

### 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

### 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.

## Participant Preparation

### 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.  
Developing effective drills in preparation for a malignant hyperthermia crisis. AORN J. 2013;97(3):329-353.

### 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 37° 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

## Set-up

### Room

Operating room or simulation equipped operating room.

### Equipment

Operating Room table  
 Mannequin dressed in a hospital gown, with hospital identification and allergy band on  
 Patient warming device applied  
 Intravenous solution running in right forearm  
 Mannequin intubated and draped for appendectomy  
 Anesthesia machine equipped with oxygen, suction and cardiac monitor  
 Intubation equipment  
 Sequential Compression Device  
 Back table basic set up  
 Mayo stand basic set up  
 Cautery

Emergency Code Cart - item requested by team  
 MH Cart – item requested by team

### MH Medications (Simulated)

Syringe of succinylcholine  
 Syringe of rocuronium  
 Propofol 100 mL vial  
 Regular insulin 10 units IV  
 D50 brioject,  
 Sodium bicarbonate brioject  
 Calcium gluconate brioject,  
 Dantrolene sodium vials  
 (10 vials [20 mg] will equal 187.5 mg)  
 Sterile water preservative free vials

### Simulator Preparation

Mannequin draped  
 Instrument table (basic set up), basin and mayo stands in place  
 1 liter of Lactated Ringers Intravenous solution to right antecubital space –  
 Intubated with 7.0 OETT  
 FiO2 100%  
 Warming blanket and machine  
 MH cart and Code Blue cart outside of room/view  
 Mock OR documentation for RN circulator

### Documentation

MH participant activity sheets  
 MH worksheet that includes dantrolene mixing instructions  
 Medical and perioperative records  
 (forms completed to 10:55am)  
 Surgical verification process form (completed)  
 Visual aid to guide the preparation of dantrolene sodium

## 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:

Responsibility	Skill met	Action/Treatment Checklist
1st Respondent Any Team Member		Call for an MH Cart AND code cart to the room Appoint a team leader.
Anesthesia Provider		Stop the triggering agent Hyperventilate with 100% oxygen Obtain lab tests per physician order Call or assign a team member to call the MH Hotline 1-800-644-9737 Start arterial line and/or any additional IV lines 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) Treat dysrhythmias -beta blockers (no calcium channel blockers) Monitor renal function Place nasogastric tube
Circulator/RN		Call for additional help 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.
Circulator/RN II Other Respondents		Apply cooling measures; obtain chilled saline/ice and place on groin, axilla, around head Insert Foley catheter Insert rectal tube for lavage Cool IV fluids
Surgeon/Physician		Conclude procedure as soon as possible Notify the family of the patient's condition
OR Team		Call report to the intensive care unit

## 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**

**Signs of MH**  
 Increased ETCO<sub>2</sub>  
 Tachycardia/tachypnea  
 Trunk or total body rigidity  
 Masseter spasm or trismus  
 Acidosis  
 Increased temp (may be late sign)

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

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

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

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

Follow ETCO<sub>2</sub>, electrolytes, blood gases, creatine kinase (CK), core temperature, urine output and color, coagulation studies. If CK and/or K<sup>+</sup> 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

## Resources

### 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

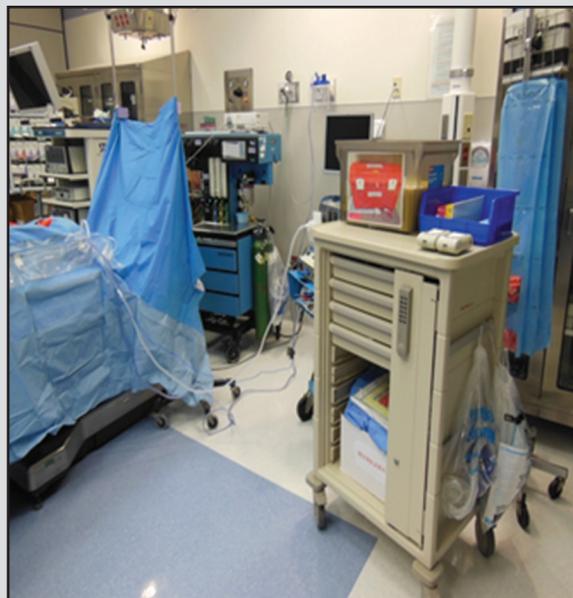
### Medications

- Dantrolene sodium
- Metoprolol injection
- Calcium chloride
- Esmolol
- Preservative free sterile water
- Mannitol 20%,
- Amiodarone
- Lasix
- IV NS

