Preparation of Anesthesia Workstations to Anesthetize MH Susceptible Patients

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Recommendations (4 alternatives):

1. Flush and prepare workstation according to manufacturer's recommendations or published studies; this may take 10 to >90 minutes. Most studies also physically disconnect vaporizers from the workstation; use a new, disposable breathing circuit; and replace the carbon dioxide absorbent. During the case, fresh gas flow should be kept at 10 liters per minute to avoid "rebound phenomenon" (increased release of residual volatile anesthetic agent when fresh gas flow is reduced after a set period of flushing).

OR

2. Use commercially available activated charcoal filters that have been shown to remove trace levels of volatile anesthetic agents following a 90 second flush with high fresh gas flows. These filters have been demonstrated in one in vitro study to be effective for 12 hours.

OR

3. If available, use a dedicated "vapor free" machine for MH-susceptible patients. The machine must be regularly maintained and safety-checked.

OR

4. If appropriate to the institution, use an ICU ventilator that has never been exposed to volatile anesthetic agents.

Supporting Evidence:

Search Strategy: We searched Medline (1948 to May 2011) for the keywords "malignant hyperthermia", "anesthesia", and "equipment". We reviewed those abstracts for pertinent articles, and then hand searched those articles' references for additional studies. We also searched the ASA Abstracts website for additional studies from 2006 to 2010. Finally, we reviewed data provided at the Dynasthetics website not found by earlier search (www.dynasthetics.com).

Background:

MH is an inherited pharmacogenetic disorder that is triggered by commonly used volatile anesthetic agents (1). These agents should be avoided when providing general anesthesia to MH-susceptible patients. There is no known upper safe limit of exposure to these agents, and anesthesia workstations are "contaminated" by them, so efforts must be made to reduce patient exposure to a minimum. MH susceptible swine did not develop MH when exposed to halothane 5 ppm concentration (2). This trace level has been used as an arbitrary "safe limit" to study preparation of workstations and the occupational exposure of MH susceptible healthcare workers.

Key Points:

The earliest solution to this problem was the use of a "vapor free" anesthesia circuit, either a dedicated anesthesia machine that had never been exposed to volatile anesthetic agents, or a disposable non-rebreathing circuit. However, maintaining a dedicated machine for the rare MH patient is impractical in most centers, because of cost and obsolescence (lack of familiarity, availability of spare parts).

Various preparation methods and flushing cycles have been used to wash volatile agents out of absorbent parts of the anesthesia machine that cannot be replaced. These machines have evolved into more sophisticated "workstations" that take longer to flush because more absorbent materials are used in their construction. Different manufacturers' workstations require specific preparation, especially flush times, so a generic set of instructions on preparation cannot be provided (3). A common problem with flushing a contaminated anesthesia workstation is the "rebound phenomenon" (3), where residual anesthetic agents diffuse out of absorbent materials when the fresh gas flow used for flushing is reduced to "usual" clinical settings (e.g., from 10 to 2 liters per minute).

The use of charcoal filters to remove volatile anesthetic agents is not new, but only recently has a commercially available product been tested to determine how quickly it could achieve a result equivalent to established preparation and flushing methods. In an anesthesia workstation saturated with volatile anesthetic agent, the Vapor Clean™ charcoal filter system reduced trace volatile anesthetic concentrations to < 5 ppm in < 2 minutes, and kept them < 5 ppm for 12 hours.[1,2]

1. Bilmen JG, Gillies RL. Clarifying the role of activated charcoal filters in preparing an anaesthetic workstation fro malignant hyperthermia-susceptible patients. Anaesth Intensive Care 2014; 42: 51-58 [Note: This study used one filter instead of two which is off-label use and NOT recommended]

2. Birgenheier N1, Stoker R, Westenskow D, Orr J.Activatedcharcoaleffectivelyremovesinhaledanesthetics frommodernanesthesiamachines. Anesth Analg.2011 Jun;112(6):1363-70

Author Commentary:

This is Level 5 evidence (bench research, expert opinion) following the Oxford Centre for Evidence Based Medicine's (www.cebm.net) levels of evidence.

The threshold of 5 ppm is based on a 1996 study of MH susceptible swine (2), the most common in vivo model for human MH. However, this abstract was never published in full and the study has not been replicated. The upper safe limit of trace anesthetic agents in MH susceptible humans is actually unknown. Some cited bench studies measured in vitro trace gas levels using the Miran? gas analyzer, which was designed for measurement of ambient air, not closed circuit bench experiments (4,6). Significant differences among brands and models of workstations mean that each model must be specifically prepared; adequate preparation is hypothetical for any workstation not reported in the literature or by its manufacturer.

Discontinuing the triggering anesthetic agent and increasing fresh gas flow with 100% oxygen is part of the treatment algorithm for MH (7). This recommendation is based on expert opinion, but anecdotally there are MH cases that resolved with only these measures. No study answers the question if the above mentioned machine alterations, or the addition of charcoal filters, would improve patient outcome during an acute MH episode. This question could be answered using the swine model of MH, but the result is unlikely to change current clinical practice.

References:

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2. Maccani RM, Wedel DJ, Kor TM, Joyner MJ, Johnson ME, Hall BA: The effect of trace halothane exposure on triggering malignant hyperthermia in susceptible swine. Anesth Analg 1996; 82:S287

3. Kim TW, Nemergut ME: Preparation of modern anesthesia workstations for malignant hyperthermia susceptible patients: A review of past and present practice. Anesthesiology 2011; 114:205-12

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5. Gunter JB, Ball J, Than-Win S: Preparation of the Dräger Fabius anesthesia machine for the malignant-hyperthermia susceptible patient. Anesth Analg 2008; 107:1936-45

6. Targ AG, Yasuda N, Eger EI: Solubility of I-653, sevoflurane, isoflurane, and halothane in plastics and rubber composing a conventional anesthetic circuit. Anesth Analg 1989; 69:218-25

7. Larach MG, Gronert GA, Allen GC, Brandom BW, Lehman EB: Clinical presentation, treatment, and complications of malignant hyperthermia in North America from 1987 to 2006. Anesth Analg 2010; 110:498-507