Malignant Hyperthermia in the Ambulatory Surgery Center

How Should We Prepare?

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MALIGNANT hyperthermia (MH) occurs when a patient who has inherited a causative mutation (usually in *RYR1*, the gene on chromosome 19 that encodes for the ryanodine receptor) is exposed to one or both anesthetic-triggering agents (*i.e.*, volatile anesthetics and succinylcholine).[1] MH is just as likely to occur in a healthy patient who receives anesthesia in a freestanding ambulatory surgery center (ASC) as in a medically complex inpatient. The Malignant Hyperthermia Association of the United States recommends that an MH "cart" be stocked with drugs and equipment used to manage MH, and that it be immediately available to any anesthetizing location where triggering anesthetics are used. The most important ingredient on this cart is dantrolene, the essential treatment of MH. For approximately 4 decades, dantrolene has been known to reverse the symptoms and reduce mortality from acute MH. Thus, dantrolene has become as essential a fixture in the operating room environment as a defibrillator. This issue of Anesthesiology contains an insightful look at the cost effectiveness of stocking dantrolene in ASCs.[2] This analysis revealed that the cost of stocking dantrolene would be less than the costs incurred by a patient's death as a result of supportive care only. The authors performed a simulation study to bias the results against the recommendation of stocking dantrolene by increasing the effectiveness of supportive care alone and reducing the effectiveness of prompt administration of dantrolene. Even with these unlikely scenarios, the argument for cost effectiveness of dantrolene is strong.

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The Malignant Hyperthermia Association of the United States recommends that the MH cart contains a minimum of 36 vials of dantrolene. This is because some patients may require up to 10 mg/kg of dantrolene for initial stabilization (calculation based on the standard 20-mg dantrolene vial and a mean average patient weight of 70 kg).[3] However, some might argue that ASCs could stock a smaller starting dose of dantrolene in anticipation of the patient being transferred to a major medical center soon after recognition of the MH event. But, the cost of delaying dantrolene administration, either in inadequate dosage (if a limited supply is available) or no administration (if it is not stocked) is significant, because larger initial doses are often needed to control the acute life-threatening complications of MH that may occur in some patients, such as hyperkalemia and severe hyperthermia. The results of this rigorous study allow us to move from the controversy of stocking dantrolene to the larger issue of preventing MH-related deaths in ASCs.

A study that assessed the trends and outcomes of MH in the United States found that its incidence is increasing and that there are geographic differences in the mortality rate.[4] Of importance, mortality was higher when patients were transferred from other hospitals or other healthcare facilities (*e.g.*, ASCs). Therefore, it is essential that all anesthetizing facilities, especially ASCs, prepare for the eventuality of an acute life-threatening MH event. All facilities should perform annually

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a simulated mock MH drill using cognitive aids[5] such as the MH Treatment Poster.* When acute MH occurs in an ASC, all initial efforts should be focused on dantrolene administration, and emergency medical services (*i.e.*, 911) should be contacted as soon as possible to transport the patient to a full-service medical center with intensive care capabilities. The Malignant Hyperthermia Association of the United States, the Ambulatory Surgery Foundation, and the Society for Ambulatory Anesthesia have jointly developed transfer guidelines for patients who develop acute MH in an ASC.[6] Simulation drills based on best practices enhance communication and teamwork and reduce organizational failures and variability in patient care; they minimize human errors that can occur because of lack of experience, particularly with rare situations such as MH crises.

The best way to prevent an MH crisis in an ASC is to avoid triggering anesthetics in susceptible patients—this is easier said than done, because nearly all MH events occur in previously healthy patients. Furthermore, many patients who develop MH have had uneventful previous anesthetics, further confusing the ability to predict MH susceptibility before any given anesthetic.[3] MH susceptibility is best predicted by a family history of MH (or suspicious episodes during general anesthesia) and a search for MH-related diseases in the family. These diseases include those caused by mutations that also segregate on chromosome 19.[7] The most common example is central core myopathy, but there are other (relatively rare) myopathies that are associated with ryanodine receptor mutations. These diseases often manifest as nonspecific muscle weakness; thus, it is too difficult to make a diagnosis based on preanesthetic screening of the history and physical examination alone. A genetic analysis is necessary to isolate any causative mutation. More often than not, however, MH-susceptible patients with ryanodine receptor mutations are phenotypically normal, although in retrospect, many will report an abnormal intolerance to exercise or heat or undiagnosed weakness.

There is no medically valid reason why known MH-susceptible patients cannot undergo general anesthesia in a freestanding ASC, as long as the anesthesia machine is properly prepared and a nontriggering anesthetic technique (*i.e.*, total intravenous anesthesia) is used. In these patients, surgery with nontriggering agents is safe, prophylactic dantrolene premedication is not necessary, and postoperative discharge times do not need to be prolonged for the sole reason of monitoring the patient for the occurrence of delayed MH.[8] There are several ways in which mechanical ventilation may be accomplished in an MH-susceptible patient without exposure to volatile anesthetics. Flushing of the anesthesia machine with fresh gas is no longer simple in this age of more complex circuitry,[9] and some machines require prolonged flushing times until volatile agent concentrations are relatively low. Additional methods include the use of a reserve anesthesia machine that has never been exposed to anesthetic agents or the use of a freestanding ventilator (similar to those used in the intensive care units), if available. All these methods are labor intensive, and not practical, especially in a busy ambulatory surgical practice. Therefore, we recommend the use of specially designed charcoal filters (Vapor-Clean; Dynasthetics, Salt Lake City, UT) which easily insert into the proximal ends of the inspiratory and expiratory limbs of the anesthetic circuit.[10] These filters will rapidly capture residual amounts of anesthetic gas remaining in the anesthesia circuit as long as the agent vaporizer is turned off (if the vaporizer is turned on, the filters can be easily saturated and anesthetic gas will reach the patient). This process can be accomplished in the several minutes that it takes to change over the machine between patients.

Managing an acute MH event in an ASC can be extremely challenging, mainly owing to the lack of ancillary personnel who would be available to help with mixing dantrolene, additional IV placement, blood sampling, and charting, to name just a few of the important tasks that must be accomplished in what will certainly be a chaotic situation. Currently available lyophilized dantrolene has an inherent drawback, as it requires reconstitution with sterile water for intravenous administration and is only available in 20-mg aliquots, each of which requires dilution with 60 ml of sterile water. However, this onerous process is expected to soon be antiquated as there will be available in the near future a different dantrolene formulation supplied in a hyperconcentrated (250 mg) vial, requiring reconstitution with only 5 ml of sterile water (Eagle Pharmaceuticals, Woodcliff Lake, NJ). This comparatively smaller vial will easily fit in any anesthesia drug drawer and has the potential to significantly change the way anesthesiologists approach the acquisition and storage of dantrolene in ASCs and other operating room environments.

In summary, every anesthetizing location that uses triggering anesthetics should be fully prepared to administer at least 10-mg/kg dantrolene in the event that a patient with acute MH requires greater than average treatment doses. Survival from an MH crisis in an ASC setting requires early recognition, prompt treatment, and timely transfer to a center with intensive care capabilities. Simulated MH drills should improve outcomes and reduce mortality and should be a routine annual event in all ASCs.

Competing Interests

The authors are not supported by, nor maintain any financial interest in, any commercial activity that may be associated with the topic of this article.

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