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Malignant Hyperthermia

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Introduction: Malignant Hyperthermia

- Malignant Hyperthermia (MH) is a life-threatening disease process that can be fatal if untreated.
- MH is an autosomal dominant pharmacogenetic disorder (Smith et al., 2018).
- This disorder is often precipitated by the use of volatile anesthetics and depolarizing muscle relaxants.
- Although MH is fairly uncommon, it accounts nearly 1% of all anesthesia related deaths (Bamaga et al., 2016).

Why Malignant Hyperthermia?

- MH can be caused by medications frequently administered by the anesthesia team.
- Anesthesia providers and nurses are tasked with early detection, treatment, and clinical monitoring for patients who develop MH.
- Vigilance along with proper education and training on this disease process can help reduce fatalities associated with MH (Smith et al., 2018).

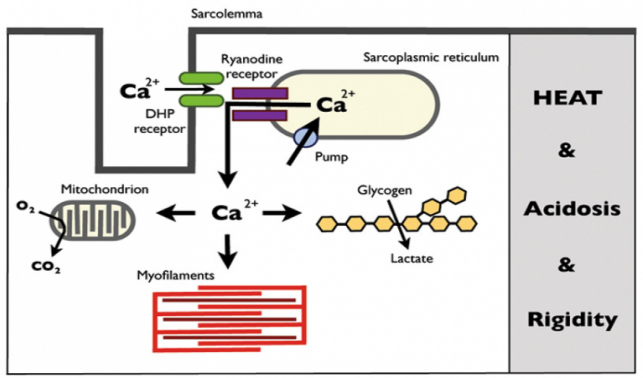
Pathophysiological Processes

Signs & Symptoms

- MH can present at any point during an anesthesia case. MH can develop shortly after giving the triggering medications and can be seen up to one hour after the discontinuation of these medications (Rosenberg et al., 2015).
- Although, MH can be seen during an individuals first exposure to anesthesia, it can often take up to three exposures before MH is triggered (Rosenberg et al., 2015).
- One of the early signs of MH is the unexplained increase in end-tidal CO2 (ETCO2) with increased ventilation (Smith et al., 2018).
- Additional symptoms of MH include tachycardia, dysrhythmias, skeletal muscle rigidity, rapid rise in core body temperature, and rhabdomyolysis (Smith et al., 2018).
- As MH progresses, later symptoms include metabolic and respiratory acidosis, hyperkalemia, myoglobinuria, and increased levels of creatine kinase (CK) (Smith et al., 2018).
- If the symptoms of MH are untreated for long enough, other pathologies such as disseminated intravascular coagulation and/or acute renal failure may occur (Smith et al., 2018).
- Another symptom of MH that is specific to children is masseter muscle rigidity (Rosenberg et al., 2015).

Underlying Pathophysiology

- MH is a disease process that can be potentiated by potent inhaled anesthetic gases such as sevoflurane, isoflurane, desflurane, halothane. MH can also be caused by non-depolarizing muscle relaxants like succinylcholine (Abdulrahman, 2020).
- In MH, a defect or mutation exists in the calcium channel termed the ryanodine receptor (RyR1). This channel is responsible for the regulation and release of calcium from the sarcoplasmic reticulum (SR) into the cell Rosenberg et al., 2015).
- By introducing these anesthetic agents into individuals with this defect, an uncontrolled release of calcium from the SR into the cell can result. This then causes a hypermetabolic state with sustained muscle contraction, rigidity, and hyperthermia. (Dagestad & Hermann, 2017).
- This hypermetabolic state results in excessive consumption and depletion of adenosine-tri phosphate (ATP) which then leads to the failure of membrane integrity and the release of CK and potassium. (Rosenberg et al., 2015).



