Case Study

Emergency Preparedness Case Study: Malignant Hyperthermia

CE

Darlene Hutton, BScN, MSN, RN

The second of this 2012 Case Study series addresses a situation that is uncommon in the surgical setting. Without proper recognition and prompt treatment, the mortality rate can be as high as 80% (Christiansen & Collins, 2004; Larach, Gronert, Allen, Brandom, & Lehman, 2010). With prompt recognition and intervention when this emergency does arise, the mortality rate has been reduced to 5% (Rosenberg, Sambuughin, & Dirksen, 2010). Malignant hyperthermia (MH) is an inherited syndrome that affects 1 of 50,000 adults and 1 of 15,000 pediatric patients undergoing anesthetic procedures (Christiansen & Collins, 2004; Rosenberg et al., 2010). In this article, the reader is exposed to a case of MH and is asked a series of questions related to risk assessment, signs and symptoms, and nursing responsibilities.

You are performing a routine preoperative interview on a 49-year-old man who is scheduled for an abdominoplasty.

Question 1: What would be risks associated with MH in this patient?

a. Any unexplained fever or muscle rigidity occurring from anesthesia
b. A personal history of MH
c. Prior complications during a previous surgery
d. Intolerance to caffeine

Correct answers: All of the above. A prior history of complications occurring during or shortly after anesthesia such as unexplained fever, cola-colored urine, or muscle rigidity may be the result of MH crisis. However, the absence of these symptoms does not eliminate future MH risk. Researchers have reported that 77 of 152 patients who have had MH had at least two prior general anesthetics with no perioperative or postoperative complications (Larach et al., 2010). A personal or family history of MH would warrant that precautions be in place prior to the surgery to avoid an episode. The most sensitive test available for the diagnosis of MH is the caffeine-halothane contracture test (Rosenberg et al., 2010). This test involves comparing fresh muscle tissue when exposed to caffeine and halothane against non-MH muscle responses. The diagnosis of MH is based on obviously higher contracture than that of the non-MH muscle. This test requires the person to be present while testing is occurring, and this test can be done only in five designated centers throughout North America (Malignant Hyperthermia Association of the United States, 2012a). Intolerance to caffeine may also be grounds for suspicion for MH but not a sensitive diagnostic marker Hutton, 2011; (Table 1).

You are the circulating nurse in the operating room for this patient. He was induced with midazolam, fentanyl, propofol, and vecuronium bromide, and maintained with 1%–2% isoflurane in nitrous oxide/oxygen. An hour after induction, his heart rate increased to 140 beats/minute, his oxygen saturation decreased to 88%, and an increase of end-tidal carbon dioxide (CO_2) to 100 mm Hg was observed.

Question 2: In which order do these signs most frequently occur in MH?

a. Increased heart rate
b. Increased end-tidal CO_2
c. Muscle rigidity
d. Hyperthermia
e. Tachypnea
f. Cyanosis or mottled skin

Correct sequence: A, E, B, C, F, and D (Hommertzheim & Steinke, 2006). A. Tachycardia is an early sign and occurs in 96% of all cases of MH, either

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TABLE 1 Frequency and Timing of Signs and Symptoms of Malignant Hyperthermia

Signs and symptoms	Early or late sign	Incidence (%)
Increased heart rate; ventricular arrhythmia	Early	96
Tachypnea	Early	85
Increased end-tidal CO_2	Early	80
Muscle rigidity	Early	80
Cyanosis or mottled skin	Early	70
Hyperthermia	Late	30

sinus tachycardia or ventricular arrhythmias. E. Tachypnea is an early sign and occurs in 85% of all cases of MH. Tachypnea results from the rapid rise of CO_2 and the body's attempt to reduce this level. B. Increased end-tidal CO_2 is an early sign and occurs in 80% of all cases of MH resulting in acidosis. In MH, patients will develop both respiratory and metabolic acidoses due to the buildup of carbon dioxide and lactic acid. C. Muscle rigidity is an early sign and occurs in 80% of all cases of MH and results from excessive amounts of calcium released from intracellular storage sites in the muscle cells. F. Flushing of the skin, cyanosis, or mottling is a sign present in 70% of all cases of MH. D. Contrary to the name, hyperthermia occurs in only 30% of patients and is a late sign. In an attempt to reprocess the calcium and return it to storage areas within the cell, the contracting skeletal muscles generate excessive heat, resulting in hyperthermia.

