**Scenario Overview**

**Summary**

Tom Jones is a healthy 18 year old scheduled for a left ankle arthrodesis who weighs 165 lbs (75 Kg). During the preoperative assessment, the nurse notes that he was diagnosed with Becker muscular dystrophy at age 17. He does not use any ambulatory assistive devices. His past surgical history includes a tonsillectomy at age 7. There is no other significant health history to report, and no history of problems with anesthesia. The patient is scheduled to have a general anesthetic.

The surgery has been in progress for 15 minutes. Team enters room. After 2 minutes, the patient will begin to exhibit signs of MH.

**Setting**

Operating room/Simulation center

**Time**

Simulation 10 - 15 minutes
Debrief 40 minutes

**Participants**

Simulation facilitator
Multidisciplinary OR team: anesthesia provider (MD and/or CRNA and/or SRNA), surgeon, surgical assistant, anesthesia technician, surgical technologist or RN in scrub role, RN circulator, charge RN
Additional learners will act as observers

**Progressive Complexity**

Patient interview
Induction of anesthesia
Physiological system failure
Resuscitation of the patient

**Potential Systems Explored**

Facility policy protocol
Roles of the perioperative team members during a Malignant Hyperthermia (MH) crisis
Supporting technical and developmental skills
Interprofessional training in communication and professionalism
Learning Objectives

1) The learner will communicate with members of the perioperative team during a MH crisis.
2) The learner will demonstrate the correct mixing protocol for dantrolene sodium.
3) The learner will demonstrate immediate crisis action per the procedure in the MH management checklist.
Pre-simulation
Review contents of the MH emergency cart
Review the MH algorithm
Visit the Malignant Hyperthermia Association of the United States website http://www.mhaus.org
Read the article: Dirksen, Van Wicklin, Mashman, Neiderer, Merritt.

Pre-Brief:
Team is provided with the following information:
Please treat this scenario as if happening in your OR.
Inject medications per usual.
Cardiac monitor displays real time vital signs.

Patient History
Tom Jones is a healthy 18 year old scheduled for a left ankle arthrodesis who weighs 165 lbs (75 Kg). During the preoperative assessment, the nurse notes that he was diagnosed with Becker muscular dystrophy at age 17. He does not use any ambulatory assistive devices. His past surgical history includes a tonsillectomy at age 7. There is no other significant health history to report, and no history of problems with anesthesia. The patient is scheduled to have a general anesthetic.
You are the RN circulator relieving for lunch at 10:55 am.
RN (confederate) (Confederates are experienced healthcare professionals, such as physician, nurse or other practitioners, who act as team members during a simulation to provide realism or additional information for the learner) gives report:
This is Tom Jones, 18 year old left ankle arthrodesis. He does not use any ambulatory assistive devices. There is no health history except for a tonsillectomy as a child. We just started. See you in half an hour!!

Additional Medical History
The patient has no allergies.

