Standards for Office Based Anesthesia Practice

Certified Registered Nurse Anesthetists (CRNAs) have long been the predominant anesthesia professional and leaders in providing anesthesia services in physicians' offices. As the professional organization representing nurse anesthetists, the American Association of Nurse Anesthetists (AANA) advocates high quality, appropriate standards of care for all patients in all settings, including the office based practice setting. As in other settings, CRNAs provide anesthesia working with physicians such as surgeons, anesthesiologists and, where authorized, podiatrists, dentists and other healthcare professionals.

The AANA has been at the forefront in establishing clinical practice standards, including patient monitoring standards. The standards for care in the office based setting are congruent with the AANA Scope and Standards for Nurse Anesthesia Practice and are intended to:

1. Provide assistance to CRNAs and other practitioners by promoting a common base for the delivery of quality patient care in the office based setting.
2. Assist the public in understanding what to expect from the practitioner.
3. Support the basic rights of patients.

Although the standards are intended to promote high quality patient care, they cannot assure specific outcomes.

There may be exceptional patient-specific circumstances that require deviation from a standard. The CRNA shall document any deviations from these standards (e.g., surgical interventions or procedures that invalidate application of a monitoring standard) and state the reason for the deviation on the patient's anesthesia record.

Anesthesia in the Office Setting

There are some unique and specific responsibilities that should be considered prior to administration of anesthesia in the office setting. When considering an office based practice, anesthesia professionals should determine if there are appropriate resources to manage the various levels of anesthesia for the planned surgical procedures and the condition of the patient. Most office based practice settings are not regulated, therefore the CRNA should consider the benefit of uniform professional standards regarding practitioner qualifications and training, equipment, facilities and policies that ensure the safety of the patient during operative and anesthesia procedures in the office setting.

At a minimum the CRNA shall determine that there are policies to address:

a. Patient selection criteria
b. Monitoring equipment with a backup electrical source
c. Adequate numbers of well trained personnel to support the planned surgery and anesthesia
d. The treatment of foreseeable complications
e. Patient transfer to other healthcare facilities

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f. Infection control practices, including OSHA requirements
g. Minimal preoperative testing, including required consultations
h. Ancillary services (e.g., laboratory, pharmacy, consultation with outside specialists)
i. Equipment maintenance
j. Response to fire and other catastrophic events
k. Recovery and discharge of patients
l. Procedures for follow-up care

The CRNA shall comply with all applicable state and federal rules and regulations relating to licensure, certification, and accreditation of an office practice.

Section I

Standard I
Perform and document a thorough preanesthesia assessment and evaluation.

Application to Office Practice
Preanesthesia assessment of the patient undergoing office based surgery should include documentation of at least:

a. assigned physical status
b. airway assessment
c. previous anesthetic history
d. allergies
e. fasting status
f. history and physical

Standard II
Obtain and document informed consent for the planned anesthetic intervention from the patient or legal guardian, or verify that an informed consent has been obtained and documented by a qualified professional.

Application to Office Practice
The CRNA shall confirm that consent has been given for the planned surgical or diagnostic procedure and that the patient understands and accepts the plans and inherent risks for anesthesia in the office setting.

Standard III
Formulate a patient-specific plan for anesthesia care.

Application to Office Practice
A patient specific plan of care is based on patient assessment and the anticipation of potential problems in the unique setting. The operating practitioner concurs that the patient is cleared for the planned anesthetic.

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Standard IV

Implement and adjust the anesthesia care plan based on the patient's physiologic status. Continuously assess the patient's response to the anesthetic, surgical intervention, or procedure. Intervene as required to maintain the patient in optimal physiologic condition.

Application to Office Practice

The CRNA shall continuously assess and monitor the patient's response to the anesthetic. Prior to administration of anesthesia the CRNA shall verify a means to deliver positive pressure ventilation and treat emergency situations including availability of necessary emergency equipment and drugs. If "triggering agents" associated with malignant hyperthermia are used, adequate dosages of dantrolene should be immediately accessible. (See accompanying AANA Position Statement titled, "Malignant Hyperthermia Crisis Preparedness and Treatment.")

