MALIGNANT HYPERTHERMIA MANAGEMENT

Site Applicability:
Richmond Hospital Operating Room

Practice Level:
RN - Specialized. OR/PACU/Critical Care RN who has completed a recognized OR/PACU/Critical Care course or has equivalent work experience.

Policy Statement:
An MH emergency cart is fully stocked and available for use at all times. All OR staff must be familiar with the location and contents of this cart.

All OR staff must be familiar with the management of patients susceptible to MH as well as the treatment protocol for MH crisis.

Continuing competency education for Malignant Hyperthermia (MH) management is provided yearly for OR & PACU nursing staff.

Need to Know:

Malignant hyperthermia (MH) is a rare, familial disorder of skeletal muscle calcium metabolism. MH is usually triggered when a susceptible individual is exposed to volatile inhalation anaesthetic agents and/or depolarizing skeletal muscle relaxants, i.e., Succinylcholine. Other drugs & conditions such as physical and emotional stress are also implicated as triggering agents in MH susceptible individuals (See Appendix 4).

The underlying pathology in MH is a defect in the sarcoplasmic reticulum (SR), the structure responsible for storage & release of calcium in muscle cells. When an MH susceptible patient is exposed to a triggering agent, it is believed that there is a prolonged opening of the SR calcium channel. This allows calcium to be released from the SR at an abnormally high rate. Subsequent calcium accumulation within the myocyte initiates prolonged **muscle contraction** followed by a series of **hypermetabolic** reactions. Generation of excess CO2, O2 depletion, muscle rigidity and massive heat production occur. Eventual cell death and rhabdomyolysis cause metabolic acidosis, hyperkalemia and myoglobinaemia/myoglobinuria. Secondary complications associated with the pathology of an MH crisis include acute renal failure, DIC, and cardiac dysrhythmias, especially ventricular in origin.

MH may onset at any time during anesthesia as well as in the early postoperative period. Early clinical signs of an MH crisis include an unexplained increase in PCO2/end tidal CO2 and/or muscle rigidity, in association with mixed respiratory & metabolic acidosis, tachycardia and dysrhythmias. Pyrexia is often a **late sign** but may develop rapidly – rates of 1°C every 3 to 5 minutes have been documented. (see Appendix 1). However, clinical presentation is not uniform.

When an MH crisis is recognized or suspected, triggering agents are stopped immediately and changed to non-triggering agents, including changeover of the anesthetic machine as applicable. **Dantrolene Sodium** is the only definitive treatment for MH and administration begins as soon as possible. All other treatments are directed towards managing symptoms or complications of MH such dysrhythmias, acidosis, hyperkalemia, and pyrexia Because MH typically occurs intraoperatively, PACU care focuses on managing the patient in the aftermath of an acute MH episode including:

- Maintaining therapy initiated emergently such as Dantrolene administration and cooling measures
- Supportive management of MH sequellae such as
  - Ventilatory support to help blow off excess metabolic CO2
  - Volume support to facilitate renal excretion of myoglobin
- Monitoring for & treating potential complications of acute MH such as
  - Recrudescence
  - Renal compromise
  - Dysrhythmias
  - Coagulopathies
- Providing emotional support to the patient and their family

Patients who have experienced an acute MH crisis are at risk for the following problems/complications:

- Temperature instability related to hypermetabolic response (acute); post-treatment relapse
- Respiratory insufficiency secondary to hypermetabolism (’ed O2 demand & ’d CO2 production
- Cardiac instability/dysrhythmias secondary to hyperkalemia, acidosis, O2 supply:demand imbalance
- Renal dysfunction secondary to myoglobinuria
- Coagulation dysfunction secondary to DIC
- Compartment syndrome
- Pain secondary to sustained muscle contraction
- Anxiety related to knowledge deficit of MH and its sequellae

Equipment and Supplies:

MH Cart (Appendix 5)
Invasive Monitoring Cart
Hypo/Hyperthermia Blanket
Blood Collection Equipment
Cooled NS IV Solution
Ice

Procedure/Protocol/Practice Guideline:

MH Susceptible Patient

When the Anesthesiologist identifies a patient who is at high risk for MH, preparations for care are as follows:

Pre-operative

- Have the MH cart and an Invasive Monitoring cart available.
- Place hypo/hyperthermia blanket on OR table.
- Changes to anesthetic machine (done by Biomed):
  Method 1
  - Remove the vaporizer or tape it in the "off" position.
  - Replace the free gas flow hose (FGF white hose) and flush the circuit system with O2 at 10L/min (if the FGF is not replaced, then flush for > 20 min).
  - Attach the unused breathing bag to the Y-piece end of the circuit system and set the ventilator to inflate the bag.
  - Use a new or disposable breathing circuit.

