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Malignant Hyperthermia

Eric Weberding
Otterbein University, eric.weberding@otterbein.edu

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Eric D. Weberding BSN, RN
Otterbein University, Westerville, Ohio

Definition

Malignant hyperthermia (MH) is an autosomal-dominant disorder that is inherited. The disturbance of calcium homeostasis associated with MH affects skeletal muscle (Schneiderbanger, Johannsen, Roewer, & Schuster, 2014). This hypermetabolic muscular disorder is triggered by exposure to depolarizing muscle relaxants such as succinylcholine or inhaled halogenated volatile anesthetics such as sevoflurane, halothane, desflurane, enflurane, and isoflurane (Stratman, Flynn, & Hatton, 2009). In susceptible individuals, this potentially lethal syndrome may cause hyperthermia, hypercapnia, muscular rigidity, hypoxemia, acidosis, tachycardia, and hyperkalemia (Schneiderbanger et al., 2014).

Relevance

MH occurs more often in children and young adults than in the adult population. MH occurs more often in adult males than adult females. Distribution across ethnicities occurs in equal proportions (Stratman et al., 2009). While a link between MH and numerous myopathies is suspected, a predisposition has only been identified in Evans myopathy, central-core disease, and King-Denborough syndrome (Stratman et al., 2009).

Although MH is a rare inherited disorder, this potentially life-threatening inherited disorder may occur approximately once in every 3,000 procedures involving general anesthesia (Beggs, McCann, & Powers, 2012). While obtaining thorough patient and family histories related to anesthesia events will reduce occurrences of MH, many individuals are unaware of their own predisposition to this disorder and relevant family histories. More efficient treatment of MH and improved understanding of the pathophysiology related to this disorder have resulted in an 11.7% decline in the mortality rate from MH from 2000 to 2005 (Johns, Stoudt, Scholtis, & Gavel, 2012).

However, to further improve outcomes for patients with malignant hyperthermia, it is imperative for multidisciplinary medical team members to promptly recognize early symptoms of MH, accurately diagnose this disorder, and respond swiftly with the appropriate treatment (Dirksen, Van Wicklin, Mashman, Neiderer, & Merritt, 2013).

Signs & Symptoms

Table 1 Clinical signs of malignant hyperthermia (Schneiderbanger et al., 2014, p.358)

Early	Late
Masseter spasm	Hyperthermia
Generalized muscular rigidity	Rhabdomyolysis
Tachycardia (>80%)	Acute renal failure
Hypercapnia	Cardiac arrhythmia
Hypoxia	Hypotension
Combined metabolic-respiratory acidosis	Circulatory failure

Underlying Pathophysiology

Individuals with MH have a mutation of the ryanodine receptor subtype 1 (RYR1) gene on chromosome 19q 13.1-13.2 (Li, Brady, Rosenberg, & Sun, 2011; Thomas & Crowhurst, 2013). When the dysfunctional receptor is exposed to triggering agents, such as halogenated volatile anesthetics and succinylcholine, a depolarizing neuromuscular blocking agent, the prolonged opening of this dysfunctional receptor occurs and results in the uncontrolled release of calcium within the skeletal muscle sarcoplasmic reticulum causing a hypermetabolic state in the susceptible individual (Kim, 2012).

As a result of this uncontrolled release of calcium and continuous muscle activation, muscle rigidity occurs. As these events continue, cellular adenosine triphosphate is depleted resulting in protracted muscular rigidity and eventually rhabdomyolysis. Rhabdomyolysis occurs when cell contents such as creatine phosphokinase, potassium, and myoglobin are released into circulation due to the deterioration of the cell membrane. Also, in a MH event, oxygen consumption is increased due to the continuous activation of aerobic and anaerobic metabolism. This increase in oxygen consumption results in acidosis, hypoxia, increased body temperature, and excessive production of CO_2 (Schneiderbanger et al., 2014). Figure 1 illustrates the pathophysiological changes that occur during a malignant hyperthermia event.

