APPENDIX H: MALIGNANT HYPERTHERMIA RESPONSE

TITLE: MALIGNANT HYPERTHERMIA RESPONSE

PURPOSE

The purpose of this policy is to ensure a well-coordinated response to malignant hyperthermia (MH) treatment by:

- Defining MH and providing guidelines for the diagnosis of MH
- Outlining responsibilities of the clinical team during the treatment of MH
- Providing guidelines on how to stock and check the MH emergency cart

DEFINITIONS

Malignant Hyperthermia:

- The MH crisis is a biochemical chain reaction response, "triggered" by commonly used general anesthetics and the paralyzing agent succinylcholine (a neuromuscular blocker), within the skeletal muscles of susceptible individuals.
- Some patients who are MH susceptible may experience a MH crisis without exposure to anesthetic drugs. Such events are rare. Strenuous exercise, exposure to heat, or perhaps high body temperature from infection may precipitate the crisis.
- The general signs of the MH crisis include increased heart rate, greatly increased body metabolism, muscle rigidity and/or fever that may exceed 110°F along with muscle breakdown, derangements of body chemicals and increased acid content in the blood.
- Severe complications include: cardiac arrest, brain damage, internal bleeding or failure of other body systems. Thus, death, primarily due to a secondary cardiovascular collapse, can result.
- **MH is a medical emergency.** Minimizing time to appropriate treatment is essential!

Diagnosis of Malignant Hyperthermia:

- The most consistent indicator of potential MH in the OR is an **unanticipated increase (e.g., doubling or tripling) of end-tidal CO_2** when minute ventilation is kept constant. The increase in CO_2 may occur over a brief period of time or may develop over longer periods of time (minutes to hours). If upward adjustments of minute ventilation (tidal volume and frequency) are required to maintain normal end-tidal CO_2, the possibility of MH should be considered and promptly evaluated.
- If sudden, **unexpected cardiac arrest** occurs, especially in a young male, hyperkalemia should be considered immediately and therapy started with calcium, hyperventilation, glucose, and insulin. Plasma potassium concentration should be measured as soon as possible. Sudden unexpected cardiac arrest is not typically due to MH, but due to sudden rapid rhabdomyolysis.
- **Unexpected tachycardia, tachypnea and jaw muscle rigidity** (masseter spasm) are often common signs of MH that follow the significant CO_2 increase.
- **Respiratory and metabolic acidosis** usually indicates fulminant MH. However, metabolic acidosis is not always present prior to severe temperature increase.

- A specific sign of the MH syndrome is **body rigidity** (i.e., limbs, abdomen and chest). When there is a suspicion of MH, attempts should be made to determine if muscle rigidity is also present.
- **Temperature elevation** usually follows the appearance of other signs of MH. Temperature change during MH is best detected by core temperature measurement (tympanic, naso- or oropharyngeal, esophageal, rectal, or pulmonary artery). Forehead skin temperature is less acceptable; it is slower in reflecting changes in core temperature and could be influenced by peripheral vasoconstriction. **MHAUS recommends that core temperature be measured whenever general anesthesia is administered for procedures lasting more than 30 minutes.**
- **Postoperative rhabdomyolysis** without intraoperative signs of MH should be treated with hydration, mannitol and bicarbonate. Plasma potassium concentration should be measured immediately or as soon as possible. The patient should be referred to a neurologist and to an MH testing center to evaluate occult myopathy and determine the need for evaluation of MH susceptibility.

Drugs and Malignant Hyperthermia:

- **All volatile inhalation anesthetics (Halothane, Enflurane, Isoflurane, Desflurane, Sevoflurane) and Succinylcholine are MH triggers.** Nitrous oxide is not a trigger.
- **DO NOT ADMINISTER** calcium channel blockers when Dantrolene has been given since it may increase the risk for hyperkalemia and subsequent cardiac arrest.
- All other currently used anesthetics and life-support drugs are considered safe.

PROTOCOL: MALIGNANT HYPERTHEMIA RESPONSE

I. Criteria for suspecting MH and Hospital Locations where MH may occur:

A. Suspect MH if one or more of the following criteria are present:

1. Unanticipated increase (e.g., doubling or tripling) of end-tidal CO_2 when minute ventilation is kept constant
2. Unexpected cardiac arrest
3. Unexpected tachycardia, tachypnea, jaw muscle rigidity (masseter spasm)
4. Respiratory and metabolic acidosis
5. Body rigidity (i.e., limbs, abdomen and chest)
6. Temperature elevation
7. Postoperative rhabdomyolysis

B. MH may occur in the following hospital locations:

1. Operating Room (including OB OR) – Primary site: MH may occur at any time during or emerging from anesthesia, including in the immediate post-operative period
2. Post Anesthesia Care Unit (PACU)
3. Emergency Department (ED)

