SARASOTA MEMORIAL HOSPITAL
PERIOPERATIVE DEPARTMENT POLICY

TITLE: MALIGNANT HYPERTHERMIA

PURPOSE: To provide guidance for health care professionals in the management of malignant hyperthermia (MH) in surgical patients undergoing general anesthesia.

POLICY STATEMENT: Preparedness is essential to prevent death from MH. This guide for planning care and treatment of patients who are MH susceptible or experiencing and MH related event.

EXCEPTIONS: The guidelines described may not apply to every patient and must of necessity be altered according to specific patient needs.

DEFINITIONS: Malignant Hyperthermia is a chain reaction event (syndrome) "triggered" in susceptible individuals by commonly used general anesthetics (e.g., halothane, enflurane, isoflurane, desflurane, and sevoflurane) or succinylcholine. The signs include a greatly increased body metabolism, muscle rigidity, and high fever. Death or brain damage may result from cardiac arrest, internal hemorrhaging or failure of other body systems.

Malignant Hyperthermia Association United States (MHAUS) Emergency Hotline: expert help is available for diagnosis and treatment of an ongoing MH episode. Call 1-800-644-9737.

PROCEDURE: All locations where general anesthesia is administered should contain the following:

a. Standard anesthesia monitors and airway support equipment.
b. A plan to treat MH, posted and readily available
c. A means to continuously monitor end-tidal CO2, oxygen saturation and core body temperature by electronic probe
d. A means to actively cool a patient (e.g., a machine to manufacture ice, and a refrigerator containing at least 3,000 ml of cold saline solution)
e. An MH cart or kit containing the items necessary to effectively manage an MH event.

1) Dantrolene, in the form of Ryanodex 250mg/vial reconstituted with 5ml sterile water is available on each MH cart for rapid administration of recommended 2.5mg/Kg initial treatment. A total of 3 vials of Ryanodex are available on each cart.
f. The list of MH cart stock items and team member roles is
available on each MH cart.

g. The anesthesia RN (or designee) will be responsible for checking and maintaining the MH carts.
   1) Following use of the MH Cart, the cart will be restocked and a new lock will be applied (as with Code Carts).
   2) Daily MH Cart Inspections will include:
      a) Verification of cart security and essential equipment.
      b) Ensure refrigerator unit is plugged in.
      c) Main OR MH cart temperature will be continuously monitored electronically by OPL. Temperature range should be 35° - 45°.
         (1) Temperature probe will need to be disconnected if cart is moved.
      d) SOR MH cart, Monitor refrigerator for appropriate temperature.
         (1) Thermometers are in the refrigerators, temperature maintained between 35° - 45°.
         (2) Record sheets are posted and up-to-date.

2. Pre-operative Assessment
   a. All patients about to undergo general anesthesia should have a thorough patient/family assessment to determine the following:
      1) Is there a family history of MH?
      2) Have there been unexplained deaths or complications arising from anesthesia in any family members?
      3) Is there a personal history of a muscle disorder, cola-colored urine following anesthesia, or unexplained high fever or muscle rigidity during surgery?
   b. If a patient is known to be MH susceptible (MHS), a fully stocked MH cart, ice and cold IV/Irrigation solutions should be immediately available.
   c. Calculate patient’s weight in kilogram (kg) and record for reference (drugs are given per kg body weight).

3. Pre-operative Preparations for susceptible patients:
   a. Anesthesia machine:
      1) Ensure that anesthetic vaporizers are disabled by removing, draining or taping switch in the off-position.
      2) Change carbon dioxide absorbent (soda lime or baralyme).
      3) Attach a new patient breathing circuit and connect a new breathing bag to the patient Y-piece.
      4) Flush the system using Flow rate of 15 L/m for
minimum of 40 minutes.

5) Before connecting the breathing circuit to the patient at the beginning of the anesthesia case, activate the O2 flush for 10 s. Whenever possible set a total fresh gas flow rate of 15 L/m. Keeping the highest fresh gas flow rate that is also above the patient’s minute volume functionally creates a non-rebreathing system and minimizes rebound of residual gas at low fresh gas flow rates.

