CHAPTER

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Malignant Hyperthermia: Treatment of Acute Episode

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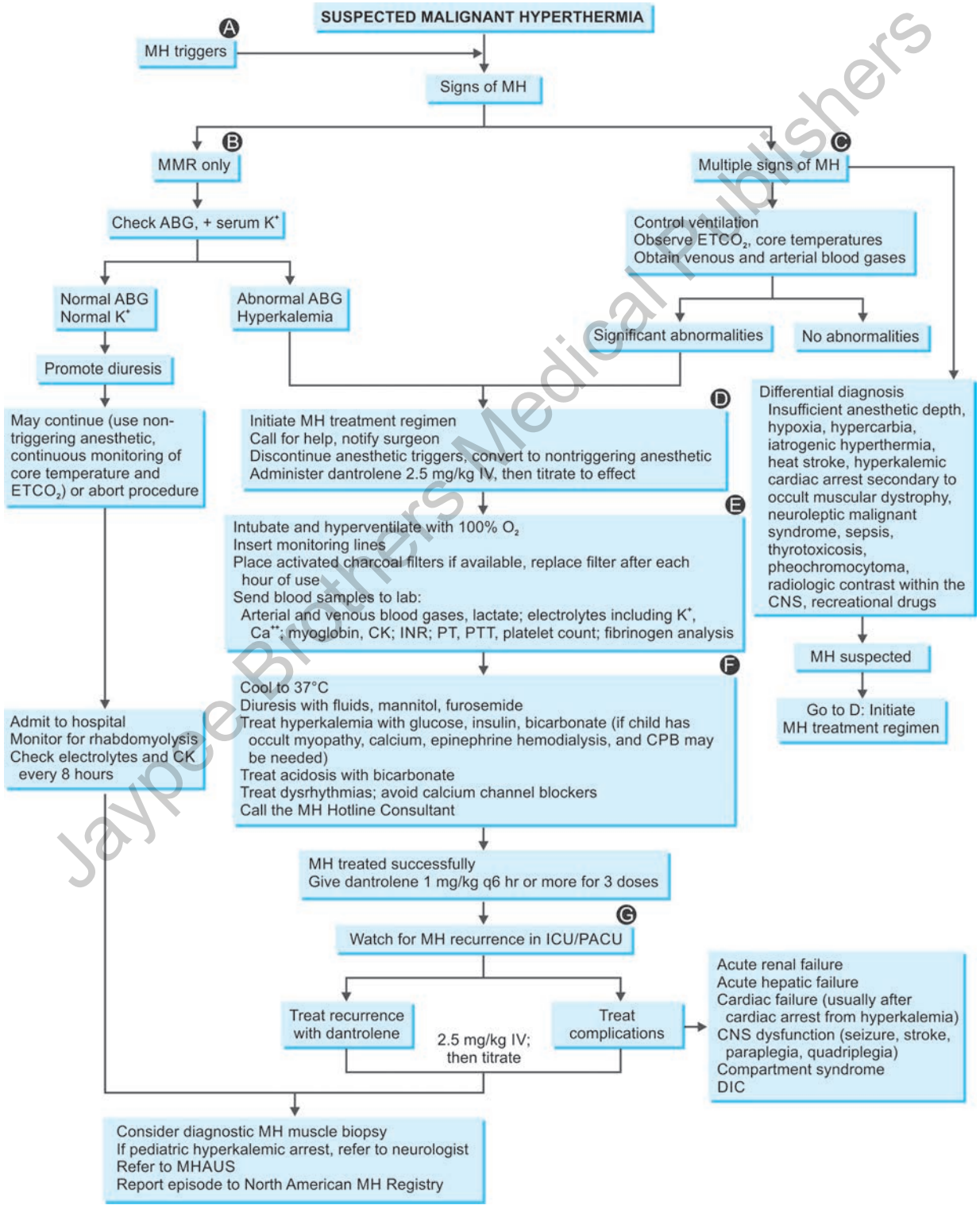

Prophylaxis of a malignant hyperthermia (MH) episode is detailed in Chapter 20. A fulminant MH crisis is an uncommon but potentially fatal event. Early diagnosis with rapid, appropriate intervention is necessary to prevent death and reduce the morbidity of this hypermetabolic state. Effective therapy requires termination of anesthetic agents that triggered MH and rapid administration of intravenous (IV) dantrolene. All acute MH reactions require dantrolene therapy. The North American Malignant Hyperthermia Association http://www.mhaus.org is an excellent resource for information and guidance for those caring for the MH-susceptible patient. Check your facility's MH cart(s) for availability of appropriate drugs and supplies—see http://www.mhaus.orgfaqs/stockingan-mh-cart. **For emergency guidance, call the MH Hotline** at 1-800-644-9737 in the United States (or 209-417-3722 outside the United States) and access http://www.mhaus.org/healthcare-professionals for additional guidance.

A The acute MH episode presents during or after exposure to triggering anesthetic agents: succinylcholine (SCC) and all volatile inhalational anesthetics. Signs and laboratory findings may include tachycardia, masseter muscle rigidity (MMR), generalized muscle rigidity, skin mottling, cyanosis, tachypnea, dysrhythmias including ventricular tachycardia and fibrillation, cardiac arrest, hypertension, diaphoresis, rapid temperature rise, excessive bleeding, myoglobinuria, increased creatine kinase (CK), hypercarbia, respiratory acidosis, metabolic acidosis, and hyperkalemia.[1]

B Masseter muscle rigidity (MMR) (muscle spasm of ≥30-second duration that significantly interferes with mouth opening despite an appropriate SCC dose) may herald a fulminant MH reaction or may be an isolated adverse anesthetic response. If MMR occurs without respiratory acidosis, metabolic acidosis, or hyperkalemia, either continue with a nontriggering anesthetic and continuous monitoring of core temperature and end-expiratory carbon dioxide (CO_2) or abort the surgical procedure. Titrate fluids and diuretics to achieve a diuresis of 1–2 mL/kg/h or greater (consider insertion of urinary catheter). All patients who develop SCC-induced MMR will experience rhabdomyolysis over the ensuing 24 hours. Hence the patient should remain in the hospital and be monitored for signs of rhabdomyolysis such as myoglobinuria and myoglobinemia. CK levels and electrolytes should be checked every 8 hours until returning to normal. Refer MMR patients to an MH diagnostic center for evaluation if no temporomandibular joint dysfunction can be elicited on subsequent physical examination. Report patients to the North American Malignant Hyperthermia Registry (http://www.mhaus.org/registry).

