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Guidelines for Best Practices for Treatment of Surgical Patients Experiencing Malignant Hyperthermia in the Operating Room

Introduction

The following Guidelines for Best Practices were researched and authored by the AST Education and Professional Standards Committee, and are AST approved.

AST developed the Guidelines to support healthcare delivery organization's (HDO) reinforce best practices in treating the patient experiencing an episode of *malignant hyperthermia* (MH) in the operating room (OR) as related to the role and duties of the Certified Surgical Technologist (CST®), the credential conferred by the National Board of Surgical Technology and Surgical Assisting. The purpose of the guidelines is to provide information OR supervisors, risk management, and surgical team members can use in the development and implementation of policies and procedures for treating the patient experiencing an episode of MH in the surgery department. The Guidelines are presented with the understanding that it is the responsibility of the HDO to develop, approve, and establish policies and procedures for the surgery department regarding MH practices per HDO protocols.

Rationale

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. Additionally, AST recognizes that the anesthesia provider and surgeon direct the care of the patient during an acute MH episode. However, the CST serves as another "pair of eyes" in the OR and should be familiar with the signs and symptoms of MH as well as the treatment protocols to be an effective member of the surgical team in treating the patient under the direction of the anesthesia provider and surgeon.

MH was first described in 1962 when Denborough reported recurring anesthetic deaths within a family.[1] MH is defined as a *fulminant hypermetabolic crisis* triggered by certain types of anesthetic agents, including the depolarizing muscle relaxant *succinylcholine* and the volatile anesthetic agents halothane, desflurane, enflurane, isoflurane, and sevoflurane; studies indicate that nitrous oxide and the noble gas xenon do not trigger MH.[2,3] A fulminant MH episode is characterized by a hypermetabolic crisis establishing as metabolic and respiratory acidosis, cardiac arrhythmias, tachycardia, skeletal muscle rigidity and *rhabdomyolysis*.[2] Contrary to common belief, *pyrexia* is not the first indicator of an MH crisis and actually is a late sign.[4] 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.[2]

Other additional early signs include tachycardia, tachypnea, and rigidity of the masseter muscle called *trismus*. However, trismus often occurs with pediatric patients, particularly 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
Calcium	Increase
Creatinine	Increase
Glucose	Increase
Lactate	Increase
Magnesium	Increase
Myoglobin	Increase
PCO_2 (partial pressure of carbon dioxide)	Increase
pH level	Decrease
Platelet count	Decrease
PO_2 (partial pressure of oxygen)	Decrease
Potassium	Increase
Prothrombin time	Decrease
Pyruvate	Increase
Sodium	Decrease

If MH is unrecognized and therefore not treated, mortality is approximately 80%.[3,6] With the introduction of *dantrolene* the mortality has decreased to <5%.[3,6,7]

Identifying patients who are susceptible to MH can be difficult. One estimate of the incidence of anesthetic-induced MH episodes is 1 in 15,000 for children and 1 in 50,000 in adults; however, another estimate is between 1:10,000 to 1:150,000 adults receiving general anesthesia.[2,4-6] MHS occurs worldwide and affects all ethnic groups with a preponderance of cases affecting children, young adults and mostly males; patients under the age of 19 years account for 45% to 52% of reported MH incidences.[6-9] The true indication of MH susceptibility (MHS) is unknown because MH is a silent disorder until triggered via commonly used *volatile anesthetics* and succinylcholine. Because MHS is inherited as a dominant train, when MH is diagnosed in a family member, all first-degree relatives are treated as MHS, even though there is only a 50% chance of transmission of a mutant gene in each case of MH.[2,3] 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, especially those with rheumatoid arthritis.[4]

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.[4] Family history of complications with anesthetic agents can be an

indicator, particularly if a family member(s) experienced an MH episode, but it is still not the most reliable indicator.