Baseline Vital Signs
BP 120/70, HR 65, Temperature 37º C, 98 F

Baseline Test Results
Sodium 136
Potassium 4.4
Chloride 100
CO2 26
Urea nitrogen 20
Creatinine 1.0
Glucose 275
A1C 5.4
Anion gap 15.0
HCT 40.9
WBC 6.8
RBC 4.88
Albumin 3.9
O2 Sat 99
<table>
<thead>
<tr>
<th><strong>Set-up</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Room</strong></td>
</tr>
<tr>
<td>Operating room or simulation equipped operating room.</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
</tr>
<tr>
<td>Operating Room table</td>
</tr>
<tr>
<td>Mannequin dressed in a hospital gown, with hospital identification and allergy band on</td>
</tr>
<tr>
<td>Patient warming device applied</td>
</tr>
<tr>
<td>Intravenous solution running in right forearm</td>
</tr>
<tr>
<td>Mannequin intubated and draped for appendectomy</td>
</tr>
<tr>
<td>Anesthesia machine equipped with oxygen, suction and cardiac monitor</td>
</tr>
<tr>
<td>Intubation equipment</td>
</tr>
<tr>
<td>Sequential Compression Device</td>
</tr>
<tr>
<td>Back table basic set up</td>
</tr>
<tr>
<td>Mayo stand basic set up</td>
</tr>
<tr>
<td>Cautery</td>
</tr>
<tr>
<td>Emergency Code Cart - item requested by team</td>
</tr>
<tr>
<td>MH Cart – item requested by team</td>
</tr>
<tr>
<td><strong>MH Medications (Simulated)</strong></td>
</tr>
<tr>
<td>Syringe of succinylcholine</td>
</tr>
<tr>
<td>Syringe of rocuronium</td>
</tr>
<tr>
<td>Propofol 100 mL vial</td>
</tr>
<tr>
<td>Regular insulin 10 units IV</td>
</tr>
<tr>
<td>D50 bristoject,</td>
</tr>
<tr>
<td>Sodium bicarbonate bristoject</td>
</tr>
<tr>
<td>Calcium gluconate bristoject,</td>
</tr>
<tr>
<td>Dantrolene sodium vials</td>
</tr>
<tr>
<td>(10 vials [20 mg] will equal 187.5 mg)</td>
</tr>
<tr>
<td>Sterile water preservative free vials</td>
</tr>
<tr>
<td><strong>Simulator Preparation</strong></td>
</tr>
<tr>
<td>Mannequin draped</td>
</tr>
<tr>
<td>Instrument table (basic set up), basin and mayo stands in place</td>
</tr>
<tr>
<td>1 liter of Lactated Ringers Intravenous solution to right antecubital space –</td>
</tr>
<tr>
<td>Intubated with 7.0 OETT</td>
</tr>
<tr>
<td>FiO2 100%</td>
</tr>
<tr>
<td>Warming blanket and machine</td>
</tr>
<tr>
<td>MH cart and Code Blue cart outside of room/view</td>
</tr>
<tr>
<td>Mock OR documentation for RN circulator</td>
</tr>
<tr>
<td><strong>Documentation</strong></td>
</tr>
<tr>
<td>MH participant activity sheets</td>
</tr>
<tr>
<td>MH worksheet that includes dantrolene mixing instructions</td>
</tr>
<tr>
<td>Medical and perioperative records</td>
</tr>
<tr>
<td>(forms completed to 10:55am)</td>
</tr>
<tr>
<td>Surgical verification process form (completed)</td>
</tr>
<tr>
<td>Visual aid to guide the preparation of dantrolene sodium</td>
</tr>
</tbody>
</table>
### Sequence of Events

2 minutes into the scenario:
- Temperature 39°C
- ETCO2 increases
- BP 80/40
- Heart rate 90
- Periodic premature ventricular contractions

3 minutes into the scenario:
- BP 70/30
- Temperature 42°C
- ETCO2 increases to 65

Anesthesia provider (or confederate) can announce suspicion of MH

Continue with the simulation until the following action/treatments are completed:

