SOCIETY FOR AMBULATORY ANESTHESIA
Outpatient • Office Based • Non-Operating Room

2022 SAMBA ANNUAL MEETING
MAY 11 – 14, 2022

Diagnosis, management and treatment of Malignant Hyperthermia (MH) in a free standing hospital-based Ambulatory Surgery Center (ASC).

Different types of Dantrolene – which ones makes the most sense to stock

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MH Case Presentation

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20 year-old 88.5kg male with past medical history of mild asthma who presents for bilateral endoscopic frontal sinusotomy, ethmoidectomy, maxillary antrostomy, sphenoidotomy, septoplasty with submucous resection of turbinates, and excision of concha bullosa under general anesthesia.

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Induction

The patient was induced the following medications:

- Midazolam 2mg pre-operative for anxiolysis
- Propofol 300 mg IV
- Lidocaine 100mg IV
- Rocuronium 10mg IV
- Succinylcholine 140 mg IV

Intubation was successful use a size #2 miller blade with a grade 1 view and a size 7.5 endotracheal tube secured at 23cm. Positive ETCO2 noted and breath sounds were equal bilaterally.

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Maintenance

The patient was maintained under with Sevoflurane, Remifentanil infusion, a background Propofol infusion, and at 30% oxygen gas flow.

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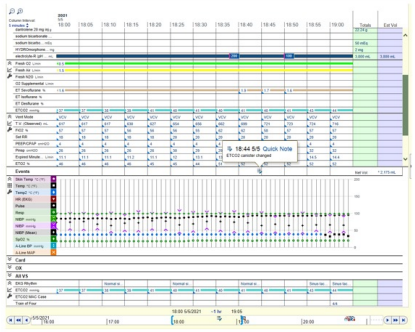
Intraoperative Record



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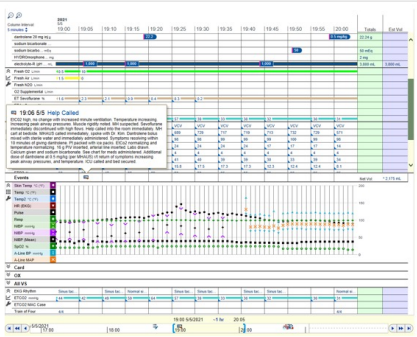
Intraoperative Record



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Timeline

- 1414 – Induction
- 1430 - Starting ETCO2 38 mmHg
- 1630 – Increase in minute ventilation
  - *ETCO2 38 mmHg*
- 1700 – Increase in minute ventilation
  - *ETCO2 37 mmHg*
  - *HR 85 BPM*
  - *Temp 36.9C*
- 1820 – Increase in minute ventilation
  - *ETCO2 41 mmHg*
  - *HR 88 BPM*
  - *Temp 37.9C*

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Timeline

- 1844 – Sodalime absorber canister changed by anesthesia provider
  - *ETCO2 52 mmHg*
  - *HR 93 BPM*
  - *Temp 38.4C*
- 1855 – Anesthesia provider change of staff
  - *ETCO 52 mmHg*
  - *HR 93 BPM*
  - *Temp 38.7C*
- 1906 – Call for help
  - *HR 96 BPM*
  - *Temp 38.6C*
  - *No Change in ETCO2 with increased minute ventilation*
  - *Muscle rigidity noted*
  - *Sevoflurane discontinued*
  - *Total intravenous anesthesia (TIVA) with Propofol started*

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Malignant Hyperthermia (MH)

- Malignant Hyperthermia is a pharmacogenic disorder of skeletal muscle
- Individuals have abnormal skeletal-muscle ryanodine receptors
- An inherited autosomal-dominant trait
- MH episodes have been estimated to occur in the general population in 1:100,000 administered anesthetics
- Triggering Agents
  - *Volatile anesthetics agents*
  - *Succinylcholine*
- Timing of Presentation
  - *Can occur soon after induction of general anesthesia*
  - *Can occur any time during the maintenance phase of general anesthesia*

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Clinical Signs of MH

Sequence of clinical signs of malignant hyperthermia

Frequent initial clinical signs of MH
• Hypercarbia (elevated end-tidal CO_2) resistant to increases in minute ventilation
• Tachypnea (or breathing over the ventilator)
• Sinus tachycardia
Unusual initial clinical signs of MH
• Masseter spasm with or without administration of succinylcholine
• Generalized muscular rigidity
• Peaked T waves or other arrhythmia (including ventricular tachycardia or fibrillation) resulting from sudden acute hyperkalemia
• Hyperthermia (variable rates of rise)
• Sweating
Delayed clinical sequelae of MH
• Cola-colored urine (myoglobinuria) resulting from significant rhabdomyolysis
• Disseminated intravascular coagulation (from prolonged or severe hyperthermia)

The sequence and timing of clinical presentation of MH varies. This table shows the initial and delayed signs of MH, based on reported cases.