The gold standard for confirming a patient with MHS is a muscle biopsy test; two types of tests are performed – in vitro contracture test (IVCT) and caffeine-halothane contracture test (CHCT).[2,5] The CHCT is performed by injecting the patient 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.[4] The tests, however, are only available in six locations in the U.S. and the cost is prohibitive at approximately $6,000 per test.[5] A DNA-based blood test has been developed in the U.S. to serve as an alternative to the invasive CHCT and IVCT. The gene that is responsible for MHS in 50% - 70% of families is the muscle ryanodine receptor in skeletal muscle, the channel in sarcoplasmic reticulum responsible for calcium release during muscle excitation and contraction; however, the gene for the other 30% - 50% of MHS families is not known and therefore, the IVCT and CHCT remain the gold standard for testing individuals.[2,10]

Dantrolene is a skeletal muscle relaxant that was developed specifically for the treatment of MH and must be administered through an IV. Dantrolene is a relatively safe drug in which very few complications have been reported. Dantrolene may prolong the duration of neuromuscular blockade; therefore, the most serious complication/side-effect following large dose administration is generalized muscle weakness that can contribute to postoperative aspiration pneumonia or respiratory insufficiency requiring postoperative ventilator support.[11] Additionally, due to the alkaline nature of dantrolene it can irritate veins and cause phlebitis; therefore, it is recommended the drug is administered through a large bore IV or central venous line.[4,11]

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:

- Droperidol
- Benzodiazepines
- Ester-type local anesthetics
- Thiopental sodium and pancuronium: These seem to be protective agents, since they raise the triggering threshold for MH.[4]

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 if safe anesthetics are used.

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 in the U.S.; 001-209-417-3722 outside the U.S.[12] Additionally, MHAUS

offers "MHApp" for the iPhone that provides information to diagnose and treat MH episodes; the app includes the ability to quickly calculate the dose of dantrolene.[13]

Evidence-based Research and Key Terms

The research of articles, letters, nonrandomized trials, and randomized prospective studies is conducted using the Cochrane Database of Systematic Reviews and MEDLINE®, the U.S. National Library of Medicine® database of indexed citations and abstracts to medical and healthcare journal articles.

The key terms used for the research of the Guidelines include: Dantrolene; Duchenne's muscular dystrophy; end-tidal carbon dioxide; fulminant hypermetabolic crisis; hyperkalemia; King-Denborough syndrome; malignant hyperthermia; myotonia; osteogenesis imperfecta; pyrexia; succinylcholine; trismus; volatile anesthetics. Key terms used in the guidelines are italicized and included in the glossary.

Guideline I

It is recommended the surgery department, including ambulatory surgery centers (ASC) and physician's clinics where surgical procedures are performed, maintain a *MH cart* containing the supplies and drugs that are immediately needed to treat an acute MH episode.

1. The following are the supplies, equipment and drugs that should be stocked in a MH cart.
    A. Supplies and equipment:
        - IV solutions;
        - Bucket for ice;
        - Urine meter x 1;
        - Foley catheter tray;
        - 60 mL syringes x 5;
        - Urinalysis test strips;
        - NG tubes, various sizes;
        - CVP kits of various sizes;
        - 22G IV catheter, 1 inch x 4;
        - 24G IV catheter, ¾ inch x 4;
        - Small and large plastic bags for ice;
        - Blood administration sets and pumps;
        - Irrigation tray with 60 mL irrigation syringe;
        - 16G, 18G, 20G IV catheters, 2-inch x 4 each;
        - Transducer kits for arterial and CVP cannulation;
        - 3 mL syringes or ABG kit x 6 for blood gas analysis;
        - 10-12 bags of saline kept in a refrigerator for IV cooling;
        - Urine collection container to determine myoglobin level;
        - 60 mL Toomey syringes x 2 with adaptor (used with NG irrigation);
        - Gastric lavage set with three-way indwelling catheter for insertion into the rectum;
        - Pulmonary artery, esophageal, nasopharyngeal, tympanic membrane, bladder, rectal temperature probes;

- Steri-drape or some type of adhesive drape to cover and protect surgical wound while treatment of MH is carried out;
- Several blood specimen tubes: 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.