Standard V

Monitor, evaluate, and document the patient's physiologic condition as appropriate for the type of anesthesia and specific patient needs. When any physiological monitoring device is used, variable pitch and threshold alarms shall be turned on and audible. The CRNA should attend to the patient continuously until the responsibility of care has been accepted by another anesthesia professional.

a. **Oxygenation**
   Continuously monitor oxygenation by clinical observation and pulse oximetry. If indicated, continually monitor oxygenation by arterial blood gas analysis.
b. **Ventilation**
   Continuously monitor ventilation. Verify intubation of the trachea or placement of other artificial airway devices by auscultation, chest excursion, and confirmation of expired carbon dioxide. Use ventilatory pressure monitors as indicated. Continuously monitor end-tidal carbon dioxide during controlled or assisted ventilation and any anesthesia or sedation technique requiring artificial airway support. During moderate or deep sedation, continuously monitor for the presence of expired carbon dioxide.
c. **Cardiovascular**
   Continuously monitor cardiovascular status via electrocardiogram. Perform auscultation of heart sounds as needed. Evaluate and document blood pressure and heart rate at least every five minutes.
d. **Thermoregulation**
   When clinically significant changes in body temperature are intended, anticipated, or suspected, monitor body temperature in order to facilitate the maintenance of normothermia.
e. **Neuromuscular**
   When neuromuscular blocking agents are administered, monitor neuromuscular response to assess depth of blockade and degree of recovery.
f. **Positioning**
   Monitor and assess patient positioning and protective measures, except for those aspects that are performed exclusively by one or more other providers.

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Interpretation
Continuous clinical observation and vigilance are the basis of safe anesthesia care. Consistent with the CRNA's professional judgment, additional means of monitoring the patient's status may be used depending on the needs of the patient, the anesthesia being administered, or the surgical technique or procedure being performed.

Application to Office Practice
Minimum monitors in the office based setting include: pulse oximetry; electrocardiogram; blood pressure; O_2 analyzer when O_2 is delivered through the breathing system of the anesthesia machine; end-tidal CO_2 when administering general anesthesia; a monitor for the presence of expired carbon dioxide when administering moderate or deep sedation; a body temperature monitor when clinically significant changes are intended, anticipated, or suspected; and peripheral nerve stimulator as indicated when administering neuromuscular blocking agents.

Standard VI

Document pertinent anesthesia-related information on the patient's medical record in an accurate, complete, legible, and timely manner.

Application to Office Practice
The CRNA confirms there is a plan for accurate record keeping and documentation of the following:

a. informed consent
b. preanesthesia and postanesthesia evaluations
c. course of the anesthesia, including monitoring modalities and drug administration, dosages and wastages
d. discharge follow-up

The CRNA shall confirm that there is a systematic mechanism for documentation of compliance with U.S. Drug Enforcement Agency rules, Board of Pharmacy regulations, Food and Drug Administration requirements, and U.S. Department of Transportation regulations for accountability and appropriate storage.

Documentation of provider licensure and credentials, facility licensure, and continued competence is recommended.

Standard VII

Evaluate the patient's status and determine when it is safe to transfer the responsibility of care. Accurately report the patient's condition, including all essential information, and transfer the responsibility of care to another qualified healthcare provider in a manner that assures continuity of care and patient safety.

Application to Office Practice
Postanesthesia care is consistent with other practice settings in that there is a designated area staffed with appropriately trained personnel. At least one qualified provider - a surgeon, anesthesia professional, or ACLS-certified registered nurse - should remain in the facility until all patients are discharged. An accurate postanesthesia record is documented.

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Standard VIII

Adhere to appropriate safety precautions as established within the practice setting to minimize the risks of fire, explosion, electrical shock and equipment malfunction. Based on the patient, surgical intervention or procedure, ensure that the equipment reasonably expected to be necessary for the administration of anesthesia has been checked for proper functionality and document compliance. When the patient is ventilated by an automatic mechanical ventilator, monitor the integrity of the breathing system with a device capable of detecting a disconnection by emitting an audible alarm. When the breathing system of an anesthesia machine is being used to deliver oxygen, the CRNA should monitor inspired oxygen concentration continuously with an oxygen analyzer with a low concentration audible alarm turned on and in use.

Application to Office Practice

The CRNA confirms equipment is routinely maintained by appropriately trained professionals. Prior to use, equipment is inspected for risk of malfunction and electrical/fire hazards.

Standard IX

Verify that infection control policies and procedures for personnel and equipment exist within the practice setting. Adhere to infection control policies and procedures as established within the practice setting to minimize the risk of infection to the patient, the CRNA, and other healthcare providers.

Application to Office Practice

The CRNA shall confirm that policies are in place and a process exists to document compliance with Occupational Safety and Healthcare Administration (OSHA) standards relating to blood borne pathogens; medical waste and hazardous materials; personal protection devices; and disposal of needles, syringes and contaminated supplies.

