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# Emergency Therapy for MALIGNANT HYPERTHERMIA

CAUTION! This protocol may not apply to all patients; alter for specific needs.

Effective February 2015

## DIAGNOSIS

### Signs of MH:

- Increasing  $\text{ETCO}_2$  (despite hyperventilation)
- Trunk or total body rigidity
- Masseter spasm or trismus
- Tachycardia/tachypnea
- Mixed respiratory and metabolic acidosis (MH can occur without significant metabolic acidosis)
- Increased temperature (may be an early or a late sign)
- Myoglobinuria

### Sudden/Unexpected Cardiac Arrest in Young Male Patients:

- Presume hyperkalemia and initiate treatment (see #6)
- Measure blood gases and electrolytes
- Measure CK, myoglobin, ABGs, until normalized
- Usually secondary to occult myopathy (e.g., muscular dystrophy)
- Resuscitation may be difficult and prolonged
- Myoglobinuria is common

### Trismus or Masseter Spasm with Succinylcholine

- Early sign of MH in many patients
- If limb muscle rigidity, begin treatment with dantrolene.
- For emergency procedures, continue with non-triggering agents, evaluate and monitor the patient, and consider dantrolene treatment.
- Check CK immediately and at 6-8 hr intervals until returning to normal. Observe for dark- or cola-colored urine. If present, liberalize fluid intake and test for serum and urine myoglobin. (see D below)
- Observe in PACU or ICU for at least 24 hours if metabolic signs of MH were present.

## ACUTE PHASE TREATMENT

### 1 GET HELP. GET DANTROLENE. Notify Surgeon. Call MH Hotline.

- Discontinue volatile agents and succinylcholine.
- Hyperventilate with 100% oxygen at flows of 10 L/min. to flush volatile anesthetics and lower  $\text{ETCO}_2$ . If available insert activated charcoal filters into the inspiratory and expiratory limbs of the breathing circuit. The Vapor-Clean™ filter may become saturated after one hour; therefore, a replacement set of filters should be substituted after each hour of use.
- Halt the procedure as soon as possible; if it is not possible to stop surgery, continue with non-triggering anesthetic technique.
- Don't waste time changing the circle system and  $\text{CO}_2$  absorbent.

### 2 Dantrium®/Revonto®/Ryanodex® 2.5 mg/kg rapidly IV, if possible through large-bore IV

To convert kg to lbs for amount of dantrolene, give patients 1 mg/lb (2.5 mg/kg approximates 1 mg/lb).

- Dantrium/Revonto – Each 20 mg vial should be reconstituted with at least 60 mL sterile water for injection, USP (without a bacteriostatic agent). There are 3 grams of mannitol in each 20 mg vial of Dantrium and Revonto.
- Ryanodex – Each 250 mg vial should be reconstituted with 5 mL sterile water for injection, USP (without a bacteriostatic agent) and shaken to ensure an orange-colored uniform, opaque suspension. There are 125 mg of mannitol in each 250 mg vial of Ryanodex.
- Repeat until signs of MH are reversed.
- Sometimes more than 10 mg/kg (up to 30 mg/kg) of dantrolene is necessary.

### 3 Bicarbonate for metabolic acidosis

- 1-2 mEq/kg if blood gas values are not yet available

### 4 Cool the patient

- If core temperature > 39°C Apply ice to surface.
- Infuse cold saline intravenously.
- Lavage open body cavities.
- Other cooling techniques may be applied at clinician's discretion.
- Stop cooling if temperature < 38°C and falling to prevent hypothermia.

### 5 Dysrhythmias

Usually responds to treatment of acidosis and hyperkalemia.

- Use standard drug therapy **EXCEPT avoid calcium channel blockers— (may cause hyperkalemia or cardiac arrest in the presence of dantrolene).**

### 6 Hyperkalemia

Treat with hyperventilation, bicarbonate, glucose/insulin, calcium.

- Bicarbonate 1-2 mEq/kg IV
- For pediatric, 0.1 units regular insulin/kg and 2 mL/kg 25% dextrose or for adult, 10 units regular insulin IV and 50 mL 50% dextrose
- Calcium chloride 10 mg/kg IV or calcium gluconate 10-50 mg/kg IV for life-threatening hyperkalemia
- Check glucose levels hourly.

### 7 Follow...

$\text{ETCO}_2$ , minute ventilation electrolytes, blood gases, CK, core temperature, urine output and color, coagulation studies. If CK and/or  $\text{K}^+$  rise more than transiently or urine output falls to less than 0.5 mL/kg/hr, induce diuresis to > 1 mL/kg/hr and give bicarbonate to alkalinize urine and prevent myoglobinuria-induced renal failure (see D below).

- Venous blood gas (e.g., femoral vein) values may document hypermetabolism earlier than arterial values.
- Central venous or PA monitoring as needed.
- Place Foley catheter and monitor urine output.

## POST ACUTE PHASE

**A** Watch for MH relapse by continuously evaluating the patient for at least 24 hours following cessation of signs of MH. 25% of MH events relapse, which can be fatal. Treat immediately if relapse occurs. Signs of MH relapse include:

- Increasing muscular rigidity in the absence of shivering
- Inappropriate hypercarbia with respiratory acidosis
- Metabolic acidosis without other cause
- Inappropriate temperature rise

**B** Give dantrolene, 1 mg/kg IV q 4-6h or 0.25mg/kg/hr by infusion and continue for at least 24 hr and sometimes longer as clinically indicated.

Dantrolene can be stopped, or the interval between doses increased to q8h or q12h if all of the following criteria are met:

- Metabolic stability for 24 hours
- Core temp is less than 38°C
- CK is decreasing
- No evidence of myoglobinuria
- Muscle is no longer rigid

**C** Follow vital signs and labs as above (see #7)

- Frequent blood gases as per clinical signs

**D** CK every 6 hours; less often as the values trend downward

Follow urine myoglobin and institute therapy to prevent myoglobin and the subsequent development of acute renal failure. CK levels above 10,000 IU/L is a presumptive sign of rhabdomyolysis and myoglobinuria. Follow standard intensive care therapy for acute rhabdomyolysis and myoglobinuria by hydration and diuretics (urine output > 2 mL/kg/hr along with alkalinization of urine with Na-bicarbonate infusion and careful attention to both urine and serum pH values).

**E** Counsel the patient and family regarding MH and further precautions; refer them to MHAUS. Fill out and send in the Adverse Metabolic Reaction to Anesthesia (AMRA) form ([www.mhreg.org/registry](http://www.mhreg.org/registry)) and send a letter to the patient and her/his physician. Refer patient to the North American MH Registry and the nearest Biopsy Center for follow-up.

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