Question 3: What are the possible causative agents causing MH in this case?

a. Midazolam
b. Fentanyl
c. Propofol
d. Vecuronium bromide
e. Nitrous oxide
f. Isoflurane

Correct answer: F. Isoflurane and other volatile inhaled agents such as desflurane, enflurane, halothane, and sevoflurane are known causative agents in MH. Succinylcholine is another agent known to potentially cause MH in the vulnerable patient Hutton, 2011; (Table 2). A patient who develops MH resulting from exposure to one of these anesthetic agents likely has one of the two identified genetic mutations predisposing to MH (Rosenberg et al., 2010). Findings from research conducted on 286 episodes of MH between 1987 and 2006 identified that 75% of cases of MH occurred in males (Larach et al., 2010).

TABLE 2 Causative and Safe Drugs

Safe preoperative drugs	Safe periopera tive drugs	Causative drugs
Benzodiazepines: Diazepam, lorazepam	All local anesthetics	Succinylcholine
Narcotics	Regional anesthetics	Inhaled volatile agents: isoflurane, desflurane, enflurane, halothane, sevoflurane
Barbiturates	General anesthetics: benzodiazepines, opioids, barbiturates, propofol, ketamine, nitric oxide	
	Pancuronium	
	Neostigmine and atropine	

Question 4: What would be immediate measures to take when a patient displays signs and symptoms of MH?

a. The circulating nurse initiates MH protocol and calls for additional nursing backup.
b. Additional nursing backup includes one to prepare dantrolene, one to prepare other medications, and one to provide cooling.
c. Prepare dantrolene.
d. The surgeon continues the procedure as soon as the patient has been stabilized.
e. The anesthesiologist hyperventilates the patient.

Correct answers: A. B. The circulating nurse initiates the MH protocol by immediately calling for 3 additional nurses: one nurse will be responsible to prepare and administer dantrolene, another will prepare and administer other medications, and one will provide cooling. The circulating nurse will be responsible to assist the anesthesiologist in preparing the necessary laboratory supplies and recording. C. Dantrolene sodium reduces muscle tone and metabolism. The likelihood of any complication increases 1.6 times per every 30-minute delay in initiating dantrolene (Larach et al., 2010). E. Hyperventilation with 100% oxygen will help offset the rapid increase in retained carbon dioxide that leads to respiratory acidosis Hutton, 2011; (Table 3).

Incorrect answer: D. If the patient exhibits signs of MH prior to initiation of surgery, the procedure should be cancelled. If the surgery has started, it should be stopped as soon as possible. If the surgery cannot be aborted, the anesthetic agent should be changed to a nontriggering

TABLE 3 Dantrolene Preparation

Dantrolene dose	2.5–4 mg/kg
Repeated doses	2.5 mg every 4–6 hr for 24–48 hr. Once a patient has been treated for 35 hr with IV dantrolene, they may be switched to oral dantrolene until the creatine kinase level is trending down, there is no acidosis, and no temperature spikes
Each vial of dantrolene	20 mg
Mix	50-cc preservative-free sterile water
Total vials in malignant hyperthermia cart	36 for immediate preparation
Note	To expedite reconstitution of dantrolene during an malignant hyperthermia crisis, the manufacturer of dantrolene recommends using warmed preservative-free sterile water (37°C–39°C).

one and the breathing circuit disconnected from the anesthesia machine (Hommertzheim & Steinke, 2006; Larach et al., 2010).

Extra personnel have arrived. The patient is now experiencing masseter muscle rigidity, cardiac rhythm remains sinus tachycardia with premature ventricular beats and short bursts of nonsustained ventricular tachycardia, the oxygen saturation is now 84%, and end-tidal CO_2 has is being maintained around 90 mm Hg despite hyperventilation.

Question 5: The nurse responsible for preparing the dantrolene identifies the patient's weight to be 100 kg. Which of the following are true of the preparation and administration of dantrolene?

a. The anticipated initial dose will range between 250 and 400 mg intravenous (IV) push.
b. Immediately prepare one vial and have 36 vials available, in case further doses are needed.
c. Repeated doses may be given every 5–10 min to a maximum dose of 10 mg/kg.
d. Each vial is to be mixed with 50–60 cc of preservative-free sterile water.

Correct answers: A. The initial dose is 2.5–4 mg/kg IV push (Fortunato-Phillips, 2000; Hommertzheim & Steinke, 2006; Larach et al., 2010; Malignant Hyperthermia Association of the United States, 2012b). For this patient who weighs 100 kg, the correct dose would range between 250 and 400 mg IV push. C. Repeat boluses may be given every 5–10 min to a maximum of 10 mg/kg; 1000 mg for this patient. Following the initial bolus, a maintenance bolus may be given every 4–6 hr for 24–48 hr (Fortunato-Phillips, 2000; Hommertzheim & Steinke, 2006; Larach et al., 2010; Malignant Hyperthermia Association of the United States, 2012). D. Only preservative-free sterile water may be used to reconstitute dantrolene.