Standard X

Participate in the ongoing review and evaluation of anesthesia care to assess quality and appropriateness.

Application to Office Practice

Prior to administration of any anesthetic in an office facility, the CRNA shall review the AANA minimal elements (Section II) and evaluate for compliance and applicability to the setting. The CRNA shall participate in assessment and review of appropriateness of anesthesia care provided in the office setting. There should be a process to document patient satisfaction and outcomes.

Standard XI

Respect and maintain the basic rights of patients.

Application to Office Practice

The CRNA shall act as the patient's advocate. The patient has the right to dignity, respect and consideration of legitimate concerns in the office setting. Patients should be involved with all aspects of their care.

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Section II
Supplemental Resources

Minimum Elements for Providing Anesthesia Services in the Office Based Practice Setting

Assessment Checklist

Practitioners

CRNA

- ❍ Will the Board of Nursing and state laws allow the CRNA to work with this physician type?
- ❍ Will your liability insurance cover office anesthesia?
- ❍ Does the state have rules/regulations specific to office-based anesthesia?
  - ❍ What classes of patients, types of surgical procedures, and anesthesia will be performed?
  - ❍ Are there established policy and procedure processes in place?

Operating Physician

- ❍ Does the physician have liability coverage and a current licensure/Drug Enforcement Agency (DEA) number?
- ❍ Does the physician have hospital privileges for procedures?
- ❍ Does the physician have admitting privileges at the nearest hospital?

Facility

- ❍ Is the facility licensed?
  - ❍ By whom? Indicate name:_____
- ❍ Is the facility accredited?
  - ❍ By whom? Indicate name:_____
- ❍ Size of operating room (OR), recovery room, and preoperative area adequate for anesthesia and surgical procedures?
- ❍ Is there a transfer agreement?
- ❍ Does the facility have an emergency service agreement?
- ❍ Available communication resources: Are telephone numbers accessible and posted for Emergency Medical Services (EMS), Malignant Hyperthermia (MH) hotline, nearby hospital, etc.?

Equipment

Local, Intravenous Sedation, Regional and General Anesthesia

- ❍ Monitors include: pulse oximetry; electrocardiogram; blood pressure; O_2 analyzer when O_2 is delivered through the breathing system of the anesthesia machine; end-tidal CO_2 when administering general anesthesia; a monitor for the presence of expired carbon dioxide when administering moderate or deep sedation; a body temperature monitor when clinically significant changes are intended, anticipated, or suspected; and peripheral nerve stimulator as indicated when administering neuromuscular blocking agents. Use of monitors should be appropriate to patient, procedure and type of anesthesia
- ❍ Oxygen supplies: Minimum of two oxygen sources must be available with regulators attached
- ❍ Continuous positive-pressure ventilation source tested and in working order (e.g., adjustable bag-mask, nonrebreathing units) appropriate to patient population
- ❍ Defibrillator (charged)

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- Suction machine, tubing, suction catheters, and Yankaur suctions
- Accessible anesthesia storage unit to provide for organization of supplies including endotracheal equipment, masks, airways, syringes, needles, intravenous catheters, intravenous fluids and tubing, alcohol, stethoscopes, and medications appropriate for patient population
- Emergency resuscitation medications, including at a minimum ACLS or PALS protocol medications, if appropriate, to include, atropine, epinephrine, ephedrine, lidocaine, diphenhydramine, cortisone, and a bronchial dilator inhaler.

General Anesthesia

- An authorized factory technician or qualified service personnel has documented that the anesthesia machine(s) and monitoring equipment are operable.
  The following items are available as an integral part of the anesthesia delivery system or equivalent stand-alone equipment:
  - O_2 fail-safe system
  - Oxygen analyzer
  - Waste gas exhaust system
  - End-tidal CO_2 analyzer
  - Vaporizers-calibration and exclusion system
  - Audible alarm system (variable pitch and low threshold capabilities)
- Pulse oximeter, electrocardiogram, blood pressure monitors
  - Temperature monitor as appropriate for patient age, physical status, and surgical procedure

Emergencies

- Emergency equipment
  - Basic airway equipment (adult and pediatric)
    - Nasal and oral airway
    - Face mask (appropriate for patient)
    - Laryngoscopes, endotracheal tubes (adult and pediatric)
    - Ambu bag or other positive pressure ventilation device
  - Difficult airway equipment (laryngeal mask airway, light wand, cricothyrotomy kit)
  - Defibrillator
  - Supplemental O_2
  - Emergency drugs
  - Compression board
  - Suction equipment (suction catheter, Yankaur type)
  - Drugs and equipment to treat MH on site
- Back-up power