  OR

  Method 2
  - Opt to use a commercially available charcoal filter that has been shown to remove trace levels of volatile anesthetic agents within 10 minutes of application, without additional preparation. These filters may have to be regularly replaced during the anesthetic *(Vapor Clean™ charcoal filter system by Dynasthetics is good for 12 hours)*

  Note: A spare anesthetic machine is sometimes "stripped" ahead of time for use during MH cases (can be exchanged for the one that belongs in the room).

- Notify PACU that they will be receiving an MH susceptible patient post-operatively

Intra-operative

The Anesthesiologist will do the following:

- Administer non-MH triggering anesthetic agents (avoiding volatile inhalation anesthetics and succinylcholine). See Appendix 4.
- Monitor core temperature continuously.
- Obtain blood samples by drawing a mixed venous ABG to investigate CK, Ca2+
- Send random urine for urinalysis and urine for myoglobin and occult blood to the lab. Note: All specimens are sent "STAT"
- Observe for signs and symptoms that may indicate an MH crisis (see appendix 1).

Post-operative

The patient susceptible to MH undergoing outpatient surgery may be discharged on the day of surgery if the anesthetic has been uneventful.

- Minimum 1.0 (one) hour stay in PACU monitoring vital signs (including temperature) at least every 15 minutes. Discharge of the Post Anesthetic Patient-Phase I: PACU discharge criteria must be met.
- Minimum 1.5-hour stay in Surgical Day Care (Phase II).Discharge of the Post Anesthetic Patient-Phase II:SDC discharge criteria must be met. Temperature must be documented within 30 minutes of discharge.

For an MH Crisis:

Push the emergency call button to get help from OR, PACU, OR aide, etc. – MH crisis management requires at least the following extra staff:

- Two to mix Dantrolene
- One to obtain refrigerated materials
- One to obtain the crash cart, set up the central line, and prepare for specimen collection

The Anesthesiologist directs all treatment given. The circulating RN delegates duties to the extra staff as they arrive.

RN role/responsibilities are as follows:

- Assist Anesthesiologist to:
  - Discontinue anesthesia.
  - Hyperventilate the patient with 100% O2 at 10 L/min.
  - Monitor core temperature (both rectal and esophageal).
  - Obtain the MH and Invasive Monitoring carts.
- Reconstitute Dantrolene (refer to dosage chart, Appendix 3)
- Send the porter to Pharmacy for a backup supply of Dantrolene (18 vials).
- Set up two IV lines using chilled 0.9% NaCl, blood administration set, 4-way stopcock and extension set.
- Assist with the insertion of invasive monitoring devices.
- Co-ordinate sending of blood and urine samples with appropriate requisitions to the lab STAT.
- Monitor urine output for volume and colour.
- Assist with active cooling of patient (avoid over cooling):
  - Surface cooling with icepacks and ice
  - Cold saline lavage per rectum, NG tube or bladder catheter
  - Peritoneal lavage with sterile iced saline (if surgically open)
  - Hypo/hyperthermia blanket turned to cool temp setting

  Note: The **above interventions may not be performed in the order stated.**

- Notify PACU/ICU that they will be receiving a post-MH crisis patient once his/her symptoms have stabilized.
- Assist with transfer of the patient to PACU/ICU. Give a verbal report to the receiving RN.

Postoperative Management of a Patient with MH Crisis.

The care in PACU will continue the Malignant Hyperthermia Treatment Protocol (Appendix 2) for "Emergency Therapy for Malignant Hyperthermia" as recommended by the Malignant Hyperthermia Association of the U.S. (MHAUS).

These guidelines from MHAUS for "Emergency Therapy for Malignant Hyperthermia" are posted on the wall in the PACU nursing station, also see Appendix 2.