C The differential diagnosis of MH includes insufficient anesthetic depth, hypoxia, hypercarbia, iatrogenic hyperthermia, heat stroke, hyperkalemic cardiac arrest secondary to occult muscular dystrophy, neuroleptic malignant syndrome, sepsis, thyrotoxicosis, pheochromocytoma, recreational drug ingestion (ecstasy, etc.), and radiologic contrast within the central nervous system (CNS). Obtain arterial blood gases (ABGs) and venous blood gas. While blood gases are being analyzed, control ventilation with an appropriate minute ventilation. Elevated expired CO_2 or expired CO_2 that is increasing rapidly in a nonbronchospastic, paralyzed, and adequately ventilated patient may be an early sign of MH. Turn off external patient warmers, measure core temperatures, and calculate the rate of temperature increase (>0.25°C/15 min is suspicious for MH).

D When fulminant MH is suspected, convert to anesthetic agents that do not trigger MH and initiate the MH treatment regimen. Reconstitute dantrolene with preservative-free sterile water and administer an initial dose of 2.5 mg/kg intravenously (IV). There are two formulations of dantrolene now available. Dantrium®/Revonto® is the older formulation, which provides *20 mg dantrolene sodium/60 mL* after reconstitution in sterile water. The second formulation, RYANODEX® (dantrolene sodium), is a new formulation that is an injectable suspension of dantrolene sodium providing *250 mg of dantrolene sodium/5 mL* after reconstitution. If the MH reaction does not rapidly resolve, additional dantrolene should be administered until MH signs of rigidity/metabolic or respiratory acidosis have abated. Assign at least one person the job of reconstituting dantrolene. If MH does not recur, give 1 mg/kg of IV dantrolene for three additional doses at 6-hour intervals. *Patients survive fulminant MH reactions only when they receive early and adequate dantrolene therapy.* Side effects of dantrolene include generalized muscle weakness and respiratory failure.

E If not already intubated, intubate the patient (without SCC). Ventilate [fraction of inspired oxygen (FiO_2 1.0)] to a partial pressure of carbon dioxide (PCO_2) of 35; this may require tripling the minute ventilation. Change the anesthesia circuit and reservoir bag. If available, insert activated charcoal filters (Vapor-Clean™, Dynasthetics, Salt Lake City, Utah) into the inspiratory and expiratory limbs of the breathing circuit. The Vapor-Clean filter may become saturated after 1 hour; therefore, a replacement set of filters should be substituted after each hour of use. Institute continuous expired CO_2 monitoring and insert urinary and arterial catheters. Because fluid shifts may be significant, consider insertion of a CVP. Monitor temperatures at two sites. Send blood samples for ABGs and venous blood gas, lactate, electrolytes including potassium (K^+), calcium (Ca^{++}), myoglobin, CK, fibrin

degradation products, prothrombin time (PT), international normalized ratio (INR), partial thromboplastin time (PTT), platelet count, and fibrinogen analysis. Check urine for myoglobin. Repeat as needed.

F Cool the patient to 37°C (cooling blankets, iced lavage of body cavities, and cool IV solutions). Promote a diuresis of at least 1–2 mL/kg/h, and treat metabolic acidosis and hyperkalemia. Young children with occult myopathies may experience severe rhabdomyolysis and hyperkalemic cardiac arrest after exposure to SCC or volatile inhalational anesthetics. Treat with calcium salts, bicarbonate, glucose, insulin, and epinephrine. Hemodialysis and cardiopulmonary bypass (CPB) may be needed. Give antiarrhythmics as needed. Do not transport the patient until stable unless CPB is required and unavailable within your institution.

G If MH signs recur, treat with IV dantrolene (2.5 mg/kg bolus, then titrate to effect). Large doses (>10 mg/kg) may be required for patients with persistent contractures or rigidity. Observe patients intensively for 12 hours after the last dantrolene dose. Patients may develop acute renal failure, acute hepatic failure, CNS dysfunction (seizures, stroke, paraplegia, or quadriplegia), cardiac failure (usually after cardiac arrest from hyperkalemia), and DIC (a recent report suggests possible association between MH and bleeding abnormalities).[1] Report the MH episode and refer the patient and family to MHAUS (www.mhaus.org or 607-674-7901). Following recovery, refer the patient to an MH diagnostic center to evaluate MH susceptibility. Children suffering a hyperkalemic cardiac arrest should be evaluated by a neurologist for occult myopathy. The patient should request a medical alert bracelet before discharge. The patient or his or her parents should inform first- and second-degree relatives of their possible MH susceptibility. A recently described scoring system for patients at risk for MH may prove useful in the future.[2]

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REFERENCES

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2. Gleich SJ, Strupp K, Wilder RT, Kor DJ, Flick R. An automated real-time method for the detection of patients at risk for malignant hyperthermia. Paediatr Anesth. 2016 Sep;26(9):876-82.

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