Pharmaceutical Accountability

- Is there an appropriate mechanism for documenting and tracking use of pharmaceuticals including controlled substances?
  - Lock box
  - DEA 222 forms
  - Count sheets
  - Waste policy
  - Expiration checklist or policy

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Policies/Procedures and Protocols

- Policies/procedures and protocols are in place regarding:
  - Preoperative lab requirements
  - Patient selection
  - Nothing by mouth (NPO) status
  - Discharge criteria
  - Case cancellations
  - Advanced Cardiac Life Support (ACLS) algorithms
  - MH protocols
  - Latex allergy protocols
  - Pediatric drug dosages
  - Emergencies
    - Cardiopulmonary
    - Chemical spill
    - Fire
    - Building evacuation
    - Bomb threat
  - Reporting adverse reactions
  - Infection control in adherence to OSHA rules for control of medical waste, and CDC recommendations for disposal of sharps and personal protection
- Compliance with HIPAA patient information protection

Record Keeping

- Record-keeping system in place for patients and providers
- Anesthesia record
- Consent forms
- Credentials
- Q/A mechanism
- Patient satisfaction/followup
- Preanesthesia equipment and supplies
- Purchasing agreements

Personnel

- OR
  - RN
  - LPN
  - OR technician
- PACU
  - RN
  - LPN
  - Anesthetist/surgeon
- ACLS certified
  - Surgeon
  - Anesthetist
  - RN
- BCLS certified
  - RN
  - LPN
  - Others

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Anesthesia Equipment and Supplies Checklist

(To be kept in log book)

Date: _____ Checked-out by: _____ Location: _____

- ❍ Oxygen pipeline pressure or primary source _____ pounds per square inch
- ❍ Oxygen tank pressure (second source) _____ pounds per square inch
- ❍ Back-up power
- ❍ Defibrillator and crash cart available
- ❍ Anesthesia cart supplies checked, i.e., intravenous equipment, anesthetics, stethoscope
- ❍ Suction equipment tested
- ❍ Ambu bag tested
- ❍ Electrocardiogram (ECG) operational
- ❍ Pulse oximeter operational
- ❍ Capnometer operational
- ❍ Blood pressure monitor
- ❍ Back-up blood pressure cuff
- ❍ Atropine
- ❍ Epinephrine
- ❍ Ephedrine
- ❍ Lidocaine
- ❍ Other emergency medications as indicated
- ❍ Endotracheal equipment, airways

If general anesthesia is planned:Anesthesia machine no._____

- ❍ Leak test and other tests performed as indicated
- ❍ Oxygen analyzer is on
- ❍ Capnometer connected
- ❍ Temperature monitor available
- ❍ Emergency airways available, i.e., laryngeal mask airway, combitube, or cricothyrotomy kit
- ❍ Succinylcholine
- ❍ Dantrolene
- ❍ Other anesthesia medications as indicated

Note (if problem): _____

_____

_____

Follow-up (who, what): _____

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Resources

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Revised by the AANA Board of Directors in 2001, 2002, November 2005, and January 2013.

Malignant Hyperthermia Crisis Preparedness and Treatment

Position Statement

Malignant Hyperthermia Association of the United States
Emergency 24-Hour Hotline: (800) MH-HYPER (644-9737)

Introduction

Malignant hyperthermia (MH) is a rare, inherited skeletal muscle syndrome that presents as a hypermetabolic reaction triggered by exposure to volatile anesthetic gases or the depolarizing muscle relaxant, succinylcholine.[1,2] The incidence of MH is difficult to quantify. MH cases have been reported ranging from 1/5,000 – 1/100,000 anesthetics, which vary regionally and are highest in children and young adults.[1,3-8] Geographic variability of MH-susceptibility exists based on gene pool variation internationally.[9]

Early recognition of an impending MH crisis and prompt emergency response is critical for a patient's survival.[10] Dantrolene is currently the only clinically accepted drug treatment for MH.[1,2] The availability of dantrolene and increased intraoperative monitoring have considerably reduced MH fatality.[2,6,11-14] An increase in the time interval between the first clinical signs of MH and the administration of dantrolene has been associated with increased complication rates.[15-17]

