Title: MALIGNANT HYPERTHERMIA AND THE CLEAN MACHINE

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Introduction. Malignant hyperthermia (MH) is a pharmacogenetic disorder characterized by acute hypermetabolic reactions in muscles; it can be triggered by potent inhalational anesthetic agents. Recommendations for the intraoperative management of MH-susceptible patients include avoidance of triggering agents, replacement of the carbon dioxide absorbent and all rubber and plastic tubing, and either changing the anesthesia machine for one never used with volatile agents[1] or flowing oxygen through a vaporizer-free anesthesia machine for at least 12 hours preoperatively[2].

Materials and Methods. We studied all ten Ohmeda Modulus II anesthesia machines in our operating rooms. Measurements were made at the end of a regular working day during which halothane had been administered. The time interval from a machine's last use with a patient ranged from ten minutes to three hours.

A Miran-103 portable infrared gas analyzer was used to measure halothane concentrations. Accuracy of ± five percent and a sensitivity of approximately one part per million is reported by the manufacturer.

Prior to all measurements the gas analyzer was calibrated and zeroed outside of the operating room. Baseline measurements of halothane were made in the room and from the anesthesia machine's common gas outlet prior to beginning each machine's study. Five percent halothane with a four liter per minute oxygen flow was then delivered for ten minutes into a scavenged breathing circuit. Halothane was discontinued by turning off the vaporizer (without removal). Halothane measurements were then again made of the room and the anesthesia machine. An oxygen flow rate of 12 liters per minute was begun and continuous measurements were made until the halothane concentration fell to zero. Operating room halothane concentration was determined again at the termination of the study.

Results. Baseline measurements from the anesthesia machine prior to beginning the study ranged from 0 to 0.7 parts per million with a mean of 0.1 parts per million. Room air pollution at the same time ranged from 0 to 0.8 parts per million with a mean of 0.4 parts per million. Immediately following ten minutes of five percent halothane at a four liter per minute flow rate, the concentration of halothane was greater than 10 parts per million (beyond the scale) from all machines. Room air pollution at that time ranged from 0 to 0.6 parts per million. With the vaporizers turned off and an oxygen flow rate of 12 liters per minute the halothane concentrations began to fall below 10 parts per million within two minutes, and reached zero by six minutes with all 10 machines (table). Room air pollution at six minutes ranged from 0 to 1.0 parts per million with a mean of 0.4 parts per million.

Discussion. In this study, less than 1 part per million of halothane was detected at the fresh gas outlet when the machine was flushed with 12 liters per minute of oxygen for 4 minutes. This concentration of halothane is below the National Institute of Occupational Safety and Health's standard for minimum waste gas exposure[3] A previous study using gas chromatography to determine halothane concentrations found that within 12 minutes the machine was washed clean of detectable halothane utilizing an oxygen flush rate of six liters per minute.[5]

The solubility of halothane in rubber, plastic and soda lime has been confirmed.[4] Therefore, gas from the fresh gas outlet of the machine should be delivered by an absorber and breathing system which has not been exposed to inhalational anesthetic agents. In practice this is easily accomplished using a disposable carbon dioxide absorber and breathing system. We submit that the use of anesthesia machines never exposed to potent inhalational agents or flushing machines for 12 hours is not necessary in managing patients susceptible to malignant hyperthermia. A safe alternative would be to: 1) remove vaporizers from the machine 2) flush machine with oxygen at high flows for 12 minutes 3) use a new disposable fresh gas outlet hose, carbon dioxide absorber and breathing circuit.

Mean Halothane ppm (range)		Baseline	Minutes Following Halothane Flow* 0	2	4	6
	Machine	0.1 (0.0-0.7)	>10 (all)	0.7 (0.0-3.0)	0.2 (0.0-0.9)	0.0 (all)
	Room	0.4 (0.0-0.8)	0.3 (0.0-0.6)			0.4 (0.0-1.0)

*Halothane 5% in oxygen at 4 liters/minute for 10 minutes. Measurements obtained during 12 liters/minute flow of oxygen.

References.

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