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Perioperative Malignant Hyperthermia

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Subject

Malignant Hyperthermia (MH)

- Malignant Hyperthermia is, "a biochemical chain reaction response "triggered" by commonly used general anesthetics and the paralyzing agent succinylcholine (a neuromuscular blocker), within the skeletal muscles of susceptible individuals" (Malignant Hyperthermia Association of the United States, n.d.)
- Incidence of MH
  - The exact incidence is difficult to appraise due to the infrequency and possible misdiagnosis of events.
  - An estimated incidence is listed from 1:10,000 to 1:220,000 in past reports (In, Ahn, Lee, & Kang, 2017).

Significance

- Although Malignant Hyperthermia is most commonly known as an adverse surgical event, it can also be caused by stress, heatstroke and strenuous exercise (Bin, Wang, and Tang, 2022).
- In the United States, there are approximately 60,000 patients that undergo a surgical procedure with general anesthesia (National Institute of Health, 2019).
- General anesthesia
  - General anesthesia is inducing a state of unconsciousness and inability to perceive pain while controlling the autonomic responses (Smith, D'Cruz, Rondeau, & Goldman, 2021)
  - Common general anesthetics that may cause perioperative Malignant Hyperthermia are divided into two categories of volatile inhaled anesthetics and depolarizing neuromuscular blocking agents.
- Malignant Hyperthermia was selected for this project because although it is rare, this is a very severe and even deadly risk of surgery. It is the responsibility of the anesthesia provider to monitor and rapidly treat this condition.
- Further education on the severity and importance of MH awareness can decrease incidence of morbidity and mortality with this condition.

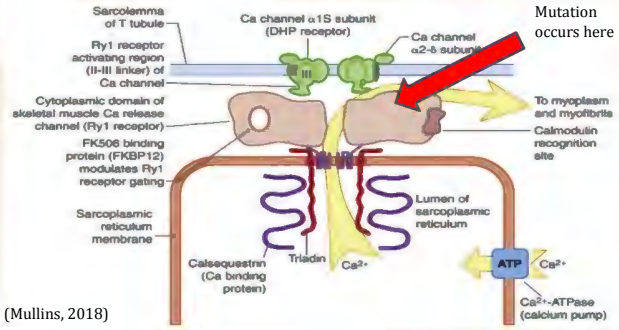
Pathophysiological Processes

Normal Physiology

- Normal skeletal muscle contraction
  - Nerve impulse propagates to the nerve terminal activating the voltage gated calcium channels (Mullins, 2018).
  - Increased calcium in the cytoplasm triggers acetylcholine(ACh) release via exocytosis form the storage vesicles (Mullins, 2018).
  - ACh binds to nicotinic ACh receptors of the postsynaptic membrane activating voltage gated ion channels (Mullins, 2018)
  - Influx of positive ions allows the sarcolemma to reach threshold and depolarize (Mullins, 2018)
  - Depolarization activates voltage-gated sodium ion channels that propagate the impulse into muscle tissue (Mullins, 2018).
  - The impulse then activates L-type calcium voltage-gated ion channels in the transverse tubules (t-tubules) (Mullins, 2018).
  - Activation of the L-type calcium channels causes a conformational change (Mullins, 2018).
  - The conformational change activates the DHPR which is linked to the RYR1 receptor causing a chain activation (Mullins, 2018).
  - Once the RyR1 receptor is activated, calcium is released from the sarcoplasmic reticulum causing muscle contraction (Mullins, 2018).

Underlying Pathophysiology

- Results due to an autosomal dominant mutation on the ryanodine receptor (type 1: RyR1), dihydropyridine receptor (DHPR) (Mullins, 2018).
- The mutation causes an abnormal intensified release of calcium from the sarcoplasmic reticulum in skeletal muscle cells (Mullins, 2018)
- Hypermetabolism of the skeletal muscles results due to the excess calcium release from the sarcoplasmic reticulum (Mullins, 2018)
- Prolonged contraction causes hypermetabolism and inhibited relaxation cause skeletal muscle tissue to consume immense amounts of adenosine triphosphate (ATP) which supplies energy to cells (Gregory & Weant, 2021).
- Hyperthermia is produced by the unrelenting contraction and continuous metabolic processes (Gregory & Weant, 2021).
- Once the ATP stores are depleted, the body begins to compensate by entering anaerobic metabolism to produce more ATP and therefore begins producing lactate or lactic acid (Gregory & Weant, 2021).
- All of the hypermetabolic processes can lead to cell injury and destruction releasing creatinine kinase (CK) and potassium to the extracellular space (Gregory & Weant, 2021).
- Hyperkalemia from cell destruction can lead to detrimental cardiac arrhythmias (Gregory & Weant, 2021).
- Together, these metabolic disturbances can lead to patient mortality.



(Mullins, 2018)

Triggering Agents

- Volatile Anesthetics
  - Desflurane
  - Enflurane
  - Isoflurane
  - Halothane
  - Sevoflurane (Gregory & Weant, 2021)
- Depolarizing Neuromuscular Blocker
  - Succinylcholine (Anectine) (Gregory & Weant, 2021)

Triggers	Safe drugs
• Ether	• Propofol
• Halothane	• Ketamine
• Enflurane	• Etomidate
• Isoflurane	• Benzodiazepines
• Sevoflurane	• Barbiturates
• Desflurane	• Opioids
• Succinylcholine	• Nitrous oxide
	• Non-depolarising muscle relaxants
	• Local anaesthetics

(Cieniewicz, 2019)

Signs & Symptoms

- Early signs and symptoms of malignant hyperthermia
  - Unexplained rise in end-tidal Carbon Dioxide (ETCO2) is usually the first sign
  - Tachycardia
  - Dysrhythmias
  - Abrupt increase in core body temperature. The rate of temperature increase is more important than the temperature peak.
  - Generalized skeletal muscle rigidity
  - Rhabdomyolysis (Smith, Tranovich, & Ebraheim, 2018).
- Late signs and symptoms of malignant hyperthermia
  - Respiratory acidosis
  - Metabolic acidosis
  - Increases in serum potassium
  - Elevation of creatinine kinase (CK)
  - Myoglobinuria (Smith et al., 2018).

