ¾ inch x 4
- IV solutions
- NG tubes, various sizes
- 60 mL Toomey syringes x 2 with adaptor (used with NG irrigation)
- Foley catheter tray
- Urine meter x 1
- Urine collection container to determine myoglobin level
- Urinalysis test strips
- Irrigation tray with 60 mL irrigation syringe
- 10-12 bags of saline kept in a refrigerator for IV cooling
- Small and large plastic bags for ice
- Bucket for ice
- 3 mL syringes or ABG kit x 6 for blood gas analysis
- Blood specimen tubes, several: If laboratory analysis cannot be immediately completed, the tubes should be placed on ice for later analysis; the future analysis and documentation of results is useful when reviewing the case.
- Steri-drape or some type of adhesive drape to cover and protect surgical wound while treatment of MH is carried out.
- Pulmonary artery, esophageal, nasopharyngeal, tympanic membrane, bladder, rectal temperature probes
- Blood administration sets and pumps
- CVP kits of various sizes
- Transducer kits for arterial and CVP cannulation
- Gastric lavage set with three-way indwelling catheter for insertion into the rectum

Drugs

- Thirty-six vials that are 20mg each of Dantrolene
- Thirty-six vials that are 100mL vials of sterile water
- Five 50 mL vials sodium bicarbonate 8.4%
- Ten 50ml vials of 20% Mannitol
- Four 2ml pre-filled syringes of furosemide
- One 100-U vial of regular insulin

- Two 50ml vials of 50% dextrose in water
- Two 10mL vial calcium chloride
- Three 1000-U vials of heparin
- Three preloaded syringes: Lidocaine 2% for injection, 100mg/5mL or 100mg/10mL. Amiodarone can also be used.
    - Lidocaine or procainamide should **not** be used if a wide-QRS complex arrhythmia is caused by the hyperkalemia; it can cause asystole.

Additional Information

The following is contact information for MHAUS.
Malignant Hyperthermia Association of the United States
1 North Main Street
PO Box 1069
Sherburne, NY 13460
607-674-7901

MHAUS has established a hotline to assist a surgical team in the immediate treatment of a patient. The hotline is staffed by anesthesiologist volunteers who are experts in the treatment of MH: 800-644-9737

AST Guideline Statement

CSTs are qualified to assist members of the perioperative team with the treatment of an MH crisis. CSTs are qualified to perform the following actions under the direct supervision of the surgeon(s):

- Apply active patient cooling mechanisms
    - Cooling blanket, ice packs to the groin, axilla, and head
    - Assist with cooling irrigation to body cavities
- Secure incision site (apply dressings and/or cover wound to protect from disruption)
- Retrieve MH equipment and supplies
    - MH emergency cart
    - Ice and iced fluids
    - Patient cooling equipment
    - Assist in mixing dantrolene with sterile water
    - Assist in the handling and administration of additional drugs and agents
- Secure code cart as appropriate
- Assist the anesthesia care provider and other members of the perioperative team as needed.

It is imperative that all health care workers within the perioperative environment receive appropriate competencies, education, and training related to the recognition and treatment of MH. All members of the perioperative team must have the ability to locate and identify the supplies and equipment required for the management of an MH crisis. Rapid action during an MH crisis is required to prevent permanent neuromuscular damage or death. Staff preparation can only serve as an aid in this instance. It is recommended that all HCFs develop policies and procedures related to the identification and treatment of this life-threatening disorder, including annual inservice education on the management of an MH crisis. The MH management policy should delineate a procedure for managing MH in the perioperative environment, pertinent

supporting data, and should clearly identify the equipment and supplies required to manage an MH crisis. Additionally, the MH management policy should identify the responsibilities of each member of the perioperative team.

Competency Statements

Competency Statements	Measurable Criteria
1. CSTs can identify and recognize the signs and symptoms of an MH crisis.	1. Educational standards as established by the *Core Curriculum for Surgical Technology*.[2]
2. CSTs are knowledgeable in the various patient-cooling modalities utilized during an MH crisis.	2. The subject area of MH is included in the didactic studies as a surgical technology student, including drug therapy.
3. CSTs are qualified to locate and identify appropriate emergency equipment and supplies required for the management of an MH crisis, and under the direct supervision of the surgeon(s) assist in the handling and administration of the equipment, supplies, and drugs.	3. The role of assisting the surgeon and perioperative team during an MH crisis is included in the didactic studies as a surgical technology student. 4. Surgical technology students demonstrate knowledge of the MH cart, such as location in the surgery department and supply list during clinical rotation. 5. CSTs perform patient care duties by assisting the surgeon(s) during an MH crisis in the perioperative setting as practitioners. 6. CSTs complete continuing education to remain current in their knowledge of MH, including following the policies of the HCF in completing annual inservice requirements.

References

1. Butterworth J, Mackey DC, Wasnick J. *Morgan and Mikhail's Clinical Anesthesiology.* 4th ed. New York: McGraw Hill; 2013.

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3. Denborough MA, Forster JFA, Lovell RRH, Maplestone PA, Villiers JD. Anaesthetic deaths in a family. *British Journal of Anaesthesia.* 1962; 34: 395-396.

4. McCarthy EJ. Malignant hyperthermia: Pathophysiology, clinical presentation, and treatment. *AACN Clinical Issues.* 2004; 15 (2): 231-237.

5. McGuiness A. Surgical Pharmacology and Anesthesia. In: Frey KB, Ross T, eds. *Surgical Technology for the Surgical Technologist: A Positive Care Approach*. 4th ed. Clifton Park, NY: Delmar Thompson Learning 2014: 234.

6. *MH Procedure Manual for Hospitals*. Sherburne, NY: Malignant Hyperthermia Association of the United States; 2011.

7. Odom-Forren J. *Drain's Perianesthesia Nursing: A Critical Care Approach*. 4th ed. St. Louis, MO: Saunders; 2012.

8. Snyder K, Keegan C. *Pharmacology for the Surgical Technologist.* 2nd ed. Philadelphia, PA: WB Saunders; 2006.

Resources

Malignant Hyperthermia Association of the United States (MHAUS) www.mhaus.org

American Society of PeriAnesthesia Nurses (ASPAN) www.aspan.org