6) Place a cooling blanket on the table.

b. DANTROLENE Prophylaxis

1) DANTROLENE prophylaxis should be considered on an individual patient basis but is not recommended for most MH susceptible patients. When used, dosage is 2.5 mg/kg IV starting 30 minutes prior to anesthesia. For consultation, contact MHAUS: 1 (800) 98-MHAUS (1-800-986-4287). MHAUS Emergency Hotline: 1(800) 644-9737.

Note: DANTROLENE can worsen muscle weakness in patients with muscle disease and should be used with caution. For most procedures, even those requiring general anesthesia, DANTROLENE prophylaxis may be omitted.

4. Intra-operative Considerations

a. Anesthetic techniques of choice:
1) Spinal, epidural, regional or local, if possible.
2) Local anesthesia: Local anesthetics do not trigger MH; thus any type of regional anesthesia is safe for MH susceptibles.
3) Safe general anesthesia agents may include:
   a) Benzodiazepines, opioids, barbiturates, propofol, ketamine, nitrous oxide, etomidate.
   b) Pancuronium, atracurium, vecuronium, rocuronium, pipecuronium, mivacurium, doxacurium or curare may be used for relaxation.
   c) Neostigmine and atropine are used for reversal without problem.
3) High Risk drugs/MH triggers:
   a) Halothane, enflurane, isoflurane, desflurane, sevoflurane, methoxyflurane, cyclopropane.
   b) Succinylcholine

b. Monitoring:
1) Essential: blood pressure, central temperature, ECG, pulse oximeter, and capnograph or capnometer
2) Strongly suggest monitoring respiratory volume and frequency.
3) Use arterial line, CVP or other invasive monitors if appropriate for the surgical procedure and underlying medical condition.
c. The unexpected development of high fever is sometimes, but not necessarily, an indication of MH. Temperature elevation is often a late sign of MH.

d. Any time the signs of MH as listed below occur intra or postoperatively, further investigation is merited.

1) Signs of MH include:
   a) Increase in end-tidal CO2
   b) Generalized muscle rigidity
   c) Masseter (jaw) muscle rigidity
   d) Hyperthermia (often a late sign)

2) Be suspicious of MH when there is:
   a) Unexplained tachycardia, tachypnea
   b) Cola-colored urine
   c) Unanticipated acidosis

Note: Each MH cart is equipped with a key ring that contains “job cards” for operative staff to be used during an MH crisis. In the event of an MH crisis, MHAUS is to be called at 9-1-800-644-9737. MHAUS will provide assistance and necessary documentation for their national registry.

5. Treatment of Acute MH (from MHAUS)
   a. Treatment team is led by the Anesthesia Care Provider
   b. Notify Pharmacist of MH event in progress
   c. Stop all volatile anesthetics and succinylcholine.
   d. Hyperventilate with 100% O2 at flows of 10 L/minute.
   e. Surgery should be terminated ASAP.
   f. **Give 2.5-mg/kg DANTROLENE sodium bolus injection rapidly. Repeat as necessary titrated to signs of MH.**
   g. Obtain I-Stat.
   h. Treat acidosis with bicarbonate – if not promptly reversed by DANTROLENE.
   i. Treat hyperkalemia with glucose, insulin and calcium.
   j. Dysrhythmias usually respond to correction of hyperkalemia and acidosis by hyperventilation, dantrolene, and bicarbonate. Use standard antiarrythmic therapy, except calcium channel blockers, which may cause hyperkalemia or cardiac arrest in the presence of dantrolene.
   k. Avoid calcium channel blockers. Persistent arrhythmias may be treated with any other standard antiarythmics. Most arrhythmias respond to correction of hyperkalemia and acidosis by hyperventilation, dantrolene and bicarbonate.
   l. Monitor core temperature.
   m. If hyperthermic, cool by nasogastric, rectal lavage and surface cooling – but avoid over cooling.
   n. Continue DANTROLENE sodium for injection for at least 24 hours after control of the episode (approximately 1-mg/kg q 6 hours).
   o. Watch for recrudescence (a new outbreak after a period of abatement) by monitoring in an ICU for 36 hours. Recrudescence occurs in about 25% of MH cases.
p. Avoid parenteral potassium.
q. Ensure adequate urine output by hydration and diuretics since myoglobinuria is common.
r. Follow coagulation profile – DIC may occur.
s. Measure Creatine Kinase (CK) every 6 hours until falling. CK may remain elevated for 2 weeks if its elevation was marked. 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 to every day to every several days). This is important because it is elevated normally in some myopathies, and this should be recognized as a part of overall evaluation and treatment.