MHAUS Malignant Hyperthermia HOTLINE phone number is (1-315-464-7079). For additional MH contact numbers see Appendix 6.

Expected Patient/Client/Resident Outcomes

The patient will demonstrate resolution of the actual/potential MH event as evidenced by:

- Vital signs within normal limits for the patient
- Oxygenation and ventilation parameters within normal limits
- Stable, perfusing cardiac rhythm with no evidence of myocardial ischemia
- Normothermia
- Metabolic parameters – pH, HCO3-, CK, serum/urine myoglobin, electrolytes – within normal limits or with evidence of substantial resolution of previous abnormalities
- Renal function within normal limits
- Absence of unexpected/abnormal bleeding

Patient/Client/Resident Education:

Both patient and family require genetic counseling. Inform first-degree relatives, letter of explanation, notification of local hospitals, anesthesia departments, local MH authority (see below), family doctors, dentists, school nurses, and complete ADR report (adverse drug reaction).

- Possibly skeletal muscle biopsy testing
- Medic Alert bracelet (1-800-430-5378)
- Registration with the North American Malignant Hyperthermia Registry (717) 531-6939

Documentation

Document events in the Nurses' Notes section of the OR record. Include notation of reference to the Anesthetic Record for the treatment protocol followed.
Complete an SLS Safety Event Report, located on the VCH Intranet.
PACU documentation should be on the Perianesthesia Record.

Related Documents:

Signs and Symptoms of Malignant Hyperthermia Crisis (Appendix 1)
Malignant Hyperthermia Treatment Protocol (Appendix 2)
Dantrolene Drug Information Sheet (Appendix 3)
Triggering & Safe Agents For Malignant Hyperthermia (Appendix 4)
Malignant Hyperthermia Cart Contents (Appendix 5)
MH Contact Numbers (Appendix 5)

References:

Association of Operating Room Nurses, AORN Position Statement, Malignant Hyperthermia Guideline in AORN Standards, Recommended Practices & Guidelines (Denver: AORN, Inc, 2002) 71-9.
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Developed By:

CRN Operating Room
CRN PACU/SDC

Endorsed By:

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Appendix 1

Signs and Symptoms of
Malignant Hyperthermia Crisis

The following signs and symptoms of an MH crisis are listed in order or incidence (early signs → late signs).

- ↑$ETCO_2$; respiratory & metabolic acidosis
  (mixed venous gas = ↑pCO_2 >55, pH 7.3 or less)
- ↑HR (tachycardia), ↑ RR (tachypnea)
- Dysrhythmias (sinus tachycardia, nodal, ventricular); labile or ↑ BP
- Muscle rigidity – masseter rigidity (jaw) or generalized
- ↓SaO_2
- Fever (↑ temperature by 1 – 2^{o}C q 5 minutes → >41^{o}C)
- Cyanosis/mottling
- ↑CK (>1500 units/mL)
- Other hematological changes:
  - ↑K^+
  - ↑Na^+
  - ↑Ca^{2+}
  - ↑Lactate

MH should be considered in the differential diagnosis of ANY unexpected ↑$ETCO_2$, ↑HR, ↑RR, or ↑ temperature, and should be evaluated.
Most ***sensitive*** indicator of MH crisis: ↑$ETCO_2$
Most ***specific*** sign of MH crisis: total body rigidity

Appendix 2

MALIGNANT HYPERTHERMIA TREATMENT PROTOCOL

MH CRISIS

1. **DISCONTINUE** volatile inhalation agents, succinylcholine, and surgery
- Call for HELP
- O2 at flow rates ≥ 10L/min [↑MV 2 – 5x]
- No need to change the circuit system or CO_2 absorber (Baralyme)

2. **DANTROLENE** sodium [2.5 – 10 – 60]
- Bolus = 2.5 mg/kg IV push (1 mg/kg/ min)
- Subsequently = 1 mg/kg IV q 5-10 minutes until the signs and symptoms of MH are controlled (i.e. ↓$ETCO_2$ within 6 min.; ABG's normalized within 20 min.)
- Suggested maximum = 10 mg/kg (higher doses may be required in some cases)
- Most cases respond to 2.5 – 4 mg/kg.
- Each vial contains 20 mg Dantrolene, 3 g Mannitol and NaOH
  - Mix with 60 mL **warm** sterile water
- pH = 9.5 – may lead to phlebitis ∴ use large bore IV's
- Once reconstituted, use within 6 hours
- Protect from light