<table>
<thead>
<tr>
<th>Responsibility</th>
<th>Skill met</th>
<th>Action/Treatment Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Respondent</td>
<td></td>
<td>Call for an MH Cart AND code cart to the room</td>
</tr>
<tr>
<td>Any Team Member</td>
<td></td>
<td>Appoint a team leader.</td>
</tr>
<tr>
<td>Anesthesia Provider</td>
<td></td>
<td>Stop the triggering agent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hyperventilate with 100% oxygen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Obtain lab tests per physician order</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Call or assign a team member to call the MH Hotline 1-800-644-9737</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Start arterial line and/or any additional IV lines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Treat hyperkalemia – calcium chloride 10mg/Kg or calcium gluconate 10-50mg/Kg; regular insulin 10 units IV in 50 mL of 50% glucose, give Na+ bicarbonate if metabolic acidosis is present (1-2 mEq/kg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Treat dysrhythmias –beta blockers (no calcium channel blockers)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monitor renal function</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Place nasogastric tube</td>
</tr>
<tr>
<td>Circulator/RN</td>
<td></td>
<td>Call for additional help</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Start dilution of dantrolene sodium of 9-12 vials. This will provide the initial dose (2.5 mg/kg for all patients). Reconstitute with 60 mL of diluent – preservative free sterile water only.</td>
</tr>
<tr>
<td>Circulator/RN II</td>
<td></td>
<td>Apply cooling measures; obtain chilled saline/ice and place on groin, axilla, around head</td>
</tr>
<tr>
<td>Other Respondents</td>
<td></td>
<td>Insert Foley catheter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insert rectal tube for lavage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cool IV fluids</td>
</tr>
<tr>
<td>Surgeon/Physician</td>
<td></td>
<td>Conclude procedure as soon as possible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Notify the family of the patient’s condition</td>
</tr>
<tr>
<td>OR Team</td>
<td></td>
<td>Call report to the intensive care unit</td>
</tr>
</tbody>
</table>
Malignant Hyperthermia

### Algorithm

**Patients at Risk**
- Familial history of adverse response to anesthetic agents

**MH Trigger Agents:**
- Potent volatile anesthetics (eg, halothane, sevoflurane, desflurane)
- Succinylcholine

**Acute Symptomatic Malignant Hyperthermia**

- Call for assistance and MH Cart

**Dantrolene sodium**
- 2.5mg/kg rapid IV
- minimum of 36 vials, 20 mg
- 100 ml bottles of sterile water for injection (without preservatives only)
- Repeat until there is control of the signs of MH

**Bicarbonate**
- for metabolic acidosis
- 1-2 mEq/kg if blood gas values not yet available

**Dysrhythmias**
- usually respond to treatment of acidosis and hyperkalemia
- Use standard drug therapy but DO NOT USE Ca+ channel blockers which may cause hyperkalemia or cardiac arrest in presence of dantrolene

**Cool**
- the patient if temperature > 39° C
- Lavage open body cavities, stomach, bladder, or rectum
- Apply ice to surface
- Infuse cold IV saline

**Hyperkalemia**
- Treat with hyperventilation, bicarb, glucose/insulin, calcium

---

Follow ETCO2, electrolytes, blood gases, creatine kinase (CK), core temperature, urine output and color, coagulation studies. If CK and/or K+ rise more than transiently or urine output falls to less than 0.5 mL/kg/hour, induce diuresis to > 1mL/kg/hour urine to avoid myoglobin-induced renal failure.

- Venous blood gas values may indicate hypermetabolism better than arterial values.
- Central venous or pulmonary artery monitoring as needed and record minute ventilation.
- Place Foley catheter and monitor urine output.
- Consider sedation and analgesia as indicated.
Debrief

**Standardized debrief questions:**

- How did the simulation experience of caring for this patient make you feel?
- Did you have the knowledge and skills to meet the objectives of this simulation experience?
- What gaps did you identify in your own knowledge?
- If you performed the scenario again, how would you handle the situation differently?
- In what ways did you perform well?
- How well did the team work together?

**Debrief questions for observers:**

- What did the group do well?
- What did the group not do well?
- Is there anything else you would like to discuss?

**MH specific debrief questions:**

- Have you experienced a MH crisis in your perioperative patients?
- During the MH scenario, what communication strategies did you use to validate the accuracy of your information or decisions with your team members?
- Were you satisfied with your ability to work through the MH crisis?