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Clinical Signs of MH

Prevalence of clinical signs during malignant hyperthermia episode

Clinical sign	Percentage with sign
Hypercarbia	92.2
Sinus tachycardia	72.9
Rapidly increasing temperature	64.7
Elevated temperature	52.2
Generalized muscular rigidity	40.8
Tachypnea	27.1
Masseter spasm	26.7
Sweating	17.6
Cola-colored urine	13.7
Cyanosis	9.4
Ventricular tachycardia	3.5
Excessive bleeding	2.7
Ventricular fibrillation	2.4

Clinical signs of malignant hyperthermia, listed with the prevalence with which each was noted in 255 patients reported to the North American MH Registry from 1987 to 2006. Signs such as hypercarbia and tachycardia were defined as being inappropriate to the clinical situation. Notably, 79.6 percent had one or more signs indicative of muscular involvement (masseter spasm, generalized muscular rigidity, cola-colored urine, peak creatinine kinase >10,000 units/L, or peak potassium >6.0 mEq/L).

Data from: Larach MG, Gronert GA, Allen GC, et al. Clinical presentation, treatment, and complications of malignant hyperthermia in North America from 1987 to 2006. Anesth Analg 2010; 110:498.

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Management of MH

Management
Call for help and MH cart; for questions at any time call MH hotline: 1-800-644-9737 in US, 1-209-417-3722 outside US
Discontinue inhaled anesthetics and succinylcholine; increase fresh gas flow to ≥ 10 L/minute, use non-triggering agents for remainder of procedure
Notify surgeon; complete surgical procedure as quickly as possible
Hyperventilate with 100% oxygen, perform endotracheal intubation if ETT not in place
Insert carbon filters into breathing circuit after flushing the breathing circuit for ≥90 seconds at ≥10 L/minute fresh gas flow
Administer dantrolene:
• Initial dose 2.5 mg/kg IV rapid bolus; eg, for a 70 kg patient, administer 175 mg IV
◦ For older dantrolene preparations (ie, Dantrium, Revonto, or dantrolene sodium), dilute each 20 mg vial with 60 mL sterile preservative-free water; eg, for 70 kg patient, prepare nine 20 mg vials
◦ For Ryanodex, dilute a 250 mg vial with 5 mL sterile preservative-free water
• Watch for reversal of clinical signs ($ETCO_2$ should begin to normalize); repeat dantrolene bolus (2.5 mg/kg IV) as necessary; cumulative doses ≥10 mg/kg IV may be required
Send laboratory studies: venous or arterial blood gases, electrolytes, CK; repeat as necessary
• Treat hyperkalemia in patients with arrhythmias or potassium >6 mEq/L
◦ Calcium:
▪ Calcium chloride
▪ Adult: 0.5 to 1 g IV (5 to 10 mL of 10% solution) per dose;
▪ Pediatric: 10 to 20 mg/kg IV (0.1 to 0.2 mL/kg 10% solution), maximum 2 g (20 mL) per dose
Repeat after five minutes if ECG changes persist

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Management of MH

- Calcium gluconate
  - Adult: 1.5 to 3 g IV (15 to 30 mL of 10% solution);
  - Pediatric: 60 to 100 mg/kg IV (0.6 to 1 mL/kg of 10% solution), maximum 3 g (30 mL) per dose
- Sodium bicarbonate: 1 to 2 mEq/kg IV push over 5 to 10 minutes (maximum 100 mEq per dose); do not administer sodium bicarbonate in the same line as calcium
- Insulin and dextrose: check blood glucose hourly
  - Adult: 10 units IV regular insulin IV push with 50 mL IV 50% dextrose
  - Pediatric: 0.1 units/kg insulin IV push with 0.5 g/kg dextrose (eg, 1 mL/kg 50% dextrose or 2 mL/kg 25% dextrose)
- Treat metabolic acidosis with base deficit ≥8 mEq/L with sodium bicarbonate 1 to 2 mEq/kg IV over 5 to 10 minutes, maximum 100 mEq per dose.