3. **ACIDOSIS**
- Correct metabolic acidosis by administering $NaHCO_3$ (8.4%)
- Initial dose = 1 – 2 mEq/kg *after* first ABG sent
- Thereafter: mEq HCO_3 = 0.3 x [base deficit x weight (kg)]
- Goal: pH = 7.2 – 7.3

4. **COOL**
- Cool NS (0.9% NaCl) 15 mL/kg IV q 15 min x 3 – large bore IV
  (Not Ringer's lactate – avoid solutions containing K^+)
- Lavage stomach, rectum, bladder and open cavities
- Surface cool (axilla groins, neck) with ice, cooling blanket, fan
- Goal: temp = 38°C

5. **DYSRHYTHMIAS** – *often respond to treatment of hyperkalemia and acidosis*
- Procainamide (10 mg/kg) or Lidocaine (1 mg/kg) are OK
- Avoid Ca^{2+} channel blockers (Verapamil or Diltiazem → ↑K^+, CV collapse)
- Dysrhythmias usually respond to treatment of acidosis and ↑K^+
- Early use of Dantrolene helps to prevent it.
- Beta-blockers (Esmolol, Propranalol) may mask the signs of tachycardia and are the second line agents

6. MONITOR/MEASURE

- ABG's (arterial, femoral, mixed venous/central)
- CVP
- Electrolytes: Na^+, K^+, Ca^{2+}, Cl^-, CK, LDH, myoglobin, lactate
- Serum CK peaks at 12 hours
- Coagulation (INR, PTT, fibrinogen, FDP)
- Urine myoglobin (myoglobin peaks at 4-8 hours)
  - Promote diuresis
  - Treat by ↑ IV fluids, Mannitol = 0.5 – 1 mg/kg, Furosemide = 0.25 – 0.5 mg/kg
  - Alkalinize urine to pH > 8.0 or serum pH 7.45 - 7.55
- Urine output – goal: $\geq$ 2 mL/kg/hr

7. ↑ POTASSIUM (K^+)

- 10% Calcium Chloride (2 – 5 mg/kg)
- Glucose (50 mL D50W) + insulin (10 units Humulin R)
- [Pediatrics 0.25 – 0.5 mg/kg D50W + 0.25 – 0.5 units/kg Humulin R]
- NaHCO3 (1 – 2 mEq/kg)
- Hyperventilation

Note: Sudden cardiovascular collapse/arrest in males age < 10 yrs after succinylcholine administration should be treated for ↑K^+ and presumed to have sub-clinical muscular dystrophy.

POST-ACUTE PHASE

1. OBSERVE

- Admit patient to ICU for $\geq$ 24 hours to observe for recrudescence (particularly fulminant cases resistant to treatment), and monitor for complications (renal failure secondary to myoglobinuria, DIC)
  - 25% of cases recrudesce within 24 – 36 hours

2. DANTROLENE

- 1 mg/kg IV q 6 h x 24- 48 hours post episode (oral Dantrolene produces unreliable serum levels and side effects)
- Oral dose may follow initial 48 hours
  - 4 – 8 mg/kg per day, divide to QID x 3 – 5 days.

3. MONITOR

- ABG's, CK, K^+, Ca^{2+}, myoglobin (serum, urine), coagulation, core temperature (esophageal, tympanic/nasopharyngeal, axilla, rectal, bladder, PA) until they return to normal values (K^+ and CK q 6 h)

4. ANALGESIA

- Narcotics are often required to treat the severe muscle tenderness – beware of compartment syndrome; ambulate slowly.