AANA Position

Availability of Dantrolene

The AANA strongly recommends all anesthesia professionals delivering MH triggering agents such as potent volatile inhalation anesthetics or administering depolarizing muscle relaxants have the requisite drugs and supplies available as defined by the Malignant Hyperthermia Association of the United States (MHAUS). Dantrolene, along with other drugs and equipment necessary to treat an MH crisis, must be available at all facilities, including ambulatory surgical centers (ASCs) and offices, where MH triggering anesthetics or depolarizing muscle relaxants are administered or stocked.[18] Table 1 summarizes the known MH triggering agents. The standard of care is the same for large and small facilities and all facility types. Stocking dantrolene for the treatment of MH in an outpatient setting is cost-effective and promotes patient safety.[2]

Table 1. Known Triggers for MH-Susceptible Patients[19]

Inhaled General Anesthetics
• Desflurane • Enflurane • Ether • Halothane • Isoflurane • Methoxyflurane • Sevoflurane
Depolarizing Muscle Relaxant
• Succinylcholine

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To treat an MH crisis, an initial dantrolene dose of 2.5 mg/kg is recommended.[20] Two formulations of dantrolene are currently available. A full complement of Dantrium®/ Revonto® is 36 vials and a full complement of Ryanodex® is three vials. If new dantrolene formulations become available, facilities should verify that the appropriate supply is stocked within the facility. MHAUS recommends that a full complement of dantrolene be available to administer at the anesthetizing location (e.g., operating room) within 10 minutes of the decision to treat for MH.[20] A facility must assess its size and proximity of anesthetizing locations when determining the appropriate number of MH carts/kits to stock. A patient experiencing an MH crisis must be stabilized prior to transport to a hospital.[16,20] Consideration needs to be given to obese patients, who may require a higher dose or total drug volume in order to be stabilized.

Approximately 55 percent of MH cases in the United States and Canada have included the administration of succinylcholine, either alone or in combination with volatile anesthetics.[14,15,17] MH risk may increase when succinylcholine is used in combination with volatile anesthetics.[14] MHAUS recommendations apply to all settings that stock MH triggering agents, even if only sedation services are provided and volatile anesthetics are not administered. Settings that stock succinylcholine, even if only for the purpose of emergency airway management, should have dantrolene available and a MH crisis protocol in place.[18]

Considerations for Policy Development

Facilities establish policies and patient safety protocols to prevent and treat MH. Facility policies address the following considerations:

Governmental Regulations and Accreditation Standards
Facilities must be aware of governmental regulations as well as standards and guidelines set by national organizations and accrediting organizations that relate to MH crisis emergency management.

Emergency Contact
A policy appropriate for the facility type exists to treat and transport a patient in MH crisis. Contact information for emergency services and the MHAUS Emergency 24-hour Hotline – (800) MH-HYPER (644-9737) - should be clearly posted and available for all facility staff.

MH Emergency Drugs and Equipment
If MH-triggering agents are used within the facility, even if only for emergency airway management, an MH cart/kit is available for emergency treatment of an MH crisis. The facility policy includes a process to inspect the MH cart/kit for expired drugs and equipment. Appendix 1 includes a detailed list of the contents of an MH cart/kit.

MH Screening
MH susceptibility is inherited with an autosomal dominant inheritance pattern. Therefore, children and siblings of a patient with MH susceptibility usually have a 50 percent chance of inheriting a gene defect for MH and would be MH-susceptible. During the preanesthesia patient assessment and evaluation, an MH screening can aid in determining a patient's risk for MH.

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When evaluating the patient, MHAUS recommends:[21]

- Review indicators of MH susceptibility, if known
- Assess level of suspicion for susceptibility to MH
- Review eligibility criteria for diagnostic testing
- Consult with MH expert, if necessary

Patients with muscular disorders should be evaluated by an anesthesia professional prior to surgery.[22] MH or MH-like events may occur in patients with underlying muscle diseases, such as muscular dystrophy and myotonia.[22,23]

Diagnostic testing options to evaluate MH susceptibility are not recommended as a screening tool for the general population.[21] Diagnostic tests are most useful when making treatment decisions for surgical patients where there is a high level of suspicion that the patient is susceptible to MH.[21] Patients known to be susceptible to MH may undergo anesthesia numerous times before an episode occurs.[1]

Anesthetic Drug Selection and Anesthesia Machine Preparation
If a patient is confirmed as MH-susceptible or has a family history of MH, proper anesthesia precautions must be taken.[7,24] MH-triggering volatile anesthetic agents and succinylcholine should be avoided. Pretreatment with dantrolene is not recommended.[1,6,8] The anesthesia plan of care focuses on the use of an anesthesia machine that has been prepared and flushed according to the manufacturer's recommendation.[25,26] Modern anesthesia workstations have variability in their components and effective flush times.[27,28] Additional considerations include use of an activated charcoal filter with the anesthesia machine and use of trigger-free drugs for induction, anesthesia maintenance, and emergent airway management.