4. MH can occur anywhere in the hospital where patients require emergency intubation with succinylcholine or in other departments that use inhaled anesthetics for procedures (i.e., IR, GI, ICU)
5. **If the patient experiences MH outside of the OR area, immediately transport the patient to the OR for appropriate care. The Anesthesia D1 to assign the specific OR treatment room. For patients already in the ICU, the ICU Attending and Anesthesia D1 will decide whether to treat the patient in the OR or ICU.**

II. Staff/Service Roles during an MH Crisis

A. ANESTHESIA

1. Recognize and diagnose MH
2. Immediately discontinue volatile anesthetics or succinylcholine upon diagnosis
3. Start TIVA (Total Intravenous Anesthesia), if anesthesia is required
4. Hyperventilate patient at 2-3 times predicted minute ventilation with 100% oxygen.
5. FiO_2 1.0 at 10 L/min. Keep the circuit system, absorber and ventilation machine.
6. Activate the MH response system by obtaining the MH Cart, clearly designating roles and responsibilities and ensuring closed loop communication
    a. Designate an anesthesia technician to obtain the MH Cart from the Anesthesia Workroom or 6G (VOIP phone 31022)
    b. Page the Anesthesia D1 during the day or Anesthesia Night Attending at night to assign an anesthesiologist to be the team leader of the MH response (VOIP phone 30001)
    c. Inform surgeons of an MH emergency and coordinate the most expeditious surgical plan to finish the surgical procedure
7. Administer Dantrolene Sodium 2.5 mg/kg by rapid IV bolus
    a. Designate an anesthesia attending, resident, CRNA, nurse, and/or pharmacist to reconstitute the Dantrolene
    b. Reconstitute each 250 mg vial of Dantrolene with 5 mL Sterile Water for Injection. Shake the vial to ensure the suspension is a uniform orange color. The resulting solution contains 250 mg of Dantrolene and 125 mg of Mannitol
    c. Designate one provider to administer Dantrolene via rapid IV Push.
    d. DO NOT use 5% Dextrose Injection, 0.9% Sodium Chloride Injection or other acidic solutions since it is not compatible with Dantrolene
    e. The contents of the vial must be used within 6 hours after reconstitution. Store reconstituted solutions at controlled room temperature (68°F to 77°F or 20°C to 25°C)
    f. DO NOT transfer Dantrolene to another container to infuse the product. Administer the reconstituted Ryanodex suspension either:
        i. Into the intravenous catheter while an IV infusion of 0.9% Sodium Chloride Injection or 5% Dextrose Injection is freely running, or

ii. Into the indwelling catheter – after assuring its patency – without a freely running infusion. Flush the line to assure that there is no residual Dantrolene remaining in the catheter.

8. Repeat Dantrolene administration as often as necessary
    a. Titrate to control clinical signs of MH to a total dose of 10 mg/kg. Note that in some patients, up to 30 mg/kg may be required
    b. Dantrolene sodium does not produce significant cardiac or pulmonary complications when administered acutely. **Therefore, there is little harm in administering Dantrolene where MH is suspected, but not yet proven**
9. Team Leader of MH Response will designate the following roles and use the MH Checklist as a guideline for management:
    a. An anesthesia provider to manage the patient's ventilation and anesthesia
    b. A circulating RN as lead nurse to call for help, activate the MH response system and delegate responsibilities to other nurses and techs
    c. An anesthesia provider or CRNA to record the events during the MH crisis on the MH Flowsheet
    d. An anesthesia care provider to insert an arterial line and additional large bore IV access, if not already present
    e. An anesthesia provider or RN to administer medications
    f. An anesthesia technician to obtain the following (VOIP phone 31022)
        i. Refrigerated items from the Anesthesia Workroom Fridge or 6G Med Room Fridge (i.e., 1L IV Plasmalyte x 3 bags, 3L NS for Irrigation x 1 bag, Regular Insulin 10mL vial with NS 100 mL IV Bag x 1 kit)
        ii. Crash Cart
        iii. Other supplies (i.e., syringe pump, spiked IV, triple lumen CVC, A-line sets)
10. Call the MH hotline **1-800-MH-HYPER (1-800-644-9737)** as needed for consultation to help with patient management
11. Perform and monitor the following laboratory tests and studies
    a. Arterial Blood Gas
    b. Basic Metabolic Panel, LDH, Thyroid Studies (TSH, Free T4, Free T3)
        i. Avoid parenteral potassium, if possible, during ongoing rhabdomyolysis
        ii. Following control of the acute episode, persistent hypokalemia may be treated with careful monitoring of the serum potassium level.
    c. Creatine Kinase (CK): Measure CKs every 6 hours until decreased
        i. CK may remain elevated for 2 weeks if event was severe
        ii. After the patient has improved and stabilized, CK should be measured on a declining time basis until it is normal (e.g., every 4 hours during the acute episode to every week during convalescence)
        iii. Monitoring is important because CK is elevated normally in some