Treat arrhythmias per ACLS, avoid calcium channel blockers; most arrhythmias respond to correction of hyperkalemia and acidosis

Cool the patient as necessary: Start cooling for core temperature >39°C, discontinue cooling when temperature decreases to 38°C

Insert Foley catheter, maintain urine output at 1 to 2 mL/kg/hour with IV fluid and diuretics

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Lab Values

Laboratory values in acute malignant hyperthermia

Laboratory study	Laboratory value that supports the diagnosis of MH
$PaCO_2$	>60 mmHg during controlled ventilation
	>65 mmHg during spontaneous ventilation
Serum potassium	>5 mEq/L, in patients without renal failure
Arterial pH	<7.25
Base deficit	≥8 mEq/L
Creatine kinase*	>20,000 units/L after administration of succinylcholine
	>10,000 units/L without administration of succinylcholine
Urine myoglobin*	>60 mcg/L
Serum myoglobin*	>170 mcg/L

Typical laboratory values used to confirm the diagnosis of acute malignant hyperthermia.

$PaCO_2$: partial pressure of arterial carbon dioxide; MH: malignant hyperthermia.

* Creatine kinase and myoglobin levels peak at approximately 14 hours after an acute MH event.

Adapted from: Larach MG, Localio AR, Allen GC, et al. A clinical grading scale to predict malignant hyperthermia susceptibility. Anesthesiology 1994; 80:771.

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Ongoing Care

- Arrange ICU bed for at least 24 hours
  - *Monitor for recurrence, rhabdomyolysis, DIC*
- After initial MH event is controlled, administered Dantrolene 1mg/kg IV every four to six hours or 0.25 mg/kg/hour for at least 24 hours

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Different types of Dantrolene – which ones makes the most sense to stock?

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Types of Dantrolene

- Dantrium 20mg powder vials
- Revonto 20 mg powder vials
- Ryanodex 250mg powder vials

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Types of Dantrolene

- Dantrium (per Pharmaceutical) and Revonto (US Worldsmeds)
  - *Advantages*
    - *Used successfully for years*
    - *Cost $2,000.00 - $3,000.00*
    - *Longer shelf life of 3 years*
  - *Disadvantages*
    - *Excessive fluid load*
    - *Significant time required to reconstitute vials to deliver total dose*
    - *Must be administered through a large vein to prevent tissue necrosis in the event of accidental extravascular injection*

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Types of Dantrolene

- Ryanodex (Eagle Pharmaceutical)
  - *Advantages*
    - *Can be prepared in a more expedited manner*
    - *Administered manner potentially reducing MH-related complications*
    - *Consider stocking in high areas in the United States which include Wisconsin, Nebraska, West Virginia, and Michigan*
  - *Disadvantages*
    - *Cost $6,000.00 – $7,000.00 for 3 vials*
    - *Shorter shelf life of 2 years*

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Joint statement by SAMBA and the ASA committee on Ambulatory Surgical Care regarding the use of succinylcholine for emergency airway management and the need for Dantrolene.

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Consensus Statement

Class B ambulatory and office-based surgery facility

- Provide oral, parental, or intravenous sedation and analgesic drugs for minimally to moderate invasive procedures
- Do not provide general anesthesia
- Do not need to stock Dantrolene if patients are not exposed to known MH triggers
- Only use succinylcholine for emergency airway use
  - *Risk of laryngospasm is hundreds of times higher than risk of MH from succinylcholine alone*
- Establishment of preexisting agreement with the nearest health care facility that stocks Dantrolene and ensuring that MH-susceptible patients are care for in a facility that stocks Dantrolene

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Conclusions

Diagnosis of MH

- *Increasing ETCO2 despite increasing minute ventilation*
- *Muscle rigidity*
- *Arrythmias and tachycardia is most common*
- *Mixed respiratory/metabolic acidosis*
- *Hyperthermia*
- *High index of suspicion*

Treatment

- *Discontinue triggering agents*
- *100% oxygen*
- *Dantrolene*
- *Call MHAUS for Help (800)-644-9737*
- *Preexisting agreement with nearest health facility for transfer of MH patients*

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Conclusions

Stocking of Dantrolene

- *If triggering agents are being used*
- *Class B ambulatory and office-based surgery facilities do not need to stock Dantrolene*

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3. Joshi GP, Desai MS, Gayer S, Vila H Jr; for Society for Ambulatory Anesthesia (SAMBA). Succinylcholine for emergency airway rescue in class B ambulatory facilities: the Society for Ambulatory Anesthesia position statement. Anesth Analg. 2017;124(5):1447–1449.
4. Larach MH, Gronert GA, Allen GC, et al. Clinical presentation treatment, and complications of malignant hyperthermia in North America from 1987 to 2006, Anesth Analg 2010; 110: 498.
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6. Revonto (dantrolene) package insert. Louisville, KY: WorldMeds, LLC; October 2016.
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Questions

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