5. COUNSEL/REFER

- Both patient and family require genetic counselling. Inform first-degree relatives, letter of explanation, notification of local hospitals, anaesthesia departments, local MH authority (see below), family doctors, dentists, school nurses, and complete ADR report (adverse drug reaction).
- Possibly skeletal muscle biopsy testing
- Medic Alert bracelet (1-800-430-5378)
- Registration with the North American Malignant Hyperthermia Registry (717) 531-6939

Appendix 3

DANTROLENE

DOSAGE

Initial bolus:	2.5 mg/kg IV push (1 mg/kg/min)
Subsequent dose:	1 mg/kg IV q 5-10 min until symptoms controlled
Suggested maximum:	10 mg/kg (higher dose may be required)
Post-crisis:	1 mg/kg IV q 6 h x 24 – 48 hours
Follow up:	4 – 8 mg/kg orally per day, divide to QID x 3 – 5 days

MIXING INSTRUCTIONS

1. Obtain warm sterile H_2O (IV) from warming cupboard outside room 1.
2. Attach secondary line IV tubing and 4 way stopcock to sterile H_2O. Clamp tubing with roller clamp prior to spiking IV bag.
3. Attach 60 cc syringe to end of stopcock and turn "off" indicator towards H_2O bag.
4. Remove silver sealed top of Dantrolene vial with scissors or forceps.
5. Remove grey stopper from vial carefully so as not to contaminate the end.
6. Release roller clamp on IV tubing, turn stopcock "off" to extra port and withdraw 60 cc sterile H_2O into syringe. Return stopcock "off" to H_20 bag.
7. Inject 60 cc sterile H_2O into Dantrolene vial, replace grey stopper and shake vigorously to mix (this may take time).
8. Pour reconstituted solution into sterile blue bowl and draw up with another 60 cc syringe, or draw up directly from vial.
9. Attach 18g needle to syringe and give to anesthetist for administration.
10. Repeat steps 1 thru 9 until desired dose (as per anesthetist's order) has been reconstituted.

CALCULATION FOR NUMBER OF VIALS REQUIRED

Dose	2.5 mg/kg
Supply	20 mg/vial
Example:	70kg = 175mg = 9 vials (70kg x 2.5mg = 175mg; 175mg ÷ 20mg = 8.75 →9 vials)

Dantrolene Dosage Chart 2.5 mg/kg		
Patient Weight (kg)	**Minimum Vials Mixed***	**Dosage**
50	7-10	125 mg = 375 mL
55	7-10	130 mg = 390 mL
60	7-10	135 mg = 405 mL
65	7-10	140 mg = 420 mL
70	8-10	145 mg = 435 mL
75	8-10	150 mg = 450 mL
80	8-10	155 mg = 465 mL

Mix each vial with 60 mL warmed sterile **water**.

1 vial = 20 mg = 60 mL
1 mg = 3 mL

Once mixed, use within 6 hours. Protect from light.
(Additional 18 vials kept in Pharmacy Night Cupboard)

Procainamide Dosage Chart 10 mg/kg		
Patient Weight (kg)	**Dosage (mL)**	**Dosage (mg)**
50	5.0	500 mg
55	5.5	550 mg
60	6.0	600 mg
65	6.5	650 mg
70	7.0	700 mg
75	7.5	750 mg
80	8.0	800 mg

1 vial = 1 gram = 10 mL

To administer by infusion pump, refer to dosage chart in the manual of to of the crash cart.

Lidocaine Dosage Chart 1 mg/kg		
Patient Weight (kg)	**Dosage (mL)**	**Dosage (mg)**
50	2.5	50 mg
55	2.75	55 mg
60	3.0	60 mg
65	3.25	65 mg
70	3.5	70 mg
75	3.75	75 mg
80	4.0	80 mg

1 pre-filled syringe = 100 mg = 5 mL

Appendix 4

TRIGGERING & SAFE AGENTS FOR MALIGNANT HYPERTHERMIA

TYPE	AGENT
Triggering (Unsafe) Agents	Depolarising Muscle Relaxants Succinylcholine ALL Volatile General Anaesthetics, e.g. Desflurane Sevoflurane Isoflurane Enflurane Ether Other K+ salts Ca++ Channel Blockers (not a trigger but can precipitate hyperkalemia and/or cardiac arrest when used with Dantrolene sodium)
Non-Triggering (Safe) Agents	ALL Non-Depolarising Muscle Relaxants, e.g. Rocuronium Vecuronium Cisatracurium Mivacurium, etc Nitrous Oxide Intravenous Anaesthetics, e.g. Ketamine (does not trigger but not recommended due to sympathomimetic effects) Propofol Sodium thiopental Opioids Benzodiazepines ALL Ester & Amide Local Anaesthetics, e.g. Reversal Agents Neostigmine with Atropine or Glycopyrolate Edrophonium Other All standard ACLS drugs with the exception of Ca++ Channel blockers
Other (Possible) Triggers	Shivering Significant emotional/physical stress Pain Anxiety/agitation