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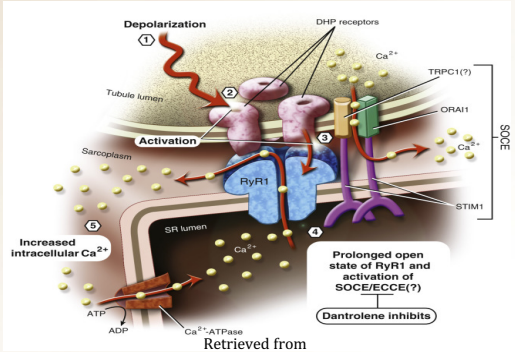
Significance of Physiology

- MH is a rare genetic disorder and because of this it is not often diagnosed until symptoms develop.
- The "gold standard" test for the diagnosis of MH is the in vitro contracture test (IVCT). This test is based the contracture of muscle fibers when introduced to caffeine of halothane. An individual is considered susceptible to MH when muscle fiber contracture results from both caffeine and halothane. However, IVCT is expensive, requires surgical intervention, and is only done at specialized testing centers (Rosenberg et al., 2015).
- Another option to determine susceptibility to MH is genetic testing. While this can provide useful data, it may also have ramifications for the future health of individuals and their immediate family members. Genetic testing can also be disadvantageous regarding the ability of a individuals to gain employment or access health and/or life insurance, therefore, the previously mentioned IVCT is preferred (Rosenberg et al., 2015).



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Treatment

- Rapid treatment of MH is essential in preventing adverse outcomes pertaining to MH. It is suggested that treatment be initiated within 3-7 minutes from the time of onset (Dagestad & Hermann, 2017).
- After the discontinuation of provoking anesthetic agents, dantrolene can be administered to treat MH. Dantrolene is a direct-acting skeletal muscle relaxant that interferes with calcium release to help stop skeletal muscle contraction (Dagestad & Hermann, 2017).
- Dantrolene is administered intravenously with a maximum dose of 10mg/kg. A maintenance dose then recommended 48 hours from the time of the last MH related symptom (Dagestad & Hermann, 2017).
- Other treatments for MH are symptomatic and include ensuring the patient is normothermic.
- In addition to the initial treatments listed above, other therapies such as extracorporeal membrane oxygenation (ECMO) and continuous renal-replacement therapy (CRRT) may be beneficial in more severe cases (Huh et al., 2017).

Implications for Nursing Care

- A large part of the prevention of MH comes in the preoperative assessment. It is vital that all members of the healthcare team ensure a thorough assessment is completed (Rosenberg et al., 2015).
- In order to optimize outcomes from patients diagnosed with MH it is imperative that nursing staff in the OR and PACU be diligent in monitoring the patient's condition.
- Nursing must be knowledgeable in the presentation of MH so subtle changes in patient condition can be identified and reported. This includes familiarity with monitoring devices such as ETCO2, pulse oximetry saturation (SpO2), and core temperature monitoring systems. Nursing must not only know how to use this equipment, but know what values are expected in different situations (Xu et al., 2019).
- Knowledge of treatment as well as how to rapidly access different treatments such as dantrolene is essential for nursing staff.
- Specific for anesthesia providers – a knowledge of alternative treatment and medications for MH susceptible patients is imperative.

Table 1
Clinical Presentation of Malignant Hyperthermia

Early Signs and Symptoms	Late Signs and Symptoms
Increased $ETCO^2$	Cutaneous changes
Tachypnea	Mottled skin
Muscle rigidity	Cyanosis
Masseter muscle spasms	Pyrexia
Generalized rigidity	Disseminated intravascular coagulation
Cardiac	Rhabdomyolysis
Tachycardia	Myoglobinemia/myoglobinuria
Arrhythmias	Renal failure
Cutaneous changes	Left ventricular failure
Generalized erythematous flush	Pulmonary edema
Electrolyte imbalance	Frothy sputum
Hyperkalemia	Metabolic acidosis
Hyperphosphatemia	Respiratory acidosis
Hypocalcemia	Hyperkalemia
	Hyper/hypocalcemia

Abbreviation: $ETCO^2$, end tidal carbon dioxide.

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Conclusions

- MH is a rare genetic disorder and a complications of anesthesia with an incidence of only 1:10,000 cases. However, once MH begins its rapid progression can cause multiple organ failure leading to death (Pan et al., 2016).
- MH is a serious complication that healthcare providers must have a thorough understanding of.
- Hyperthermia in MH can measured with a core temperature increase of 1-2 degrees Celsius every 5 minutes (Rosenberg et al., 2015).
- Rapid detection and treatment is the key to decreasing mortality related to MH.
- Children, younger adults, and males are at an increased risk for MH (Rosenberg et al., 2015).
- Dantrolene works by decreasing RyR1 channel activity and is imperative in treating MH (Rosenberg et al., 2015).

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