

New Device Simplifies Workstation Preparation for Malignant Hyperthermia-susceptible Patients

To the Editor:

I read with interest the review article by Kim and Nemergut entitled "Preparation of Modern Anesthesia Workstations for Malignant Hyperthermia-susceptible Patients."¹ The authors are to be congratulated on this comprehensive review describing the challenges to preparing a modern anesthesia machine for use with malignant hyperthermia (MH)-susceptible patients. Indeed, their review of the literature suggests that a straightforward method of preparing the machine that can be applied to all workstations has not been determined. Further, the current information on the Malignant Hyperthermia Association of the United States website does not provide practical guidance to prepare all types of anesthesia machines.* For the anesthesia practitioner, reading the available literature does not provide a clear approach to be used in practice.

A new device promises to provide an easy method for preparing any anesthesia workstation for MH-susceptible patients in just a few minutes. The Vapor-Clean device (Dynasthetics Inc., Salt Lake City, UT) consists of charcoal filters designed to be placed between the anesthesia machine and the inspiratory and expiratory limbs of the breathing circuit. The rationale for this approach is sound and based on the well-known property of activated charcoal to absorb potent anesthetic vapors that can trigger MH. If a clean breathing circuit is used and the Vapor-Clean device is in place, anesthetic vapor contaminating the internal components of the anesthesia workstation is prevented from reaching the patient. Previous studies have documented the utility of activated charcoal for preparing the anesthesia machine but to date, a convenient device designed and approved by the Food and Drug Administration for this purpose has not existed.^{2,3} A study of the Vapor-Clean has demonstrated that the concentration of anesthetic agents (isoflurane, sevoflurane, and desflurane) in the breathing circuit can immediately be reduced to less than 5 ppm immediately upon placing the device in the circuit.⁴ The concentration of anesthetic vapor that protects the susceptible patient from an MH reaction has never been determined with certainty, but concentrations less than 5 ppm are generally considered acceptable, and the results documented in the abstract exceed that goal.

With the introduction of the Vapor-Clean device, a simple approach to rapidly preparing any anesthesia workstation

for the MH susceptible patient now exists. Additional studies will likely document the universal utility of this device for all workstations and anesthetic vapors, but given the simplicity of the device and the well-known properties of activated charcoal, I submit that there is sufficient evidence to adopt this device into clinical practice. The manufacturer provides a clear protocol for using the device that can be easily implemented by any practitioner. With the advent of the Vapor-Clean device, it would seem that the challenge of protecting MH susceptible patients from trace amounts of anesthetic vapor has been solved.

Jeffrey M. Feldman, M.D., M.S.E., Children's Hospital of Philadelphia, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania. feldmanj@email.chop.edu

References

1. 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
2. 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
3. Jantzen JP, Eck J, Kleemann PP: An activated charcoal filter for eliminating volatile anesthetics: A contribution to the management of malignant hyperthermia. *Anaesthesist* 1989; 38: 639-41
4. Birgenheier N, Stoker R, Westenskow D, Orr J: Technical communication: Activated charcoal effectively removes inhaled anesthetics from modern anesthesia machines. *Anesth Analg* 2011; 112:1363-70

(Accepted for publication April 29, 2011.)

Preparation of Modern Anesthesia Workstations for Malignant Hyperthermia-susceptible Patients: When Are They Really Clean?

To the Editor:

With great interest I read the review by Kim and Nemergut¹ about the practice of preparation of modern anesthesia workstations for patients susceptible to malignant hyperthermia (MH). Decontamination of anesthesia workstations is a cornerstone in prevention of MH in susceptible patients. Thus, the Malignant Hyperthermia Association of the United States[†] as well as several review articles^{2,3} have recommended the workstations be cleared before anesthesia by flushing the machine with 100% oxygen with a flow rate of at least 10 l/min for 20 min, replacement of the fresh gas outlet hose, the anesthetic circuit, and the carbon dioxide absorbent. Fur-

* <http://medical.mhaus.org/index.cfm/fuseaction/Content.Display/PagePK/MedicalFAQs.cfm>. How should the anesthesia machine be prepared before surgery for an MHS patient? Accessed January 27, 2011.

Copyright © 2011, the American Society of Anesthesiologists, Inc. Lippincott Williams & Wilkins. *Anesthesiology* 2011; 115:434-49

† <http://www.mhaus.org>. Accessed February 28, 2011.

thermore, vaporizers should be removed to avoid unintended contamination of the machine.

Recent reports suggest that these procedures may be not sufficient for purging modern anesthesia workstations^{4–8} because it has been shown that reducing residual gas contents within the machines to concentrations less than 5 ppm requires significantly longer time than in older machines. In their review Kim and Nemergut¹ therefore recommend on the one hand modification of current guidelines and on the other hand a comprehensive study of all anesthesia machines in current use.