Appendix 5

MALIGNANT HYPERTHERMIA CART CONTENTS

TOP SHELF	
Unsterile scissors *(hanging down side of cart)*	
Dantrolene Sodium 20 mg vials	18
Sterile Water 1000cc bags	2
Dextrose 50% in 50mL pre-filled syringe	2
Sodium Bicarbonate 50 mEq in 50mL pre-filled syringe	6
MH reference duotang and articles	
Requisitions for bloodwork, urinalysis, night cupboard	
Mannitol 20% in 500mL water (pre-mixed)	2
Furosemide 20mg/2mL	5
Procainamide 100mg/mL (10mL vial)	2
60 mL syringe (luer lock)	4
Urinalysis containers	6
Reconstitution devices	3
IV tubing set	2
IV extension set	2
4-way stopcock	3
#14 gauge Jelco	4
Blood gas kits	4
18 gauge needles	6
Insulin syringes	2
Vacutainers for blood work specimens (yellow, purple, blue)	
***** Lidocaine and Calcium Chloride for injection can be found on crash cart *****	
SECOND SHELF	
Foley catheters #8, 10, 12, 14, 16, 18 Fr	1 each
CBI (3 way) Foley catheters #18, 20, 22, 24 Fr	1 each
Foley catheter insertion tray	1
Urometer drainage bag	1
Y-type cysto tubing	1
60mL syringe (catheter tip)	2
Foley catheter plug	1
Sterile bowl	1
Rectal temperature probe & adaptor	1
Pressure infusion bag (1000 cc)	2
Blood transfusion sets (“Y” tubing)	2
BOTTOM SHELF	
Adult Ambu-bag	1
Pediatric Ambu-bag	1
Fresh CO2 absorber	1
Baralyme	2
Fresh gas flow hose (special white hose hangs on the cart)	1
Anesthesia breathing circuit – disposable – Adult	1
Anesthesia breathing circuit – disposable – Pediatric	1
Anaesthesia ventilation bag *(new in package)*	2
Vapor Clean™ charcoal filters (Dynasthetics)	

ADDITIONAL ITEMS NEEDED FOR MH MANAGEMENT

INVASIVE MONITORING CART	
Blood gas kits	4
Blood gas requisitions	4
CVP supplies	
Arterial line supplies	
Esophageal temperature probe & adaptor	
REFRIGERATOR	
NaCl 0.9% 1000cc bags (IV infusion)	6
NaCl 0.9% 1L bottles (for irrigation)	4
Insulin Humulin Regular	
Nacl 0.9% 3L bags (for CBI)	2
NG tubes (14 Fr, 16 Fr)	2
Crushed ice (freezer)	2 bags
Ice packs (freezer)	
MISCELLANEOUS	
Ice (PACU)	
Buckets for ice (SPD)	
Hypo/Hyperthermia blanket	
IVAC pump	
Extra suction	

Appendix 6

MH CONTACT NUMBERS

MH hotline:	(315) 428-7924 or 1-800-644-9737
Local MH Authority:	BC Women's Hospital, Vancouver, BC 604-875-2158
Canadian Malignant Hyperthermia Association	(416) 340-3128 Fax: (416) 340-4960 Website: www.mhcanada.org
Malignant Hyperthermia Investigation Unit	Department of Anesthesia Toronto General Hospital Toronto, ON M5G 2C4 (416) 340-3128
MHAUS – Malignant Hyperthermia Association of the United States	Website: www.mhaus.org Phone: (315) 464-7079 (outside USA)
MHAUS MH Registry	1-888-274-7899 email: bwb+@pitt.edu

MH Testing Centres

University of Manitoba
Winnipeg, Manitoba R3A 1S1
(204) 787-2560 Fax: (204) 787-4807

Toronto General Hospital
Toronto, Ontario M5G 2C4
(416) 340-3128 Fax: (416) 340-4960

Ottawa Civic Hospital
Ottawa, Ontario K1Y 4E9
(613) 761-4169 Fax: (613) 761-5209