B. Drugs:
- Three 1000-U vials of heparin;
- Two 10 mL vial calcium chloride;
- One 100-U vial of regular insulin;
- Ten 50 mL vials of 20% Mannitol;
- Thirty-six 20 mg vials of Dantrolene;
- Thirty-six 100 mL vials of sterile water;
- Two 50 mL vials of 50% dextrose in water;
- Five 50 mL vials sodium bicarbonate 8.4%;
- Four 2 mL pre-filled syringes of furosemide;
- Three pre-loaded syringes:
  - Lidocaine 2% for injection;
  - 100mg/5mL or 100 mg/10mL Amiodarone can also be used;
  - Lidocaine or procainamide should **not** be used if a wide-QRS complex arrhythmia is caused by *hyperkalemia*; it can cause asystole.

Guideline II

The CST in both the first scrub and assistant circulator roles should know the treatment protocols for treating MH as recommended by MHAUS to be an effective member of the surgical team.

1. A written treatment plan should be posted in a noticeable place of the surgery department.[14] A plan is available from MHAUS.
   A. Surgery personnel should know the location of the plan as well as be familiar with the plan's instructions.
   B. A surgery department committee should be responsible for reviewing and updating the plan on a regular basis. The committee should consist of anesthesia providers, CSTs, pharmacists, risk management, RNs, and surgeons.
2. CSTs should know the physical signs of MH and be alert to the presentation of these signs as indicators of the patient's condition.
   A. The key physical signs that are evident in the patient experiencing an MH crisis include an increase in end-tidal CO_2, tachycardia, tachypnea, trismus, and pyrexia. End-tidal CO_2 is most often the earliest sign of an acute MH episode.[4]
      1) The CST should be able to assist in identifying the increased level of exhaled CO_2 by viewing the rapid change in color of the CO_2 absorbent canister as well as the ventilator absorbent canister becoming warm to the touch.[15]
      2) Not all of these signs may be present in all patients.[4] If an acute MH reaction is determined to be likely, treatment should be immediately administered.

Table 2: Clinical Signs of MH

Early Signs	Late Signs
Hypercapnia	Renal failure
Hypoxia	Cardiac arrhythmias & dysrhythmias
Masseter rigidity & spasm	Circulatory failure
Metabolic & respiratory acidosis	Hyperthermia
Muscular rigidity	Hypotension
Tachycardia	Rhabdomyolysis

3. The primary duty of the CST in the first scrub role is focused on assisting the surgeon with the procedure, if it is not discontinued, as well as providing methods to help control the patient's body temperature.
    A. If the surgical procedure cannot be discontinued, the CST continues to assist the surgeon in completing the procedure as efficiently and quickly as possible while also continuing to preserve the sterility of the back table and Mayo stand. Due to the myriad number of activities being completed by non-sterile individuals in the care of the MH patient, the CST will need to closely monitor the sterile field to prevent it from being compromised which is a primary duty of the CST for all surgical procedures.[16-18]
    B. The CST should not transfer care ("break scrub") of the patient to another CST and remain during the entire procedure. Attempting to transfer care will disrupt the continuity of care being provided to the patient at the sterile field as well as the duties that need to be completed when transferring care, such as counts, will be difficult to accomplish.
    C. The CST may assist the surgeon in providing and administering irrigation that has been cooled.
    D. After sterile dressings have been placed and drapes removed, the CST should not break down the back table and Mayo stand until the patient has been transported out of the OR.[19]
4. CSTs in the assistant circulator role should have knowledge of and be prepared to assist the non-sterile surgical team treating the patient.
    A. An acute, rapidly progressing MH reaction must be quickly diagnosed followed by the rapid administration of dantrolene; discontinuation of triggering anesthetic agents and maintenance of general anesthesia with IV non-triggering anesthetics if surgery must be continued; tubing and canisters changed on the anesthesia machine; surgeon notified immediately; assistance from other OR personnel immediately obtained; MHAUS hotline called and kept on speaker phone throughout the MH episode to provide suggestions.[4,12]
        1) Due to the numerous patient care activities that will be simultaneously taking place, the surgery team should immediately call upon assistance from other surgical personnel who are not busy with another surgical procedure.[11] 2 – 3 individuals should be immediately assigned the task of mixing dantrolene to provide to the anesthesia provider.[11]