Incorrect answer: B. One vial contains 20 mg of dantrolene. The anesthesiologist orders 250 mg. For this patient who weighs 100 kg, 13 vials of dantrolene would need to be immediately prepared: 20 mg multiplied 13 times equals 260 mg. For each subsequent bolus repeated every 5–10 min, another 13 vials would need to be prepared. If the total maximum dose of 1,000 mg is reached for this patient, then a total of 50 vials would be prepared over the course of treatment. The recommendation from Malignant Hyperthermia Association of the United States (2012) is that 36 vials of dantrolene be readily available within 5 min of the onset of an MH crisis. D. Each vial needs to be mixed with between 50 and 60 cc of preservative-free sterile water. For the initial bolus using 13 vials to reconstitute 250 mg, a total of 650 ml of sterile water is required.

Question 6: For the nurse responsible for other medications, what medications would be anticipated?

a. Sodium bicarbonate
b. Insulin, IV glucose, calcium chloride
c. Lasix
d. Amiodarone or lidocaine

Correct answers: A, B, C, and D (Fortunato-Phillips, 2000; Hommertzheim & Steinke, 2006; Larach et al., 2010; Malignant Hyperthermia Association of the United States, 2012). With the rapid rise in metabolic rate leading to an increased production of heat and CO_2, respiratory and metabolic acidoses will develop. Anesthesia will hyperventilate the patient to blow off CO_2 and manage the respiratory acidosis. To manage the potential for metabolic acidosis, an initial dose of IV sodium bicarbonate, 1–2 mEq/kg, may be given. Repeated doses may be given on the basis of arterial blood gas results. B. IV Insulin, glucose, and calcium chloride may be ordered to treat hyperkalemia resulting from disruption of skeletal muscle cell membrane and leaking of electrolytes, namely potassium, into the blood stream. C. As MH progresses, the disruption of skeletal muscle cell membrane leads to leaking of myoglobin into the blood stream that may obstruct the renal tubules, resulting in acute renal failure. To promote continuous diuresis, Lasix continues to be the suggested drug stocked on the MH cart. The Malignant Hyperthermia Association of the United States (2012) suggests taking mannitol off the MH cart because dantrolene contains 3 g of mannitol in each 20-mg vial (Malignant Hyperthermia Association of the United States, 2012). D. Cardiac dysrhythmias occur in

up to 96% of MH and results from hyperkalemia. To prevent worsening of potentially lethal ventricular rhythms, an infusion of an antiarrhythmic drug such as amiodarone or lidocaine may be ordered. Correcting the acidosis and hyperkalemia is the best intervention to prevent ongoing ventricular rhythms.

Question 7: As the nurse responsible for cooling, what actions would be anticipated?

a. Prepare to insert a Foley catheter, a nasogastric tube, and a rectal tube as ordered
b. Administer cold IV saline as an initial 500–1,000 cc bolus
c. Administer cold saline for lavage cooling
d. Apply ice to core areas of the patient's body
e. Monitor and record patient temperature

Correct answers: All of the above (Hommertzheim & Steinke, 2006). The nurse responsible for cooling management of the patient will be required to obtain cold saline and ice. Cold saline will be administered IV, via Foley catheter and rectal and nasogastric tubes as ordered. The temperature will be continuously monitored and recorded by the cooling nurse with the goal being to reach a core body temperature of 38°C. Ice packs are to be placed to the patient's neck, groin, and axillae; cooling blanket should be applied to the patient's surface. As this case is an abdominoplasty, the cooling nurse may also be required to provide refrigerated saline to the scrub nurse for the surgeon to administer into the abdominal cavity.

CONCLUSION

The surgery was discontinued and the patient recovered well in the postanesthetic care unit with no further incidence. Dantrolene, 1 mg/kg, was administered every 4 hr for 48 hr after surgery. All baseline functions returned to normal. As a surgical team treating a patient presenting with MH, each member's role is vital in optimizing patient outcome. Prompt recognition of the most frequent signs alerts the team of a potential MH emergency. Implementation of an MH protocol and having one assigned nurse to manage the preparation of dantrolene, another to manage preparation and administration of other medications, and a third to manage cooling of this patient will maximize team efforts in treating this life-threatening condition.

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