myopathies, and should be recognized as a part of overall evaluation and treatment

d. Coagulation profile (PT/INR, PTT, Fibrinogen, D-Dimer, Lactate) – Disseminated intravascular coagulation (DIC) may occur
e. CBC, Platelets, Serum Myoglobin
f. Urine Hemoglobin and Myoglobin, Urinalysis
g. EKG

12. Monitor core temperature and treat for hyperthermia
    a. If hyperthermic or core temperature rises rapidly, cool the subject using one or more of the following modalities:
        i. Cold IV Plasmalyte-148
        ii. Cold Sodium Chloride 0.9% for Irrigation via lavage of NG, bladder, rectum and/or open cavities
        iii. Ice packs for external surface cooling
        iv. Consider calling the SICU (x69954) for intracool catheters and/or cooling blankets
    b. Cease cooling efforts when temperature has fallen to 38°C
13. Monitor and treat other conditions that can occur (e.g., acidosis, hyperkalemia, dysrhythmias, and myoglobinuria)
    a. Monitor arterial blood gases and treat acidosis if not promptly reversed by Dantrolene administration
        i. Sodium Bicarbonate (8.4%) IV at initial dose of 1-2mEq/kg
        ii. Or may titrate based on base deficit: Give 0.3 x weight (kg) x base deficit
        iii. Ensure adequate minute ventilation to avoid paradoxical intracellular acidosis and continue to monitor ABGs
    b. Monitor serum K^+ and EKG and treat for hyperkalemia (peaked T-waves, widened QRS, QT and PR prolongation, wide complex ventricular tachycardia)
        i. Treat cardiac arrhythmias associated with hyperkalemia
            (i) Calcium Chloride (10%) IV 10 mg/kg
            (ii) Monitor serum K^+ and ionized Ca^{++}
            (iii) Avoid calcium channel blockers
        ii. Treat hyperkalemia
            (i) Sodium Bicarbonate (above)
            (ii) Regular Insulin IV bolus 0.15 units/kg (or 10 units).
                (a) Insulin is considered a **"High Alert"** medication. As such, two providers must double check the dose prior to administration
                (b) Dilute 1 mL=100 units Regular Insulin into a 100 mL NS Bag (final concentration 1 unit/mL). Draw up 10 mL=10 units dose.

(iii) Follow Regular Insulin with Dextrose 50% IV bolus 1 mL/kg. Monitor serum glucose.

c. Monitor and treat for dysrhythmias

ii. Usually responds to treatment of acidosis and hyperkalemia by hyperventilation, Dantrolene, Sodium Bicarbonate, and Calcium Chloride (see above)

iii. Treat dysrhythmias using ACLS algorithms and crash cart

14. Place or confirm foley catheter. Monitor urine output
    a. Ensure urine output of at least 2 mL/kg/hr by hydration and diuretics to minimize myoglobinuria
    b. Hydrate aggressively (may require CVP monitoring). Avoid potassium containing solutions that contain **more than** 5 mEq/L of potassium
    c. Diuresis with Furosemide 0.5-1 mg/kg IVP
15. Once patient stabilized, transport to the ICU and provide detailed handoff to ICU team
    a. Continue intravenous Dantrolene for at least 24 hours after control of the episode (approximately 1 mg/kg IV Push every 6 hours)
    b. Watch for recrudescence and monitor core temperature by appropriate monitoring in an ICU for at least 24 hours
        i. May reoccur in about 25% of MH cases.
        ii. Greatest risk in muscular patients or who have received an anesthetic for at least 150 minutes prior to MH symptoms.
16. Report the event to MHAUS
    a. Submit a confidential Adverse Metabolic or Muscular Reaction to Anesthesia (AMRA) report for patients who have had acute MH episodes to the **North American MH Registry of MHAUS** (see www.mhreg.org)
    b. Have the patient call **1-888-274-7899** to add their name to the North American MH Registry Database
17. Refer patients and families to MHAUS for information on the disease

B. NURSING

1. Designate circulating RN of the case as lead nurse to delegate responsibilities to other nursing staff
2. Active the MH response system by calling the OR Front Desk (x68134) to have them:
    a. Overhead page the OR to request for adequate help in the MH crisis
    b. (Dial x68134)
    c. Call PACU (x68127) or 6G (x68168) to bring 4 large plastic bags of ice to the MH crisis
    d. Page the AOD (x63519) to arrange for ICU disposition
    e. Call the OR Pharmacy (x60242) or Inpt Pharmacy (x60275) to request other medications as needed
3. Reconstitute and administer Dantrolene