  Review learning objectives.
  Review participants, roles and team expectations.
  Review of communication expectations
Typical Contents of a Malignant Hyperthermia Cart

3-way stopcocks
Luer-lock vented dispensing pins
Secondary IV extension tubes
18 G needles
60 mL syringes
10 mL syringes
Lab test tubes
Cooling equipment
18 French nasogastric tube
Rectal tube
5-to-1 connectors
16 French foley catheter/urimeter
Plastic bin for ice
Kelly clamps
Plastic bags for ice or ice packs
Ambu bag

Medications
Dantrolene sodium
Metoprolol injection
Calcium chloride
Esmolol
Preservative free sterile water
Mannitol 20%,
Amiodarone
Lasix
IV NS
Example: Malignant hyperthermia cart

Example: Room set up
Example: Visual aid to guide dantrolene sodium preparation


**NECESSARY SUPPLIES** (for multiple set-ups)
- 36 vials dantrolene sodium, 20 mg
- 100 mL bottles of sterile water for injection
- 6 luer-lock vented dispensing pins
- 6 luer-lock 60 mL syringes

* **KEY POINTS:**
  1. Use 60 mL of diluent—STERILE WATER without preservatives only
  2. Dilution of 9-12 vials will provide the initial dose (2.5 mg/kg for all patients)
  3. Designee will assist in mixing remaining doses

**MIXING PROCEDURE** (dedicate 2 people to the task if possible)
1. Wipe the rubber access port with an alcohol wipe.
2. Place the vented dispensing pin in the 100 mL vial of sterile water; attach the 60 mL luer-lock syringe.
3. Turn the sterile water vial upside down and withdraw 60 mL sterile water.
4. Remove the metal seal (if present) from the dantrolene sodium and wipe the top with alcohol.
5. Add the 60 mL syringe with sterile water to the dantrolene sodium.
6. Swirl the vial with the syringe attached until crystals are dissolved (fluid should turn to a clear yellow color).
7. Withdraw the contents of the vial (60 mL) into the 60 mL syringe, take it off the luer-lock vented dispensing pin and give to the anesthesia care provider or designee to administer by continuous rapid IV push until MH symptoms subside.
**Malignant Hyperthermia**

**Perioperative Simulation Scenarios**

**Resources**

**Example: Sample form**

### Participant MH Worksheet for Proposed Correct Treatment

<table>
<thead>
<tr>
<th>MH Worksheet</th>
<th>MH Hotline: 1-800-644-9737</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient _________</td>
<td>Last 4 _________</td>
</tr>
<tr>
<td>Staff Present: Anesthesia _________</td>
<td>Surgeon _________</td>
</tr>
</tbody>
</table>

**Immediate Actions**

- Stop Triggering Agent
- Notify Anesthesiologist on call
- Hyperventilate
- Call MHAUS Hotline 1-800-644-9737

**Interventions**

- Give dantrolene as indicated
- Apply cooling measures (groin, axilla, head, under patient) discontinue when patient’s temperature is 38°C, 99 F
- Place Foley with temperature probe
- Give cool IV Fluids (switch to Normal Saline)
- Insert monitoring lines when able
- Aline
- Central Line
- Have 2 large bore IVs patent and eventually a central line

- **Treat Hyperkalemia**
  - Calcium chloride 10mg/kg or calcium gluconate 10-50 mg/Kg
  - Regular insulin 10 units IV in 50 mL of 50% glucose
  - Give Na+ bicarb if metabolic acidosis is present (1-2 mEq/kg)

- **Treat Dysrhythmias**
  - Amiodarone or lidocaine
  - Beta blockers (metoprolol, esmolol)
  - Do not use calcium channel blockers (can cause cardiac arrest in the presence of dantrolene)

- Monitor renal function: IV fluids, furosemide, mannitol
- Obtain lab tests: ABG fluids, furosemide, mannitol
  - Electrolyte panel: increase K+, Ca++, Mg++, decrease Na+
  - CBC: decreased platelets
  - Coagulation studies: prolonged PTT, PT
  - Serum studies: increase CPK and myoglobin, creatinine, glucose, lactate

**Vital Signs**

<table>
<thead>
<tr>
<th>Time</th>
<th>ETCO2</th>
<th>Temp</th>
<th>Pulse</th>
<th>Rhythm</th>
<th>BP</th>
<th>RR</th>
<th>SP02</th>
<th>O2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Medications** (give Dantrolene as soon as possible)