6. Post-operative Procedures:
   a. If the anesthetic course has been uneventful:
      1) Continue to monitor temperature and ECG for 1-2 hours.
      2) Observe patient for 4 hours following ambulatory surgery prior to discharge.
   b. If MH has occurred:
      1) The Surgeon and Anesthesiologist will determine the need to recover patient in the ICU. Usually, for 24 hours or during duration of Dantrolene administration.
      2) Continue IV DANTROLENE for 24 hours, titrated to alleviation of muscle rigidity, tachycardia, acidosis, and CK levels as ordered. Suggested DANTROLENE dosage is at least 1 mg/kg q 6 hours IV. (After that, 1 mg/kg q 6 hours may be given orally x 24 hours).
      3) Monitor the patient’s coagulation status, watching for DIC.
      4) Look for myoglobinuria and renal failure, and treat as needed.
      5) Monitor potassium and CK levels q 6 hours.
      6) Use potassium-containing solutions with caution.
      7) Monitor urine output.
      8) Optional (anesthesia care provider): Register patient with North American MH Registry. Forms are available on the internet at http://www.mhaus.org, or by contacting:
         MHAUS
         11 East State Street
         P.O. Box 1069
         Sherburne, NY 13460
         1 800 98 MHAUS
         (or you may use on-line registration)
      9) Provide patient and family education. Alert patient and patient’s family to the dangers of MH in other family members. Refer for testing at nearest center (list available from MHAUS).

7. Documentation:
a. Document MH episode on the perioperative record to include but not limited to:
   1) Patient responses and interventions
   2) Times of events and therapies
   3) Personnel involved
   4) Patient outcomes

b. Document MH episode on an Occurrence Report according to SMHCS policy 00.RSK.12.

RESPONSIBILITY: It is the responsibility of the department/unit directors, anesthesia clinical manager, and the chief of anesthesia to ensure that nursing and anesthesia personnel are aware of this policy.

The anesthesia RN will be responsible for ensuring that the MH Carts are checked and maintained according to policy.

REFERENCES: Malignant Hyperthermia Association of the United States (MHAUS),
http://www.mhaus.org


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ATTACHMENT (S): A. Malignant Hyperthermia Flow Chart
B. Laboratory Findings of Acute MH
C. Physiology of Malignant Hyperthermia
# MALIGNANT HYPERTHERMIA

## Approvals

Signatures indicate approval of the new or reviewed/revised policy

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<tr>
<td>Title:</td>
<td>Connie Andersen, Vice President, CNO</td>
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Attachment A: Malignant Hyperthermia Flow Chart

Flow chart from AORN Perioperative Standards and Recommended Practices, AORN Malignant Hyperthermia Guideline (p628), 2012.

- **Assess**
  - At increased risk? (Yes)
    - **MH susceptible**
      - **Prevention**
        - **Muscle Testing**
          - **Family involvement**
            - **Patient/family teaching**
  - At increased risk? (No)
    - Minimal risk
      - **Treatment of Symptoms**
        - **Monitor physical parameters**
          - **Continue treatment of symptoms**
            - **48-72 hours postoperative**
      - **Dantrolene**
        - **Lab values, oxygenation/ventilation, fluid balance, temperature**
        - **Acute unexpected event**
### Attachment B: Laboratory Findings of Acute MH