4. Prepare and administer other emergency medications as directed by the MH Lead
5. Obtain blood or urine for laboratory tests ordered
6. Assist in cooling the patient as directed by the MH Lead

C. SURGERY

1. Assess and coordinate the most expeditious surgical plan to finish the surgical procedure (e.g., close the wound, complete the procedure, modify the procedure)
2. Assist in cooling the patient using the specified methods
3. Assist with any other activities as directed by the MH Lead

D. ANESTHESIA TECHNICIANS

1. Bring the MH Treatment Cart to the OR suite
2. Bring the Crash Cart to the OR suite
3. Bring refrigerated items from the Anesthesia Workroom Refrigerator or 6G Med Room Refrigerator to the OR suite
    a. 3 bags of cold 1L IV Plasmalyte
    b. 1 bag of cold 3L NS for Irrigation
    c. Regular Insulin 100units/mL 10 mL vial with NS 100 mL IV Bag
4. Bring a syringe pump, spiked IV, triple lumen CVC, and A-line sets to the OR suite
5. Set up, obtain and/or arrange other supplies and equipment as necessary
6. Restock the supplies in the MH cart upon conclusion of MH treatment in the OR

E. PHARMACY

1. Reconstitute Dantrolene
2. Prepare other emergency medications as directed by the MH Lead
3. Restock the medications in the MH cart upon conclusion of MH treatment in the OR

F. FRONT DESK PERSONNEL

1. Activate the MH response system and call for additional help (See Nursing Section)
2. Arrange for specimens to be sent to the laboratory
3. Obtain additional supplies as requested

G. PACU (or 6G)

1. Bring 4 large plastic bags filled with ice to the OR suite
2. Offer other assistance to the OR team

H. ADMINISTRATOR ON DUTY (AOD)

1. Arrange for ICU disposition post treatment
2. Offer other assistance to the OR team

III. Documentation

A. Document MH Response Events on the MH Response Flow Sheet (see Appendix H1)

B. Documentation of the response to the event will be placed in the patient's medical chart

C. Report event to MHAUS via a confidential Adverse Metabolic or Muscular Reaction to Anesthesia (AMRA) Report to the North American MH Registry of MHAUS

IV. Maintenance of the Malignant Hyperthermia Cart

A. A Malignant Hyperthermia Emergency Cart (MH Cart) will be maintained in Building 25 Anesthesia Workroom and Building 5 6G.

B. The Refrigerated Medications for the MH Cart will be maintained in Building 25 Anesthesia Workroom Refrigerator and Building 5 6G Refrigerator.

C. The MH Cart will be stocked with the drugs listed in Appendix H2 and the supplies listed in Appendix H3 as described in the body of this policy

D. The MH Cart will be secured with a tamper-evident seal

E. The MH Cart will have attached to it a list of the drugs contained within and the name and date of the drug that will expire first.

F. The MH Cart will have the Malignant Hyperthermia Policy attached

G. On establishment of the MH Cart, a Pharmacist will verify the presence of all drugs and supplies listed in Appendix H2. The Anesthesia Technician will ensure the presence of all supplies listed in Appendix H3. The Pharmacist will then seal the box with a tamper-evident seal and fill in the required information on the "Operating Room Malignant Hyperthermia Cart" form on the cart.

H. The cart will be checked by the Pharmacist and Anesthesia Technician every 30 days, and after every deployment for integrity and outdating of contents. A record of such inspections will be recorded by the Pharmacist and kept for at least three years in the pharmacy.

V. Resources

A. wwww.mhaus.org

B. Hirshey Dirksen SJ, Van Wicklin SA, Mashman DL, Neiderer P, Merritt, DR. Developing Effective Drills in Preparation for a Malignant Hyperthermia Crisis. AORN Journal 2013; 97(3): 329-353.

C. Ryanodex [Package Insert]. Eagle Pharmaceuticals, Inc. Woodcliff Lake, NJ; 2016. http://www.ryanodex.com/wp-content/uploads/2014/07/ryanodex-prescribing-information.pdf. Accessed Nov 20, 2017.