B. If the patient has not been catheterized, an indwelling Foley catheter should be inserted to monitor urine outflow and color for *myoglobinuria*.[11] A brownish- or tea-colored urine indicates the presence of myoglobinuria.[15]
C. CSTs should know the location of the MH cart to immediately transport to the OR.
    1) CSTs should know the drugs and supplies that are stocked in the cart to quickly retrieve and assist in treating the patient. This includes retrieving ice packs, cold IV fluids and irrigating fluid, and assisting with mixing dantrolene with sterile water and providing other drugs requested by the anesthesia provider.
    2) CSTs should assist in applying patient cooling methods, e.g., cooling blanket; ice packs to the axilla, groin and head, and lowering the temperature of the OR.[5] A refrigerator unit should be located in the surgery department and stocked with iced saline.[14] Additionally, quick access to an ice machine is important.[14]
    3) Table 3 is the protocol for treating MH taken directly from MHAUS that CSTs should be very familiar.[12] These activities take place simultaneously and therefore, are not presented in a specific order, except for the first three treatments that should be immediately undertaken. Prompt treatment involves quickly administering dantrolene, cooling the patient's core temperature to 38° C, hyperventilating the patient, and resolving hyperkalemia.[12]

Table 3: Treatment Protocol for MH Crisis

Treatment	Dosage or Action
1. Immediately discontinue volatile anesthesia agents, including succinylcholine. Anesthesia should be continued by using IV opioids, sedatives, and if necessary, nondepolarizing muscle relaxants.[3]	Surgery may be continued, but with the use of different anesthetic agents.[6]
2. Hyperventilate with 100% O_2	100% oxygen at a high flow rate to lower the *$ETCO_2$* and flush volatile anesthetics.[12]
3. Dantrolene	2.5mg/kg IV immediately administered through a large bore IV or central venous line; repeated as frequently as needed until the patients responds with a decrease in $ETCO_2$, decreased muscle rigidity, and/or decreased heart rate.[4,12]
4. Anesthesia provider will remove vaporizers; change soda lime canister; replace fresh gas tubing; insert charcoal filters in circuit.	It is not necessary for the anesthesia machine to be changed out.[6]
5. Sodium bicarbonate	1-2 mEq/kg IV to combat metabolic acidosis due to increase of lactate in the circulatory system and treat hyperkalemia.[12]

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 or below.[11]
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.[6]
9. Procainamide (Anesthesia provider will avoid administering calcium channel blockers that can cause potassium levels to increase and/or cause myocardial infarction in the presence of dantrolene).[11]	200 mg IV to treat arrhythmias secondary to electrolyte imbalances.
10. Calcium chloride or calcium gluconate; insulin; sodium bicarbonate	Treat hyperkalemia due to the release of potassium into the circulatory system as muscle cells are destroyed. Calcium chloride 10mg/kg up to 2,000 mg maximum dose or calcium gluconate 30 mg/kg up 3,000 mg maximum dose.[12] 10 units regular insulin IV and 50 mL 50% glucose.[12]
11. Monitor urine output per hour and color.	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	Venous or arterial obtained every five to 10 minutes to determine the degree of metabolic acidosis.[12]
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.

4) Dantrolene is the only drug that is effective in the treatment of MH. It directly interferes with muscle contraction by inhibiting the release of calcium ion from the sarcoplasmic reticulum by binding to the ryanodine receptor type 1 (RYR-1).[4]

Dantrolene is freeze-dried and available in two different doses. Dantrium® is packaged in 20 mg vials and must be reconstituted with 60 mL of sterile water. The sterile water is injected into the vial, and the vial requires vigorous shaking to mix and the solution is clear and no particles are present.[11,12] Ryanodex® represents an improvement in that the mixture can be mixed must faster; each 250 mg vial is reconstituted with 5 mL of sterile water and shaken until the mixture appears orange-colored that quickly occurs in about 15 seconds.[12] Using pre-warmed sterile water improves the solubility of dantrolene.[11]

The initial dose is 2.5 mg/kg repeated until reversal reaction occurs.[4,12] Larger doses, >10mg/kg, rarely occur, but may be required for patients whose contractures or rigidity do not resolve, and in muscular individuals.[5,12] 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.[5] If there is no clinical response, primarily no decrease in the end-tidal CO_2, another diagnosis should be considered.