<table>
<thead>
<tr>
<th><strong>ABG</strong></th>
<th><strong>Normal Ranges</strong></th>
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<tbody>
<tr>
<td>pH</td>
<td>7.35-7.45</td>
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<tr>
<td>PO2</td>
<td>80-100 mm Hg</td>
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<tr>
<td>PCO2</td>
<td>35-45 mm Hg</td>
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<table>
<thead>
<tr>
<th><strong>Electrolytes</strong></th>
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<tr>
<td>K</td>
<td>4.0-5.4 mEq/L</td>
</tr>
<tr>
<td>Ca</td>
<td>4.5-5.5 mEq/L</td>
</tr>
<tr>
<td>Mg</td>
<td>1.8-2.4 mg/dL</td>
</tr>
<tr>
<td>Na</td>
<td>138-148 mEq/L</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Serum</strong></th>
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<tbody>
<tr>
<td>Lactate</td>
<td>0.7-2.1 mmol/L</td>
</tr>
<tr>
<td>Pyruvate</td>
<td>0.03-0.08 mmol/L</td>
</tr>
<tr>
<td>CPK (creatnine phosphokinase)</td>
<td>40-280 U/L</td>
</tr>
<tr>
<td>LDH (lactic dehydrogenase)</td>
<td>3.13-6.18 U/L</td>
</tr>
<tr>
<td>Aldolase</td>
<td>Age specific</td>
</tr>
<tr>
<td>Myoglobin</td>
<td>6-85 ng/mL</td>
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<tr>
<td>Glucose</td>
<td>80-120 mg/dL</td>
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<tr>
<td>Creatinine</td>
<td>0.5-1.4 mg/dL</td>
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<td>PT</td>
<td>10-12</td>
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<td>PTT</td>
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<tr>
<td>Platelets</td>
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Table from AORN Standards, Guidelines & Recommended Practices, Malignant Hyperthermia Guideline (p224), 2007.
### Physiology of Malignant Hyperthermia

**Physics of Muscle Contraction/Relaxation in Normal Tissue Versus Malignant Hyperthermia (MH) Crisis**

The central regulator of contraction and metabolism in the muscle is calcium. With an MH crisis, biochemical, metabolic, and physiologic conditions are a direct result of sudden and progressive increases in intracellular myoplasmic calcium.

<table>
<thead>
<tr>
<th>Normal Muscle Contraction</th>
<th>Events Triggered by MH</th>
</tr>
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<tbody>
<tr>
<td>Tubules of sarcoplasmic reticulum (SR) in skeletal muscle contain calcium ions.</td>
<td>Tubules of SR in skeletal muscle contain calcium ions.</td>
</tr>
<tr>
<td>Calcium is released into myoplasm from SR through calcium release channels.</td>
<td>Calcium is released into SR through calcium release channels at an abnormally high rate.</td>
</tr>
<tr>
<td>The ryanodine receptor is the calcium release channel within the skeletal muscle cell that mediates calcium release.</td>
<td>Abnormalities associated with the function of the ryanodine receptor and the process encoding for the receptor may account for MH in certain patients.</td>
</tr>
<tr>
<td>Calcium ions lead to activation of actin and myosin filaments.</td>
<td>Imbalance in calcium ions within skeletal muscle cells stimulates metabolism. Sustained hypermetabolic state progresses to:</td>
</tr>
<tr>
<td>Calcium ions bind to the tropomyosin-troponin complex, shifting it away from actin filaments.</td>
<td>- Excess lactate production</td>
</tr>
<tr>
<td>Myoplasmic calcium is reduced via membrane adenine triphosphatase (ATPase) pump which breaks ATP down to adenosine diphosphate + phosphate + heat.</td>
<td>- High adenosine triphosphate (ATP) consumption</td>
</tr>
<tr>
<td>Calcium returns to the SR.</td>
<td>- Increased carbon dioxide (CO2)</td>
</tr>
<tr>
<td>Muscle relaxation</td>
<td>- Increased heat production</td>
</tr>
</tbody>
</table>

**REFERENCES**