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Malignant Hyperthermia

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Pathophysiological Process

Introduction

As mentioned by Biesecker et al., (2020) "Malignant hyperthermia (MH) is a syndrome of acutely disordered skeletal muscle excitation-contraction coupling" (p. 1277). MH has a sudden onset and if not treated promptly can lead to detrimental complications and even death.

Rapid movement of calcium ions into the cell is the primary incident of this hypermetabolic state, leading to numerous physiological and clinical effects. MH is induced with the use of neuromuscular blocking agents and inhaled anesthetics which are frequently used by anesthesia providers.

MH is a complex disorder that can be genetically predisposed and as stated by Litman et al., (2018) "700 variants have been identified in RYR1; however, only 35 have been functionally validated as MH–causative pathogenic variants" (p.159). MH exacerbation is rare, but as a student registered nurse anesthetist (SRNA) being knowledgeable in identifying signs and symptoms, managing clinical changes, and promoting preventive measures will allow for improved patient outcomes within the operating room (OR).

Signs and Symptoms

In the OR the anesthesia provider (e.g., physician anesthesiologist or certified registered nurse anesthetist) is managing the autonomic nervous system through pharmacologic manipulation, oxygenating & ventilating the airway structures, and assessing hemodynamic changes on the monitor.

MH exacerbation commonly includes the following:

- Tachycardia (greater than 100 beats per minute)
- Variable blood pressure (low or high)
- Hyperthermia (greater than 100.4 degrees Fahrenheit)
- Tachypnea (respiratory rate greater than 20 breathes per minute)
- Elevated carbon dioxide production (end-tidal carbon dioxide greater than 45 mm Hg)
- Metabolic acidosis (elevated hydrogen ions)
- Musculoskeletal issues (rhabdomyolysis, and muscle rigidity)

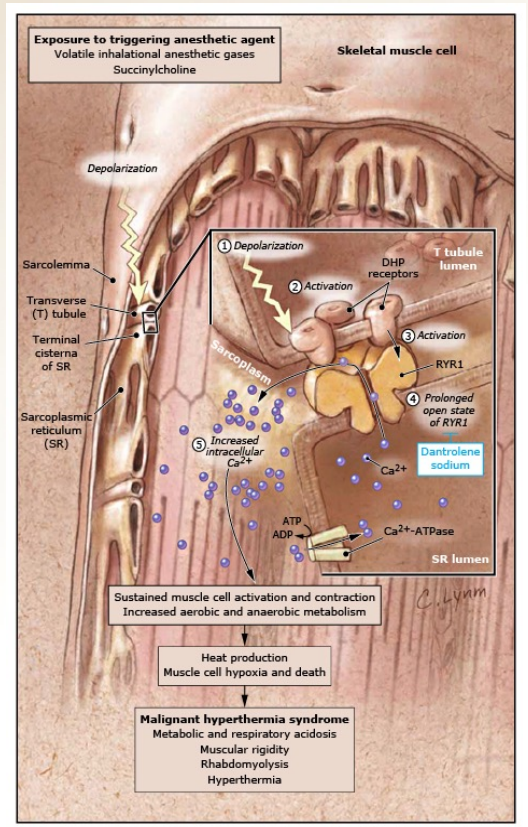
MH has no cardinal characteristics, but complications occur in a rapid and random sequence. Thus, if these symptoms present and a causative agent is not promptly identified, then immediate suspicion should be MH. (Riazi et al., 2018)

Underlying Pathophysiology

MH is a hypermetabolic state that arises through increased calcium ions within the cell. A regulator of calcium balance is the ryanodine receptor found at the sarcoplasmic reticulum in smooth muscle tissue. As stated by Litman et al., (2018) "abnormalities of the ryanodine receptor result in the accumulation of excessive myoplasmic calcium in the presence of one of the anesthetic triggering agents" (p. 159). MH does have hereditary significance, and if a family member has had a MH suspected reaction precaution should be taken. Genetic testing and MH contracture biopsy can be performed to assess a patient's susceptibility to a MH reaction prior to a planned procedure where anesthetic triggers could be utilized (Ibarra-Moreno, 2019).

Progression of Condition

Accumulation of calcium leads to an accelerated use of energy within the cell causing increased oxygen consumption, while decreasing oxygen supply leading to anaerobic metabolism. This anaerobic state causes insufficient production of energy leading to dysfunction of the body, thus presenting the numerous clinical effects that are seen with MH (Hopkins et al., 2020). If MH is not promptly managed there can be severe damage including lactic acidosis from anerobic metabolism, rhabdomyolysis leading to compartment syndrome, acute renal failure, disseminated coagulation cascade, and even cardiac dysrhythmias leading to cardiac arrest. (Hopkins et al., 2020)



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Implications for Nursing Care

MH is a complication of anesthesia that cannot be managed solely by one provider, thus when recognized immediate steps should be taken by the OR staff. It is recommended that there be MH specific protocols, and carts that are readily available. An alternative resource is stated by Riazi et al., "In the United States a "hotline" has been established to provide emergency assistance (1-800-644-9737) in the management of MH." (2018, p.713). When MH is recognized prompt initiation of correcting the hypermetabolic process is the sole way to prevent further complications.

Treatment

Recommended interventions of reversing MH:

- Eliminate the suspected agent (volatile anesthetic or intravenous anesthetic).
- Turn off and remove vaporizer.
- Provide 100% oxygen at maximum flow.
- Increase minute ventilation 2 to 3 times normal.
- Insert activated charcoal filters on inspiratory and expiratory limbs of ventilatory circuit.
- Administer symptom management medications (e.g., dantrolene sodium, sodium bicarbonate, antiarrhythmic, insulin, or blood products).
- Active body cooling.

As mentioned, if a MH protocol or resource is available refer to the facility's policies in managing this condition. (Hopkins et al., 2021)

Conclusion

MH is a multifaceted condition that has genetic predispositions and can be induced with the use of certain anesthetic medications. Thus, the use of genetic testing, biopsy and thorough patient interview prior to anesthesia is imperative in preventing this lethal event. Further, use of simulations to practice the course of MH can be effective in preparing the anesthesia provider and OR staff in immediate management.

It should be emphasized that preventative measures of MH supersedes the use of pharmacologic methods to prevent the progression of this condition. MH signs and symptoms are warnings to an impending crisis and warrant immediate intervention. The anesthesia provider needs to promptly alert the necessary medical staff, implement measures to prevent progression and keep the patient safe during their anesthetic care.

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