Adding activated charcoal filters to the airway circuit will remove volatile anesthetic agents and is effective in keeping anesthetic agent concentration below 5 ppm for up to 12 hours with fresh gas flows of at least 3 L/min.[25,28,29] However, the anesthesia machine will still need to be flushed with high fresh gas flows (≥ 10 L/min) for 90 seconds prior to placing the activated charcoal filters on the proximal end(s) of the inspiratory and expiratory limb(s) of the anesthetic circuit.[25,29-31]

Other alternatives include the use of a dedicated "vapor free" machine for MH-susceptible patients or, if appropriate to the institution, the use of an intensive care unit (ICU) ventilator that has never been exposed to volatile anesthetic agents.[26]

MH Symptoms
The initial symptoms of an MH episode are not specific and can range from mild to severe.[6,32] Clinical signs of MH are summarized in Table 2.

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Table 2. Clinical Signs of MH[5,6,8,10]

Early Clinical Signs
• Abrupt increase in $ETCO_2$ • Cardiac arrhythmias • Generalized muscle rigidity • Hypoxia • Profuse sweating • Trismus / Masseter muscle rigidity (MMR) • Metabolic-respiratory acidosis • Mottling of the skin • Tachycardia • Tachypnea in spontaneously breathing patients • Unstable arterial pressure
Late Clinical Signs
• Acute renal failure • Circulatory failure • Dark colored urine due to myoglobinuria • Disseminated intravascular coagulation • Elevated blood creatine phosphokinase levels • Elevated blood myoglobin levels • Hyperkalemia • Hyperthermia (> 38.8° C)* • Hypotension • Rhabdomyolysis • Severe cardiac arrhythmias and cardia arrest

*A rapid temperature increase of >1° C in 15 minutes is more diagnostically relevant than peak temperature.[6]

Trismus / Masseter Muscular Rigidity

Trismus, or masseter muscular rigidity (MMR), which is characterized by difficulty in opening the jaw, is a rare but dangerous phenomenon. Mild and/or transient MMR is a normal response to succinylcholine and is not considered to be a significant prognostic sign of MH.[33]

If a patient has received succinylcholine and his/her jaw cannot be opened or the patient has peripheral muscle rigidity, the clinician should assume this is an MH event and immediately begin MH treatment (i.e., dantrolene administration).[33,34] Generalized rigidity may not be present, but when it is, it is typically associated with MH susceptibility.[33] The physiologic changes associated with the onset of MH, such as rise in $ETCO_2$, may be delayed for up to 15 minutes after MMR, but will occur if triggering anesthetic agents are continued.[33] Anesthesia should be discontinued and an elective surgery should be postponed.[33] In an emergency, the anesthetic may continue with non-triggering anesthetic agents.[33,34]

Following MMR, patients should be admitted to an intensive care unit and monitored for signs of MH.[34] Rhabdomyolysis occurs in most patients who experience MMR.[33] Creatine kinase (CK) and urine myoglobin values should be monitored regularly.[33-35] CK levels peak 14-24 hours after an MMR episode.[35] Muscle biopsy for a definitive diagnosis may be considered.[34]

Core Temperature Monitoring
Temperature elevation is an early sign of an impending MH crisis.[11,17] MHAUS recommends core temperature monitoring for all patients undergoing general anesthesia lasting more than 30 minutes.[11,36] Appropriate sites for continuous electronic core temperature monitoring include the esophagus, nasopharynx, bladder, and pulmonary artery.[36]

MH Crisis Treatment
Numerous clinicians (e.g., surgeon/proceduralist, anesthesia professional, nursing staff) are required within a short time period when an MH crisis occurs for successful resuscitation. The use of a team leader, cognitive aids (e.g., the MHAUS manual), and staff dedicated to systematically read the protocol steps will support the clinical team with resources required to manage an MH crisis.[5]