<table>
<thead>
<tr>
<th>Time</th>
<th>Medication</th>
<th>Route</th>
<th>Amount Given</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Dantrolene Given**

<table>
<thead>
<tr>
<th>Time</th>
<th>Amount</th>
<th>Dose</th>
<th>Time</th>
<th>Amount</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 mg</td>
<td>1</td>
<td>20 mg(220 mg)</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mg(40 mg)</td>
<td>2</td>
<td>20 mg(240 mg)</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mg(60 mg)</td>
<td>3</td>
<td>20 mg(260 mg)</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mg(80 mg)</td>
<td>4</td>
<td>20 mg(280 mg)</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mg(100 mg)</td>
<td>5</td>
<td>20 mg(300 mg)</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mg(120 mg)</td>
<td>6</td>
<td>20 mg(320 mg)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mg(140 mg)</td>
<td>7</td>
<td>20 mg(340 mg)</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mg(160 mg)</td>
<td>8</td>
<td>20 mg(360 mg)</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mg(180 mg)</td>
<td>9</td>
<td>20 mg(380 mg)</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mg(200 mg)</td>
<td>10</td>
<td>20 mg(400 mg)</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Labs**

<table>
<thead>
<tr>
<th>PH</th>
<th>PCO2</th>
<th>PO2</th>
<th>HCO3-</th>
<th>BE</th>
<th>Hct</th>
<th>O2Sat</th>
<th>Na+</th>
<th>K+</th>
<th>Ca++</th>
<th>Glucose</th>
<th>CK</th>
<th>Myoglobin</th>
</tr>
</thead>
</table>
Malignant Hyperthermia

1. Malignant hyperthermia (MH) is a potentially lethal syndrome that occurs in predisposed patients who are exposed to MH triggering agents to induce_________________ anesthesia.
   a. local
   b. regional
   c. general

2. A malignant hyperthermia crisis is characterized by all the following except:
   a. hyperthermia.
   b. hypermetabolism.
   c. sustained muscle contractions.
   d. neuroleptic malignant syndrome.

3. MH most often occurs in older children and young adults.
   a. True
   b. False

4. Which one of the following agents is NOT responsible for triggering an MH episode?
   a. Isoflurane
   b. Succinylcholine
   c. Nitrous oxide

5. Dantrolene sodium is the only medication known to reverse an MH crisis.
   a. True
   b. False

6. What is the number of recommended vials of dantrolene to be kept in a health care facility at all times?
   a. 40
   b. 36
   c. 15

7. Each vial of dantrolene is reconstituted with 60 mL of:
   a. preservative free sterile water for injection.
   b. lactated Ringer’s solution.
   c. 50% IV dextrose solution.

8. Dantrolene sodium mixed solution needs to be shaken vigorously.
   a. True
   b. False

9. Surgery CANNOT be safely performed on MH susceptible people.
   a. True
   b. False

10. When applying ice packs for surface cooling of the patient, what are three areas on which you would apply them?
    a. Groin, axillae and neck
    b. Abdomen, popliteal area and feet
    c. Head, back and palms

11. What is the first step the team should take in caring for a patient in MH crisis?
    a. Call for a stat chest radiograph.
    b. Apply heating pads to patient.
    c. Stop all anesthetic agents and administer 100% oxygen.
    d. Continue with the surgery.
## Resources

### Malignant Hyperthermia Test: Answers

1. C  
2. D  
3. A  
4. C  
5. A  
6. B  
7. A  
8. A  
9. B  
10. A  
11. C

---

**Acknowledgments**

Lead authors: Christine R. Valdez, MN, CNS-BC, CNOR, CNS-CP, Operative Care Division, Perioperative Clinical Nurse Specialist, VA Portland Health Care System, Portland, OR; and Beth H. Fitzgerald, MSN, RN, CNOR, Perioperative Simulation Specialist, Christiana Care Health System, Newark, DE  

Special thanks to members of the 2014 Simulation Taskforce for their assistance in the development of this simulation scenario.