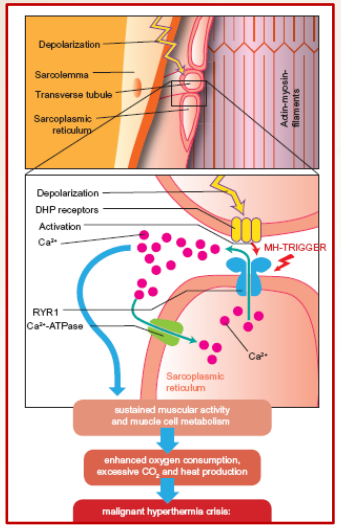


Figure 1 Pathophysiologic changes during a MH event (Schneiderbanger et al., 2014 p. 357)

Significance of Pathophysiology

The following physiologic manifestations are linked to MH:

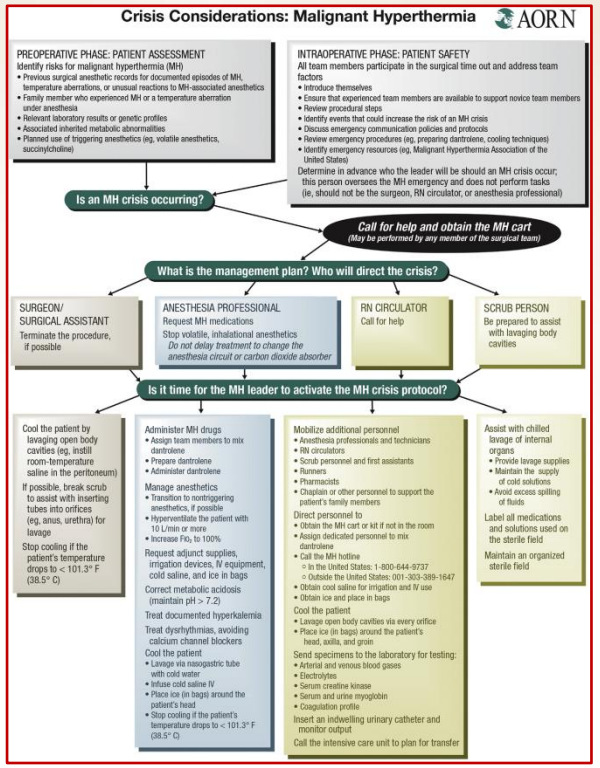
1. *Muscular rigidity most often involving the masseter:* results from the uncontrolled and ongoing release of calcium from the sarcoplasmic reticulum (Schuster, Johannsen, Schneiderbanger, & Roewer, 2013).
2. *Hyperthermia:* results from the increased use of adenosine triphosphate combined with the constricting peripheral vasculature. The body's ability to dissipate heat is markedly impaired (Schneiderbanger et al., 2014).
3. *Increased $ETCO_2$:* results from an increase in myoplasmic calmodulin-dependent protein kinase (Ca^{2+}). An unexplained increase in $ETCO_2$ is a common and early sign of MH in mechanically ventilated and intubated patients (Kim, 2012).
4. *Acidosis:* respiratory acidosis results from increased CO_2 levels. Metabolic acidosis results from increased lactate levels (Dirksen et al., 2013).
5. *Myoglobinuria:* results from damage to the cell membrane allowing intracellular contents, such as magnesium, potassium, creatine, and myoglobin to seep into the bloodstream (Dirksen et al., 2013).
6. *Renal Failure:* due to cell membrane damage, released myoglobin obstructs renal tubules causing acute renal failure (Kim, 2012).
7. *Tachycardia/tachypnea:* Excessive amounts of CO_2 (hypercarbia) and excessive K (hyperkalemia) in the blood stimulate the sympathetic nervous system resulting in rapid heart rate and/or rapid breathing (Dirksen et al., 2013).
8. *Cardiac arrhythmias/failure:* Potentially fatal dysrhythmias occur due to hyperkalemia and the kidneys inability to excrete excess K (Dirksen et al., 2013).

Implications for Nursing Care

- ✓ MH treatment objectives: stop the abnormal metabolic reaction with dantrolene and restore normal hemodynamic conditions, temperatures, and metabolic functions. (Seifert, Wahr, Pace, Cochrane, Bagnola, 2014)
- ✓ Recommended management approach: Utilize a multidisciplinary medical team trained to promptly and accurately diagnose MH, work cooperatively, understand multiple roles and responsibilities, and efficiently utilize readily available equipment and medications; medical teams should periodically review MH protocol and participate in mock drills to practice tasks and roles (Dirksen, 2013)
- ✓ See Figure 2 for recommended roles and treatment

Implications for Nursing Care

Figure 2 Personnel roles and treatment interventions in a MH event (Seifert et al., 2014, p. 197)



Conclusions

The ultimate goal is to prevent the occurrence of MH. As discussed by Beggs, McCann, and Powers (2012), prior to the administration of anesthesia, obtaining thorough patient and family histories related to adverse anesthesia reactions may alert the anesthesia provider to the patient's possible predisposition to MH and dictate the selection of non-triggering MH anesthesia agents. However, when prevention is not realized, continued vigilance and crisis preparedness on the part of multidisciplinary medical team members will further reduce the MH mortality rate and improve patient outcomes (Schneiderbanger et al., 2014).

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