Initial response during an MH crisis includes activation of the MH plan, discontinuation and elimination of potent inhalation anesthetics, increased ventilation rate with 100 percent oxygen, addition of an inline activated charcoal filters, treatment with intravenous dantrolene, active cooling by all available routes, and treatment of electrolyte and pH abnormalities.[5,32,37] Calcium-channel blockers should be avoided if dantrolene is used, because they may cause hyperkalemia.[38] When activated charcoal filters are used during an MH crisis, even though the volatile anesthetic agent is discontinued when MH is first suspected, activated charcoal filters may become saturated after one hour.[31,37] Therefore, the activated charcoal filters should be replaced after each hour of use.[29,37]

Obtain blood gas (venous or arterial) to determine degree of metabolic acidosis.[37] Consider administration of sodium bicarbonate, 1-2 mEq/kg dose, for base excess greater than -8 (maximum dose 50 mEq).[37] In an ASC or office-based facility, blood gas analysis may not be available. A single dose of sodium bicarbonate 1-2 mEq/kg may be considered for treatment of metabolic acidosis.[39] Clinical judgment, vigilance, and patient assessment are key factors in the treatment of an MH crisis.

Patient Transfer
ASCs and office-based facilities have transfer agreements in place with a nearby hospital which has inpatient capabilities to care for a patient in an MH crisis.[4,16,32] The patient should be transferred out of an ASC or office when, according to the clinician's judgment, the patient is stable.[16] Hospitals have a procedure and policy for transfer of a stabilized MH patient to an ICU.

Signs of stability may include:[16]

- $ETCO_2$ declining or normal
- Heart rate stable or decreasing without dysrhythmia
- IV dantrolene has begun
- Temperature declining
- If present, generalized muscular rigidity resolving

Detailed communication regarding the transfer of care needs to occur between clinicians at the transferring and receiving facilities to support continuity of patient treatment and monitoring.[4,16] For a detailed MH patient transfer protocol, review the *Guide for the Transfer of Care of the Malignant Hyperthermia Patient from Ambulatory Surgery Centers to Receiving Hospital Facilities*.[16]

Post-Anesthesia Care Unit (PACU) and ICU

In rare cases, an MH episode may occur in the immediate postoperative period.[7,8,40] In an MH-susceptible patient, if no signs of MH are noted one hour postoperatively after an MH safe anesthetic technique, it is unlikely that MH will occur.[8,9,40] The patient should be monitored in a phase I PACU for at least one hour and in a phase II/step down PACU for at least another hour.[8,24,32,41,42] MH-susceptible patients require close vital sign and temperature monitoring in the PACU and, if indicated based on the clinician's evaluation, may be kept longer for further observation.[8,40,41] Patients undergoing procedures in an ASC or office may be discharged home the same day.[24,41] Discharge instructions with clear guidance on signs, symptoms, and instruction on how to manage complications are important to provide to patients and their caregivers.[40]

After an MH crisis, the patient may need to be treated with dantrolene for at least 24-36 hours.[3,43] Patients should be monitored in the ICU for MH complications,[43] including:

- MH recrudescence, which can occur in up to 25 percent of patients within hours of the initial MH crisis[5,9,24,43]
- Disseminated intravascular coagulation[9]
- Myoglobinuric renal failure[9]

Although an MH crisis is typically seen in the operating room (OR) and rarely in the PACU, MH cases have also been documented in sedated patients in the ICU,[44-46] underscoring the importance of clinical vigilance, identification of the syndrome, and prompt treatment.

MH Crisis Counseling

If an MH crisis occurs, the event and immediate care steps should be discussed with the patient and family. Recommendation may be made to purchase and wear medical identification items or other identifiers.[47] The patient and family members may consider genetic counseling and be referred to MHAUS for further information and resources.[6,32,48]

Quality Improvement

As soon as possible, the team should debrief the MH event to review the response process and develop an action plan for any identified improvements. The team should engage in ongoing team competency training, integration of an emergency manual checklist, and a peer support process for staff emotional recovery, as needed.

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Ongoing Competency
Healthcare providers maintain familiarity with current MHAUS recommendations and guidelines. Conducting MH crisis team training, that includes the OR, PACU, and ICU teams, as a part of ongoing and annual competency education will prepare the clinical team to recognize, respond to, and treat an MH crisis.[4] Ongoing training may also include pharmacy, laboratory, and emergency medical services personnel to highlight their roles in MH-preparedness, promote continued awareness, and safeguard patient safety.