### Resources



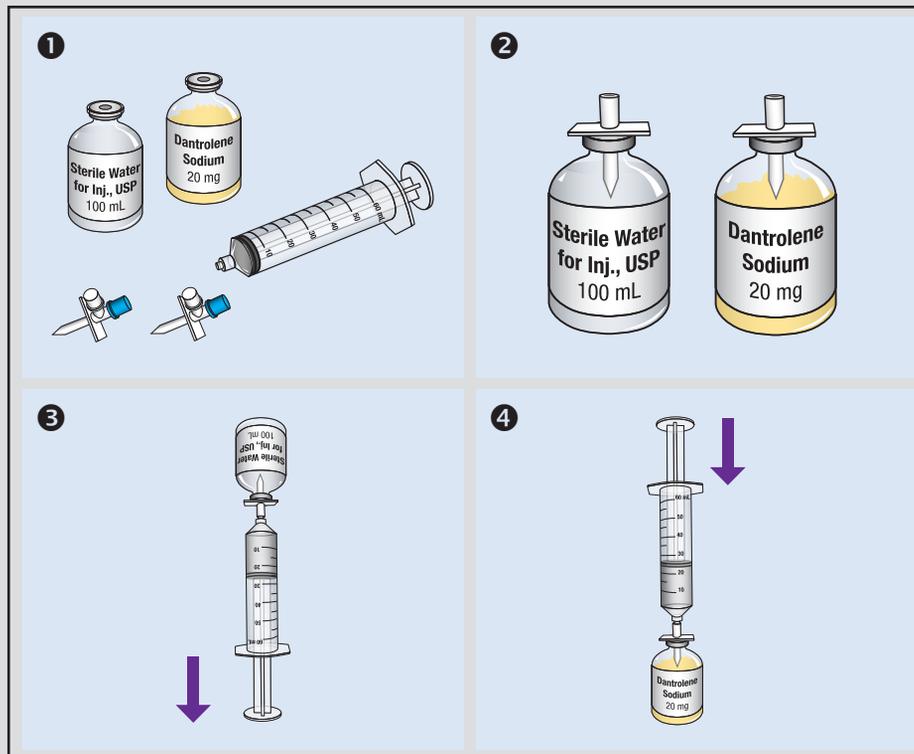
Example: Malignant hyperthermia cart



Example: Room set up

## Resources

Example: Visual aid to guide dantrolene sodium preparation



From Hirshey Dirksen SJ, Van Wicklin SA, Mashman DL, Neiderer P, Merritt DR. Developing effective drills in preparation for a malignant hyperthermia drill. *AORN J.* 2013;97(3):331-353. Reprinted with permission from AORN, Inc, Denver, CO.

**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.

## Resources

Example: Sample form

**Participant MH Worksheet for Proposed Correct Treatment**

**MH Hotline: 1-800-644-9737**

Patient \_\_\_\_\_ Last 4 \_\_\_\_\_ Weight \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_  
 Staff Present: Anesthesia \_\_\_\_\_ Surgeon \_\_\_\_\_ Primary RN \_\_\_\_\_ Other \_\_\_\_\_

**Immediate Actions**

Stop Triggering Agent       Notify Anesthesiologist on call  
 Hyperventilate               Call Code 99 or Rapid Response Team  
 Call MHAUS Hotline 1-800-644-9737

**Interventions**

Give dantrolene as indicated  
 Apply cooling measures (groin, axilla, head, under patient) discontinue when the 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:** watch for acidosis, increase PaCO2  
     – **Electrolyte panel:** increase K+, Ca++, MG++, decrease Na+  
     – **CBC:** decreased platelets  
     – **Coagulation studies:** prolonged PTT, PT    Watch for DIC (disseminated intravascular coagulation)  
     – **Serum studies:** increase CPK and myoglobin, creatinine, glucose, lactate

**Vital Signs**

Time	ETCO2	Temp	Pulse	Rhythm	BP	RR	SPO2	O2

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

Time	Medication	Route	Amount Given

**Dantrolene Given**

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

**Labs**

PH	PCO2	P02	HC03-	BE	Hct	O2Sat	Na+	K+	Ca++	Glucose	CK	Myoglobin

## Resources

## Malignant Hyperthermia Pre/Post Test

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

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