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Appendix H1: MH Response Flow Sheet

Date:	Patient Name / MRN:	Location/Room Number:	Anesthesia Provider(s):	Recorder (Anesthesia/CRNA):
Time:	**Medications Used During Case (circle all that apply):** Succinylcholine / Desflurane / Isoflurane / Sevoflurane	Patient's Weight (kg)	Surgery Provider(s):	RN(s):

Intervention	Time
1. ☐ **Discontinue Triggers** (succinylcholine, inhaled anesthetics) **2.** ☐ **Start TIVA** (Total Intravenous Anesthesia), if anesthesia required **3.** ☐ **Hyperventilate 2-3 Times Predicted Minute Ventilation** **4.** ☐ **FiO2 1.0 at 10 L/min.** Keep circuit, absorber and machine.	
5. Obtain MH Cart / Call for Help / Inform OR Team ☐ Designate **Anesthesia Technician to obtain MH Cart** *Anes Wkrm* or *6G* *(VOIP phone 31022)* ☐ **Page the Anesthesia D1** or Anesthesia Night Attending *(VOIP phone 30001)* ☐ D1 to designate an Anesthesiologist as **Team Leader** ☐ **Inform Surgeons** of MH emergency and to coordinate the most expeditious surgical plan to finish the surgical procedure	
6. ☐ **Administer Dantrolene 2.5 mg/kg per dose IV Push** *MH Cart* **Repeat Dose until Symptoms Subside** (up to 10-30 mg/kg) ☐ Dilute only 5 mL Sterile Water for Injection in each 250 mg Dantrolene vial (i.e., 75 kg patient = 1 vial Dantrolene per dose) ☐ Assign one team member to reconstitute Dantrolene ☐ Designate one provider to administer Dantrolene via IV Push	**Med/Dose/Time:**
7. Team Leader to Designate Roles and Responsibilities ☐ Designate an **Anesthesia Provider to manage vent and anesthesia** ☐ Designate **Circulating RN as Lead Nurse**. Lead RN to delegate RN duties and to **call OR Front Desk** *(x68134)* to notify the following: ☐ **Overhead Page OR** to request help in MH crisis *(x68134)* ☐ **Call PACU** *(x68127)* to bring 4 large plastic bags of ice ☐ **Page the AOD** *(x63519)* to arrange for ICU disposition ☐ **Call OR Pharmacy** *(x60242)* to request meds as needed ☐ Designate an **Anesthesia Provider or CRNA to record the events** during the MH crisis on the MH Flowsheet *MH Cart* ☐ Designate a **Provider to insert lines** (arterial line, additional large bore IV access), if not already present ☐ Designate a separate **Provider to administer medications** ☐ Designate an **Anesthesia Technician to obtain**: **From the Anesthesia Workroom** *(phone 31022)* ☐ Syringe Pump, Spiked IV, Triple Lumen CVC, A-line Sets **From the Main OR Anesthesia Workroom Refrigerator or 6G Med Room Refrigerator (6G10)** ☐ 1L IV Plasmalyte x 3 bags ☐ 3L NS for Irrigation x 1 bag ☐ Insulin 10 mL vial / NS 100 mL IV Bag x 1 kit **From the Nearest Available Location** ☐ Crash Cart	

Intervention	Time
8. ☐ **Call MH Hotline** *(1-800-644-9737)* for additional help, as needed	
9. Obtain and Monitor Labs and Studies *sample lab sheets in MH Cart* ☐ **ABG Kit:** ABG ☐ **Light Blue:** PT/INR, PTT, Fibrinogen, D-Dimer ☐ **Gold Gel:** Basic Metabolic Panel, CK, LDH, Serum Myoglobin, Thyroid Studies (TSH, Free T4, Free T3) ☐ **Lavender:** CBC, Platelets ☐ **Grey:** Lactate ☐ **Urine Dipstick / Collection Cup:** Hemoglobin / Myoglobin, UA ☐ **Monitoring Equipment:** EKG, Core Temperature	**Result/Time:**
10. Cool Patient to Goal Temp of 38°C using one or more methods: ☐ Cold Plasmalyte-148 IV *Anes Workroom Fridge* or *6G Med Room Fridge 6G10* ☐ Cold Sodium Chloride 0.9% for Irrigation via nasogastric, bladder, rectal and/or open cavity lavage *Anes Workroom Fridge* or *6G Med Room Fridge 6G10* ☐ Ice for external surface cooling *PACU* or *6G Kitchen 6G6* ☐ Consider calling SICU *(x69954)* for intracool catheter and/or cooling blanket	
11. Treat Acidosis (if not reversed by Dantrolene administration) ☐ Sodium Bicarbonate 8.4% IV 1-2 mEq/kg *Crash Cart* ☐ Ensure adequate minute ventilation	**Med/Dose/Time:**
12. Treat Hyperkalemia and Associated Dysrhythmias ☐ Calcium Chloride 10% IV 10 mg/kg *Crash Cart* **Avoid Calcium Channel Blockers** ☐ Sodium Bicarbonate (above) *Crash Cart* ☐ Regular Insulin IV 0.15 units/kg (or 10 units) *Anes Wkrm Fridge* or *6G Med Room Fridge 6G10* ***HIGH ALERT / TWO PROVIDERS MUST DOUBLE CHECK*** Instructions: Dilute Insulin 1 mL (= 100 units) in 100 mL NS Bag (Final Conc = 1 unit/mL), then give Insulin 10 mL = 10 units IV ☐ Dextrose 50% IV 1 mL/kg *Crash Cart* Monitor serum glucose. ☐ Treat dysrhythmias using ACLS algorithms *Crash Cart*	**Med/Dose/Time:**
13. ☐ **Place or Confirm Foley to Monitor Urine Output** ☐ Aggressive hydration. Ensure UO of at least 2 mL/kg/hr. ☐ Consider diuresis with Furosemide 0.5-1 mg/kg IVP *Anes Workroom Omnicell* or *6G Omnicell*	**Med/Dose/Time:**
14. ☐ **Transport to ICU** (and continue Dantrolene 1 mg/kg IV Push q6h)	