Conclusion

Malignant hyperthermia is a rare, yet potentially fatal condition. Anesthesia professionals may be the first to recognize the onset of an MH crisis, but a coordinated team response is vital in the effective treatment and management of MH. Accessibility to an MH cart, stocked with dantrolene, is a requirement supported by MHAUS and the AANA for all facilities where MH-triggering agents are available. All facilities (e.g., hospital, ASCs, offices) can promote patient safety and MH awareness by establishing policies and protocols for clinical team competency training, mock drills, patient screening, anesthetic selection and anesthesia machine preparation, emergency response, MH treatment and management, patient transfer, patient and family counseling, and continued quality improvement.

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Appendix 1: Contents of an MH Cart/Kit

MHAUS recommends that the following drugs and equipment are available to treat an MH crisis.[18]

Drugs

1. Dantrolene
    a. Dantrium® / Revonto® – 36 vials should be available in each institution where MH can occur, each vial to be diluted at the time of use with 60 ml sterile water, USP (without a bacteriostatic agent). There are 3 grams of mannitol in each vial of 20 mg of dantrolene (0.15 g mannitol/ 1 mg dantrolene).
    b. Ryanodex® – 3 vials should be available in each institution where MH can occur, each to be diluted at the time of use with 5 ml of sterile water for injection, USP (without a bacteriostatic agent). There are 0.125 grams of mannitol in each vial of 250 mg of Ryanodex® (0.0005 grams mannitol/1 mg dantrolene).
2. Sterile water for injection USP (without a bacteriostatic agent)
3. Sodium bicarbonate (8.4 percent) – 50 ml x 5
4. Dextrose 50 percent – 50 ml vials x 2
5. Calcium chloride (10 percent) – 10 ml vial x 2
6. Regular insulin – 100 units/ml x 1 (refrigerated)
7. Lidocaine* for injection (2 percent) – 100 mg/5 ml or 100 mg/10 ml in preloaded syringes (3). Amiodarone is also acceptable. Advanced Cardiac Life Support protocols, as prescribed by the American Hospital Association, should be followed when treating all cardiac derangements caused by MH.
8. Refrigerated cold saline solution – A minimum of 3,000 ml for IV cooling

    * Lidocaine or procainamide should not be given if a wide-QRS complex arrhythmia is likely due to hyper-kalemia; this may result in asystole.

General Equipment

1. Charcoal Filters - Two pairs of activated charcoal filters (Vapor-Clean™, Dynasthetics, Salt Lake City, UT). Attach activated charcoal filters to inspiratory and expiratory ports of the anesthesia machine to quickly reduce the concentration of gas (<5 ppm) from the anesthesia machine. In this situation, even though the anesthetic gas has been discontinued when MH was first suspected, the Vapor-Clean™ filter may become saturated after one hour; therefore, a replacement set of filters should be substituted after each hour of use.
2. Syringes – (60 ml x 5) to dilute dantrolene
3. Intravenous catheters – 16G, 18G, 20G, 2-inch; 22G, 1-inch; 24G, 3/4-inch (4 each) (for IV access and arterial line)
4. NG tubes – sizes appropriate for patient population
5. Toomey irrigation syringes – (60 ml x 2) with adapter for NG irrigation

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Monitoring Equipment

1. Esophageal or other core (e.g., nasopharyngeal, tympanic membrane, rectal, bladder, pulmonary artery catheter) temperature probes.
2. CVP kits (sizes appropriate for patient population). It is recommended that these be used in patients who are critically ill.
3. Transducer kits for arterial and central venous cannulation.

Nursing Supplies

1. Large sterile Steri-Drape (for rapid drape of wound)
2. Urine meter x 1
3. Irrigation tray with piston (60cc irrigation) syringe
4. Large clear plastic bags for ice x 4
5. Small plastic bags for ice x 4
6. Bucket for ice
7. Test strips for urine hemoglobin

Laboratory Testing Supplies

1. Syringes (3 ml) for blood gas analysis or ABG kits x 6 or point of care monitors; ISTAT with TB syringes (the point of care ISTAT device has replaced lab blood gene and electrolyte measurement).
2. Blood specimen tubes for CK, myoglobin, SMA 19 (LDH, electrolytes, thyroid studies), PT/PTT, fibrinogen, fibrin split products; and lactate, CBC, platelets. If no immediate laboratory analysis is available, samples should be kept on ice for later analysis. This may well prove useful on retrospective review and diagnosis. Blood cultures are very useful and should be included to rule out bacteremia.
3. Urine collection container for myoglobin level. Pigmenturia (e.g., brown or red urine and heme positive dipstick) indicates that renal protection is mandated, when the urine is centrifuged or allowed to settle, and the sample shows clear supernatant, i.e., the coloration is due to red cells in the sample.

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