Significance of Pathological Processes

- In comparison to the total amount of surgeries that take place all around the world, the incidence of Malignant Hyperthermia is relatively low. Although the incidence is low, there should be precautions taken to ensure the utmost patient safety when exposed to triggering agents. Anesthesia providers should understand the severity of Malignant Hyperthermia, be able to identify signs and symptoms while promptly treating with the supplies available.

(University of Florida Department of Anesthesiology, n.d.)

Diagnosis

- There are four components leading to a Malignant Hyperthermia diagnosis: clinical presentation, family or medical history, in-vitro caffeine-halothane contracture testing, and genetic testing (Bin, Wang, and Tang, 2022).
- Two types of testing give a definitive diagnosis of Malignant Hyperthermia susceptibility: genetic testing and muscle biopsy (Malignant Hyperthermia Association of the United States, n.d.)
- The diagnosis gold standard is in vitro caffeine-halothane contracture testing (Bin, Wang, and Tang, 2022).
- Caffeine-Halothane Contracture testing must take place in specific labs and there are only four in the United States (Gregory & Weant, 2021).
- It is not suggested to test every surgical patient for the mutation that causes Malignant Hyperthermia (Gregory & Weant, 2021).
- One or simultaneous occurrences of the following manifestations may indicate the onset of Malignant Hyperthermia and lead to further testing:
  - Muscular spasm or rigidity (localized or diffuse)
  - Unexplained tachycardia or arrhythmias
  - Body temperature that rises 1-2 degrees celsius over 5-15 minutes
  - Circulatory and Respiratory failure leading to arrhythmia, cyanosis, and oliguria (Bin, Wang, and Tang, 2022)..

Treatment

- The initial and possibly most important step to treat and episode of Malignant Hyperthermia is the removal of the causative agent (Gregory & Weant, 2021).
- If succinylcholine is used and more paralytics are needed, a non-depolarizing neuromuscular blocker such as rocuronium or vecuronium are indicated (Gregory & Weant, 2021).
- The anesthesia provider should increase the fraction of inspired oxygen to 100% and then hyperventilate the patient to eliminate excess carbon dioxide (Gregory & Weant, 2021).
- If accessible, activated charcoal filters should be added to the inspiratory and expiratory arms of the respiratory circuit (Gregory & Weant, 2021)..

Treatment Continued

- The drug of choice for Malignant Hyperthermia treatment is Dantrolene and it should be used as soon as possible (Gregory & Weant, 2021).
- Dantrolene impedes calcium ion release from the sarcoplasmic reticulum and therefore interferes with skeletal muscle contraction (Gregory & Weant, 2021).
- Dantrolene is used in an acute Malignant Hyperthermia crisis but can also be used in prophylaxis of Malignant Hyperthermia (Gregory & Weant, 2021).
- The prophylactic Dantrolene dose is 2.5 milligrams per kilogram (mg/kg) administered one hour and 15 minutes prior to surgery (Gregory & Weant, 2021).
- In an acute Malignant Hyperthermia crisis the Dantrolene dose is also 2.5mg/kg but is given every 10 to 15 minutes until symptoms recede (Gregory & Weant, 2021).
- Once the symptoms have subsided, it is recommended to give 1mg/kg every four to six hours or 0.25mg/kg in a continuous infusion for a minimum of 24 hours (Gregory & Weant, 2021).
- However, Dantrolene is not available in all countries (Gong, 2021)
- When Dantrolene is not available, diagnosis, early warning and immediate effective interventions are needed (Gong, 2021)

Implications for Nursing Care

- The entire perioperative team including anesthesia and PACU should be aware of the signs and symptoms of Malignant Hyperthermia.
- Malignant Hyperthermia can present during general anesthesia or in the early post-operative stage (Mullins, 2018)
- Prompt treatment is necessary to prevent the detrimental effects of Malignant Hyperthermia (Gregory & Weant, 2021).
- Further education for both anesthesia and nursing staff can increase awareness of MH and decrease patient mortality.
- Simulation of Malignant Hyperthermia situations have shown beneficial outcomes in training perioperative staff (Schaad, 2017).

Conclusion

- Malignant Hyperthermia is a rare possibly fatal ailment that requires prompt intervention.
- Malignant Hyperthermia is inconsistent in it manifestations (Mullins, 2018).
- Dantrolene has shown to be very effective in the treatment of Malignant Hyperthermia (Gregory & Weant, 2021).
- Stocking Dantrolene is highly recommended wherever the depolarizing neuromuscular blocker succinylcholine is used (Larach, 2019).
- Without Dantrolene, extreme vigilance is needed to treat the manifestations to prevent mortality (Gong, 2021)
- Drills simulating a Malignant Hyperthermic crisis are suggested to practice the immediate response needed during these situations (Gregory & Weant, 2021).

References

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