APPENDIX H2: List of MH Cart Drugs

A. Medications

1. Dantrolene (Ryanodex) 250 mg x 3 vials **(in MH Cart)**
   (dilute each 250 mg vial with 5 mL Sterile Water for Injection at the time of use).
2. Sterile Water for Injection USP (preservative free) 10 mL x 3 vials **(in MH Cart)**
3. Regular Insulin (100 units/mL) 10 mL x 1 vial **(in Refrigerator)**

B. Fluids

1. Sodium Chloride 0.9% 100 mL IV x 1 bag **(in Refrigerator)**
   (dilute Insulin to a 1 unit/mL concentration)
2. 1L cold Plasmalyte-148 IV x 3 bags **(in Refrigerator)**
3. 3L cold Sodium Chloride 0.9% for Irrigation x 1 bag **(in Refrigerator)**

APPENDIX H3: List of MH Cart Supplies and Equipment

A. General Equipment/Nursing Supplies

1. Toomy irrigation syringes (60 mL x 2) for NG irrigation
2. Rectal tubes (sizes appropriate for your patient population) and collection bag
3. Three-way irrigating foley catheters: (sizes appropriate for your patient population)
4. Irrigation tray with piston syringe (x 1) for NG irrigation
5. 5-in-1 Connector x 4
6. Cysto/Bladder Irrigation Set 81" (2.1m) Regulating Clamp
7. Large clear plastic bags for ice x 4
8. Small plastic bags for ice x 4
9. Bucket for ice

B. Medication Preparation

1. Vented spikes x 3 spikes (to reconstitute Dantrolene)
2. Syringes 10 mL luer lock x 3 syringes (to reconstitute Dantrolene)
3. Blunt Fill Needles 18G x 3 (to reconstitute Dantrolene)
4. Red syringe caps x 3 caps
5. Syringes to draw up insulin: 1 mL x 1 syringe, 10 mL x 1 syringe
6. Blunt Fill Needles 18G x 8 to draw up medications

C. Monitoring Equipment

1. All immediately available in anesthesia cart and pre-assembled in workroom

D. Laboratory Testing Supplies

1. Needled-type ABG kits x 6
2. Blood Specimen Tubes:
    a. Gold Gel: Basic Metabolic Panel, CK, LDH, Thyroid Studies (TSH, Free T4, Free T3), Serum Myoglobin
    b. Light Blue: PT/INR, PTT, Fibrinogen, D-Dimer
    c. Grey: Lactate
    d. Lavender: CBC, Platelets
3. Chem Strips/Dipstick for Urinalysis: Urine Hemoglobin
4. Urine Collection Container: UA, Urine Myoglobin

E. Documents

1. Physician Order Form x 2
2. Laboratory Request Forms: Blood/Serum Form x 2; Urinalysis Form x 2 (see prefilled example on MH Cart)
3. Adverse Metabolic Reaction to Anesthesia (AMRA) Report Form (obtain from MH Registry Website)
4. MH Response Flow Sheet to provide documentation of the crisis (on MH Cart)
5. MH Policy (posted on the outside of the MH Cart)
6. MH Intervention Checklist (posted on the outside of the MH Cart)

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Malignant Hyperthermia Emergency Alert

Malignant Hyperthermia (MH) is a rare life-threatening reaction that is most often triggered by the use of inhalation anesthetics or succinylcholine.