However, main problem of all studies concerning patient safety in MH is the lack of a definition for a clear-cut threshold concentration of a trigger agent. Or in other words: how much of a volatile anesthetic is required to trigger a MH crisis? Or: what waste concentration within the anesthesia machine can be assumed to be safe? Unfortunately, no investigations are available to answer these relevant questions. Although those cases might be rare, some susceptible patients have received anesthesia using volatile anesthetics without any pathologic reaction, and later suffer from a severe or fatal crisis. For example, in one case a 41-yr-old man died during his 13th general anesthesia without having any problems during the previous procedures.⁹ Thus, it can be speculated that different concentrations of a trigger agent can induce MH in individual patients. However, the reason for this is unclear.

Furthermore, different anesthetics might have different trigger potencies for MH. Studies in MH-susceptible swine showed that halothane caused MH symptoms after a much shorter time than desflurane or sevoflurane.¹⁰ Thus, it is tempting to speculate that different waste concentrations of volatile anesthetics have to be defined depending on their trigger potency, and a “one size fits all” concentration of 5 ppm is not acceptable.

For humans no information regarding this issue is available. There are only *in vitro* investigations at isolated muscle preparations. These studies showed that enflurane, isoflurane, desflurane, and halothane exhibit different effects on skeletal muscle bundles.¹¹ The relevance of these studies for the clinical setting is uncertain. Furthermore, different mutations in the ryanodine receptor gene are associated with different phenotypes in the *in vitro* contracture test setting.¹² Thus, it might be speculated that acceptable threshold concentrations of volatile anesthetics depend on specific MH causative mutations. However, it is unclear how this problem should be adequately addressed in modification of current guidelines.

To date there are no reports available presenting cases of MH in susceptible patients who received anesthesia with use of a workstation that was decontaminated according to the current guidelines. Thus, one might assume on the one hand that the current guidelines enable a very high degree of safety also in modern anesthesia workstations. On the other hand, because MH is a rare entity there might be a high possibility

that MH will occur in the future because of insufficient washout procedures.

Therefore, 100% patient safety may only be established using a completely fresh prepared workstation including a change of all parts that were in contact with volatile gases. After such preparation measurement of gas waste is mandatory to ensure a concentration of 0 ppm. This concept might be advantageous in emergency situations when a long preparation time is not possible. However, this requires an additional anesthesia workstation at the department, which has been realized in our institution especially when a defect machine is in need of a substitute.

In conclusion, I agree with Kim and Nemergut¹ that Malignant Hyperthermia Association of the United States as well as the European Malignant Hyperthermia Group should discuss the aforementioned problem and make recommendations on how to prepare modern anesthesia workstations to ensure safety in MH-susceptible patients. Until that time, only fresh machines should be used.

Frank Wappler, M.D., University Witten/Herdecke, Clinics of Cologne, Cologne, Germany. wapplerf@kliniken-koeln.de

References

1. Kim TW, Nemergut ME: Preparation of modern anesthesia workstations for malignant hyperthermia-susceptible patients. *ANESTHESIOLOGY* 2011; 114:205–12
2. Wappler F: Malignant hyperthermia. *Eur J Anaesthesiol* 2001; 18:632–52
3. Rosenberg H, Davis M, James D, Pollock N, Stowell K: Malignant hyperthermia. *Orphanet J Rare Dis* 2007; 2:21
4. Petroz GC, Lerman J: Preparation of the Siemens KION anesthetic machine for patients susceptible to malignant hyperthermia. *ANESTHESIOLOGY* 2002; 96:941–6
5. Prinzhausen H, Crawford MW, O'Rourke J, Petroz GC: Preparation of the Dräger Primus anesthetic machine for malignant hyperthermia-susceptible patients. *Can J Anesth* 2006; 53:885–90
6. Crawford MW, Prinzhausen H, Petroz GC: Accelerating the washout of inhalational anesthetics from the Dräger Primus anesthetic workstation: Effect of exchangeable internal components. *ANESTHESIOLOGY* 2007; 106:289–94
7. Whitty RJ, Wong GK, Petroz GC, Pehora C, Crawford MW: Preparation of the Dräger Fabius GS workstation for malignant hyperthermia-susceptible patients. *Can J Anesth* 2009; 56:497–501
8. 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
9. Püschel K, Schubert-Thiele I, Hirth L, Benkmann HG, Brinkmann B: Malignant hyperthermia during the 13th general anaesthesia (author's transl). *Anaesthesist* 1978; 27:488–91
10. Wedel DJ, Gammel SA, Milde JH, Iaizzo PA: Delayed onset of malignant hyperthermia induced by isoflurane and desflurane compared with halothane in susceptible swine. *ANESTHESIOLOGY* 1993; 78:1138–44
11. Metterlein T, Schuster F, Kranke P, Roewer N, Anetseder M: In-vitro contracture testing for susceptibility to malignant hyperthermia: Can halothane be replaced? *Eur J Anaesthesiol* 2011; 28:251–5
12. Girard T, Urwyler A, Censier K, Mueller CR, Zorzato F, Treves S: Genotype-phenotype comparison of the Swiss malignant hyperthermia population. *Hum Mutat* 2001; 18:357–8

(Accepted for publication April 29, 2011.)