Dantrolene should be administered every six to eight hours for 24-72 hours after the initial episode to prevent recurrence; the dosage is 1mg/kg.[4] 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.[4]

D. The anesthesia provider may request assistance with removal of vaporizers, changing the soda lime canister, and if possible, replacing the fresh gas tubing.[4] The anesthesia provider may request assistance with obtaining charcoal filters that he/she can place in the anesthesia machine circuit; the filters remove the inhalation agent in 1 – 2 minutes to assist in reversing effects of the MH reaction.[4]

E. If the patient was not intubated for the procedure, the anesthesia provider may request assistance, e.g., handing him/her the laryngoscope, providing the requested size of endotracheal tube with syringe attached, performing cricoid pressure.

F. Anesthesia provider may request assistance with monitoring the patient's core temperature.
   1) Skin temperature does not accurately provide the core temperature.[14]
   2) Acceptable sites for obtaining the core temperature include axilla, bladder, distal esophagus, nasopharynx, pulmonary artery, and rectum.[14]

G. The key indicators of patient stability that the surgery team should monitor so as to reduce or discontinue the drugs related to the indicator include $ETCO_2$ is normal; heart rate is normal with no signs of arrhythmias; hyperthermia is resolved; muscular rigidity is resolved.[12]

Guideline III

Per MHAUS recommendation, health care personnel (HCP) should exhibit caution when the possibility of inhaling noxious vapors in a poorly ventilated area exists.[2]

1. It is recommended that HCP who are exposed to or working with agents that emit noxious vapors do so in a well-ventilated area, especially HCP who are MHS positive. For example, laboratory personnel should work with agents that emit noxious vapors under an exhaust hood.[2] However, there is no strong evidence supporting that MHS positive individuals should limit their choices of a profession, but should exercise caution in avoiding inhalation if working with agents that emit a noxious vapor.[2]
    A. There is a single report of a suspected episode of MH in a nurse who was cleaning up an isoflurane spill; however, an IVCT or CHCT was never performed as follow-up and it is likely the level of exposure exceeded what is normally encountered in a health care facility OR.[21]
        1) The National Institute for Occupational Safety and Health (NIOSH) standard for establishing an acceptable level of halothane in the OR is 2 parts per million (ppm) or 0.0002%.[22] A 1996 study reported that MH susceptible swine did not experience a MH episode after exposure to 5 ppm halothane.[23] It is, therefore, highly unlikely that a low level of exposure to volatile anesthetic agents will trigger a MH episode while also taking into consideration the standards that must be met for the exchange of air in the OR.[2]
    B. There are reports of MH-mimicking episodes in MHS positive individuals from environmental exposures outside of the OR due to the inhalation of halogenated gases from fire extinguishers and gasoline vapors.[24,25]

Guideline IV

The surgery department should review the policies and procedures (P&P) regarding treatment of MH in surgical patients on an annual basis.

1. The surgery department should include members of the surgical team and administration when reviewing the P&Ps, including CSTs, infection control officer, risk management, RNs, and surgeons.
    A. The surgery department should document when the P&Ps were reviewed, revision completed (if necessary), and who participated in the review process.
2. CSTs should be familiar with the P&Ps for treating the surgical patient experiencing a MH episode. The orientation of new employees should include reviewing the P&Ps.

Guideline V

The surgery department should conduct a post-MH incident review with all those involved in treating the patient.

1. The review should include time from identification of acute MH episode to beginning of treatment, particularly administration of dantrolene; how well the team worked together; and identify what could have been done better to improve the level of treatment if an episode were to occur again.

Guideline VI

CSTs should complete continuing education to remain current in their knowledge of MH crisis and the treatment of surgical patients.[26]