Early Warning Signs of MH

Muscle Rigidity
Sinus Tachycardia
Hyperthermia (rapid rise in core temperature)
Hypercarbia (resistant to increasing minute ventilation)

What to do with Recognition of MH

Call both **30001** AND **31022**
to announce "Malignant Hyperthermia Emergency"
and provide exact Patient Location

Response to MH Emergency Alert

Anesthesia will bring MH Cart and Cooling Supplies

(Anesthesia Policy 10.0 Malignant Hyperthermia Response 2018-01)

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Malignant Hyperthermia Response: Dantrolene Dosage Chart

Dose: **Dantrolene 2.5 mg/kg per dose via rapid IV push**

Repeat dose until symptoms subside (up to 10-30 mg/kg)

Dilution: Use 5 mL Sterile Water for Injection to dilute each 250 mg vial of Dantrolene
Final Concentration 50 mg/mL

Patient's Weight in Kilograms (kg)	# of Dantrolene 250 mg vials Needed	Total Dose Needed (mg)	Volume to Administer (mL)	Patient's Weight in Pounds (lbs)
5 kg	1 vial	12.5 mg	0.25 mL	**11** lbs
10 kg	1 vial	25 mg	0.5 mL	**22** lbs
15 kg	1 vial	37.5 mg	0.75 mL	**33** lbs
20 kg	1 vial	50 mg	1 mL	**44** lbs
25 kg	1 vial	62.5 mg	1.25 mL	**55** lbs
30 kg	1 vial	75 mg	1.5 mL	**66** lbs
35 kg	1 vial	87.5 mg	1.75 mL	**77** lbs
40 kg	1 vial	100 mg	2 mL	**88** lbs
45 kg	1 vial	112.5 mg	2.25 mL	**99** lbs
50 kg	1 vial	125 mg	2.5 mL	**110** lbs
55 kg	1 vial	137.5 mg	2.75 mL	**121** lbs
60 kg	1 vial	150 mg	3 mL	**132** lbs
65 kg	1 vial	162.5 mg	3.25 mL	**143** lbs
70 kg	1 vial	175 mg	3.5 mL	**154** lbs
75 kg	1 vial	187.5 mg	3.75 mL	**165** lbs
80 kg	1 vial	200 mg	4 mL	**176** lbs
85 kg	1 vial	212.5 mg	4.25 mL	**187** lbs
90 kg	1 vial	225 mg	4.5 mL	**198** lbs
95 kg	1 vial	237.5 mg	4.75 mL	**209** lbs
100 kg	1 vial	250 mg	5 mL	**220** lbs
105 kg	2 vials	262.5 mg	5.25 mL	**231** lbs
110 kg	2 vials	275 mg	5.5 mL	**242** lbs
115 kg	2 vials	287.5 mg	5.75 mL	**253** lbs
120 kg	2 vials	300 mg	6 mL	**264** lbs
125 kg	2 vials	312.5 mg	6.25 mL	**275** lbs
130 kg	2 vials	325 mg	6.5 mL	**286** lbs
135 kg	2 vials	337.5 mg	6.75 mL	**297** lbs
140 kg	2 vials	350 mg	7 mL	**308** lbs
145 kg	2 vials	362.5 mg	7.25 mL	**319** lbs
150 kg	2 vials	375 mg	7.5 mL	**330** lbs

Call OR Pharmacy x60242 or Inpatient Pharmacy x60275 if more Dantrolene vials are needed

MH Cart Contains #3 Medication Draw Up Kits:
Dantrolene (Ryanodex) 250 mg vial + Sterile Water for Injection 10 mL vial
Syringe 10 mL, Vented Spike, Blunt Fill Needle, Red Syringe Cap

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ZSFG Malignant Hyperthermia Intervention Checklist

1. ☐ **Discontinue Triggers** (succinylcholine, inhaled anesthetics)
2. ☐ **Start TIVA** (Total Intravenous Anesthesia), if anesthesia required
3. ☐ **Hyperventilate 2-3 Times Predicted Minute Ventilation**
4. ☐ **FiO2 1.0 at 10 L/min.** Keep circuit, absorber and machine.

5. **Obtain MH Cart / Call for Help / Inform OR Team**
   - ☐ Designate an **Anesthesia Technician to obtain the MH Cart** *Anes Wkrm or 6G* *(VOIP phone 31022)*
   - ☐ **Page the Anesthesia D1** or Anesthesia Night Attending *(VOIP phone 30001)*
   - ☐ D1 to designate an Anesthesiologist as **Team Leader**
   - ☐ **Inform Surgeons** of MH emergency and to coordinate the most expeditious surgical plan to finish the surgical procedure

6. ☐ **Administer Dantrolene 2.5 mg/kg per dose IV Push** *MH Cart*
   Repeat Dose until Symptoms Subside (up to 10-30 mg/kg)
   - ☐ Dilute only 5 mL Sterile Water for Injection in each 250 mg vial of Ryanodex (Dantrolene) (i.e., 75 kg patient = 1 vial Dantrolene per dose)
   - ☐ Assign one team member to reconstitute Dantrolene
   - ☐ Designate one provider to administer Dantrolene via IV Push

7. **Team Leader to Designate Roles and Responsibilities**
   - ☐ Designate an **Anesthesia Provider to manage vent and anesthesia**
   - ☐ Designate **Circulating RN as Lead Nurse**. Lead RN to delegate RN duties and to **call OR Front Desk** *(x68134)* to notify the following:
     - ☐ **Overhead Page OR** to request for help in the MH crisis *(x68134)*
     - ☐ **Call PACU** *(x68127)* to bring 4 large plastic bags of ice
     - ☐ **Page the AOD** *(x63519)* to arrange for ICU disposition
     - ☐ **Call OR Pharmacy** *(x60242)* to request meds as needed
   - ☐ Designate an **Anesthesia Provider or CRNA to record the events** during the MH crisis on the MH Flowsheet *MH Cart*
   - ☐ Designate a **provider to insert lines** (arterial line, additional large bore IV access), if not already present
   - ☐ Designate a separate **provider to administer medications**
   - ☐ Designate an **Anesthesia Technician to obtain:**

     From the Anesthesia Workroom *(phone 31022)*
     - ☐ Syringe Pump, Spiked IV, Triple Lumen CVC, A-line Sets

     From the Main OR Anesthesia Workroom Refrigerator or 6G Med Room Refrigerator (6G10)
     - ☐ 1L IV Plasmalyte x 3 bags
     - ☐ 3L NS for Irrigation x 1 bag
     - ☐ Insulin 10 mL vial / NS 100 mL IV Bag x 1 kit

     From the Nearest Available Location
     - ☐ Crash Cart

8. ☐ **Call MH Hotline** ***(1-800-644-9737)*** for additional help, as needed

9. **Obtain and Monitor Labs and Studies** *sample lab sheets in MH Cart*
   - ☐ **ABG Kit:** ABG
   - ☐ **Light Blue:** PT/INR, PTT, Fibrinogen, D-Dimer
   - ☐ **Gold Gel:** BMP, CK, LDH, Myoglobin, Thyroid (TSH, Free T4, Free T3)
   - ☐ **Lavender:** CBC, Platelets
   - ☐ **Grey:** Lactate
   - ☐ **Urine Dipstick / Collection Cup:** Hemoglobin / Myoglobin, UA
   - ☐ **Monitoring Equipment:** EKG, Core Temperature

10. **Cool Patient to Goal Temp of 38°C** using one or more methods:
    - ☐ Cold Plasmalyte-148 IV *Anes Workroom Fridge* or *6G Med Room Fridge 6G10*
    - ☐ Cold Sodium Chloride 0.9% for Irrigation via nasogastric, bladder, rectal and/or open cavity lavage *Anes Workroom Fridge* or *6G Med Room Fridge 6G10*
    - ☐ Ice Packs for external surface cooling *PACU* or *6G Kitchen 6G6*
    - ☐ Consider calling SICU *(x69954)* for intracool catheter / cooling blanket

11. **Treat Acidosis** (if not reversed by Dantrolene administration)
    - ☐ Sodium Bicarbonate 8.4% IV 1-2 mEq/kg *Crash Cart*
    - ☐ Ensure adequate minute ventilation

12. **Treat Hyperkalemia and Associated Dysrhythmias**
    - ☐ Calcium Chloride 10% IV 10 mg/kg *Crash Cart*

      Avoid Calcium Channel Blockers
    - ☐ Sodium Bicarbonate (above) *Crash Cart*
    - ☐ Insulin IV 0.15 units/kg (or 10 units) *Anes Wkrm Fridge* or *6G Med Rm Fridge 6G10*

      HIGH ALERT / TWO PROVIDERS MUST DOUBLE CHECK

      Instructions: Dilute Regular Insulin 1 mL (= 100 units) in 100 mL NS Bag (Final Conc = 1 unit/mL), then give Insulin 10 mL = 10 units IV
    - ☐ Dextrose 50% IV 1 mL/kg *Crash Cart* Monitor serum glucose.
    - ☐ Treat dysrhythmias using ACLS algorithms *Crash Cart*

13. ☐ **Place or Confirm Foley to Monitor Urine Output**
    - ☐ Aggressive hydration. Ensure UO of at least 2 mL/kg/hr.
    - ☐ Consider diuresis with Furosemide 0.5-1 mg/kg IVP *Anes Wkrm Omni* or *6G Omni*

14. ☐ **Transport to ICU** (and continue Dantrolene 1 mg/kg IV Push q6h)

The MH response must be documented on the MH Flowsheet
(MH Flowsheet is found in MH Cart Drawer 2 in the Patient Care Folder)

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