1. Surgery department personnel including PACU personnel should be trained in the recognition and treatment of MH.
    A. Practice drills and simulation training of treating a MH episode should be conducted on a regular basis.[5,11,14]
    B. The importance of teamwork and communication cannot be overemphasized as related to the successful management of an acute MH crisis.[11]
2. The continuing education should be based upon the concepts of adult learning, referred to as andragogy. Adults learn best when the information is relevant to their work experience; the information is practical, rather than academic; and the learner is actively involved in the learning process.[27]
3. It is recommended surgery departments use various methods of instruction to facilitate the learning process of CSTs.[27]
    A. If the education is primarily lecture, methods to engage learners include presentation of case studies for discussion, and audience discussion providing suggestions for reinforcing MH treatment protocols.
    B. Other proven educational methods include interactive training videos, and computerized training modules and teleconferences.
    C. The continuing education should be delivered over short periods of times such as in modules, and not in a one-time lengthy education session.
4. The surgery department should provide a pocket-sized guide about dantrolene including indications, dosage and administration, and adverse reactions to surgery personnel.[5]
5. Posters that describe the signs and symptoms of MH including treatment and MHAUS hotline number should be posted in key locations in the surgery department.[5]
6. Continuing education programs should be periodically evaluated for effectiveness including receiving feedback from surgery department personnel.
7. The surgery department should maintain education records for a minimum of three years that include dates of education; names and job titles of employees that completed the continuing education; synopsis of each continuing education session provided; names, credentials, and experience of instructors.

Competency Statements

Competency Statements	Measurable Criteria
1. CSTs can identify and recognize the signs and symptoms of an MH crisis. 2. CSTs in the first scrub role are knowledgeable of the various patient-cooling modalities utilized during an MH crisis. 3. CSTs in the assistant circulator role are qualified to locate and identify appropriate emergency equipment and supplies required for the management of an acute MH crisis, and under the direct supervision of the anesthesia provider assist with equipment and supplies, and providing the requested drugs. 4. CSTs are qualified to participate on the committee that develops and reviews the health care facility MH treatment plan. 5. CSTs are qualified to participate in the post-MH incident review.	1. Educational standards as established by the *Core Curriculum for Surgical Technology*.[28] 2. The didactic subject of MH is included in a CAAHEP accredited surgical technology program. 3. Students demonstrate knowledge of the MH cart, such as location in the surgery department and supply list during clinical rotation. 4. CSTs perform patient care duties by assisting the surgeon(s) and anesthesia provider during an MH crisis in the OR as practitioners. 6. CSTs complete continuing education to remain current in their knowledge of MH, including the policies of the HDO by completing annual in-service requirements.[26]

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Glossary

Dantrolene: postsynaptic muscle relaxant that lessens excitation-contraction coupling in muscle cells. It achieves this by inhibiting Ca ions release from sarcoplasmic reticulum stores. It is the primary drug used for the treatment and prevention of malignant hyperthermia.

Duchenne's muscular dystrophy: pseudohydroptrophic muscular dystrophy marked by weakness and pseudohypertophy of the affected muscles. It is caused by mutation of the gene responsible for producing the protein dystrophin.

End tidal CO2: waveform capnography represents the amount of carbon dioxide (Co2) in exhaled air, which assesses ventilation. It consists of a number and a graph. The number is capnometry, which is the partial pressure of C02 detected at the end of exhalation. End tidal Co2 is normally 35-45 mm Hg.

Fulminant hypermetabolic crisis: inheritable (autosomal dominant with genomic imprinting) state of skeletal muscles triggered when a genetically susceptible person is exposed, in a stressful situation, to a triggering agent.

Hyperkalemia: excessive amount of potassium in the blood.

King-Denborough syndrome: congenital myopathy associated with susceptibility to malignant hyperthermia, skeletal abnormalities and dysmorphic features with characteristic facial appearance.

Malignant hyperthermia: rare life-threatening condition that is usually triggered by the exposure to specific drugs used for general anesthesia, the most common being succinylcholine, a neuromuscular blocking agent.

Myotonia: tonic spasms of muscles or temporary rigidity after muscular contraction.

Osteogenesis imperfecta: inherited disorder of the connective tissue marked by defective bone matrix, short stature, abnormal bony fragility. Additional clinical findings are multiple fractures with minimal trauma, blue sclera, early deafness, opalescent teeth, a tendency to capillary bleeding, translucent skin and joint instability.

Pyrexia: condition of fever.

Succinylcholine: crystalline compound that is a skeletal muscle relaxant producing short-term paralysis to aid with endotracheal intubation.

Trismus: Tonic contraction of the muscles of mastication; informally referred to as "lockjaw".

Volatile anesthetics: liquid anesthetic that at room temperature changes to a vapor that can be inhaled to produce general anesthesia.

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