Anesthesiology
V 75, No 3A, Sep 1991

EQUIPMENT AND MONITORING IV

A420

TITLE: WHAT REALLY HAPPENS WHEN THE WRONG AGENT IS POURED INTO A VAPORIZER?

AUTHORS: G.T. Schulte, M.D., F. E. Block, Jr., M.D.
AFFILIATION: The Ohio State University, Columbus, Ohio 43210

Introduction: The creation of agent mixtures from the addition of the wrong agent to a vaporizer is a documented phenomenon in anesthesia[1,2]. Piezoelectric crystal technology and conventional infrared analysis (at 3.3 microns) do not distinguish anesthetic agents. Recently some manufacturers have been touting the ability of their new monitors to identify anesthetic agents. These new analyzers are based upon mass spectrometry, Raman scattering, or different wavelengths of infrared light. The importance of the ability to distinguish agents has not been determined, however.

Methods: A Foregger 500 Anesthesia machine with Isoflurane, Enflurane, and Halothane vaporizers was used to create six different situations. These included: Isoflurane/Halothane and Enflurane/Halothane in a Halothane vaporizer, Enflurane/Isoflurane and Halothane/Isoflurane in a Isoflurane vaporizer, and mixtures of Isoflurane/Enflurane and Halothane/Enflurane in an Enflurane vaporizer. For each agent mixture created, the vaporizer used was first filled with the correct agent and was run at 5 liters/minute fresh oxygen flow at a vaporizer dial setting of 5% until it reached the "refill" line. This created our expected agent baseline and our expected MAC. At the refill line, the incorrect agent was added to the "full" line. The vaporizer continued at the same flow and the same dial setting until it was exhausted.

A Paradygm Solo single-room mass spectrometer and a Biochem Piezoelectric agent analyzer were used to study vaporizer output. Datex supplied the relative absorbances for its conventional infrared analyzers (Halothane 1.0, Isoflurane 5.2, Enflurane 6.4) and from this information we calculated the readings that would be seen with a conventional infrared analyzer. MAC multiples (the sum of the MAC's of the delivered agents), the sum of the percents of the two anesthetic agents, and the expected MAC's were plotted.

Results: In five of the six cases, the MAC multiple (based upon the actual output of the vaporizers) was less than or only slightly higher than the expected MAC from the initial baseline. All the analyzers indicated a reading close to, or higher than, the actual MAC output. The infrared values were high when Enflurane or Isoflurane was added to the Halothane vaporizer.

In the case of a mixture of Halothane/Enflurane in an Enflurane vaporizer, the delivered MAC multiple was approximately double the expected MAC. In addition, the conventional infrared analyzer suggested a decreasing anesthetic concentration while the actual MAC multiple was increasing. The piezoelectric technology was accurate in summing the percents of the agents in each tested combination.

Discussion: The importance of agent-specific analyzers has recently been debated. Misfilling of vaporizers should not occur. Published standards state that vaporizers "should" be equipped with keyed filler devices. Early versions of these keyed filler devices often did not work very well and many clinicians do not like to use them. Many vaporizers now in service, even on new anesthesia machines, lack the keyed filler devices.

Most agent filling errors will pass unnoticed and will cause no harm to the patient. Indeed we have not been able to document a single case of patient injury or death from misfilling of a modern vaporizer. Certain errors with a traditional infrared analyzer, particularly if the anesthesiologist believes the monitor rather than the patient, could theoretically lead to disaster. The piezoelectric crystal analyzer has the advantage of reading very close to the sum of the delivered percents of the agents, and thus it can alert the anesthesiologist of a problem.

While the physics behind the output of a mixture of agents in a modern vaporizer are not completely understood, this study shows that the output of the vaporizers changes over time. In the case of Halothane/Enflurane in an Enflurane vaporizer, the MAC multiple (based upon the actual vaporizer output) was much greater than the expected MAC. Conventional infrared analysis did not indicate a problem, though changes in vital signs would have suggested anesthetic overdose. For the sake of this possibility, agent identification is desirable if not essential. If agent identification is not available, keyed vaporizer fillers should be required.

References:
1. Anesthesiology 1984;60:342-6
2. Anesthesiology 1985;63:726-7

A421

Title: VISUALIZING THE MIXING OF FRESH GAS AND EXPIRED GAS IN THE MAPLESON D CIRCUIT: A LABORATORY MODEL

Authors: Lloyd Halpern MD, Bruno Bissonnette, MD
Affiliation: Dept. of Anesth, Hospital for Sick Children, Univ. of Toronto, Toronto, Canada M5G1X5

Introduction: The ideal site to sample end-tidal C02 in small children ventilated with a Mapleson D circuit remains controversial. High fresh gas flow (FGF) near the site of sampling dilutes the expired gas and causes underestimation of end-tidal C02. The purpose of this study is to visually identify the most proximal site in the Mapleson D circuit where the measurement of expired gas concentration is uninfluenced by FGF.

Method: A laboratory model was used (Fig. 1). It consisted of a 2 liter glass jar (test lung) connected to a standard 3.5mm endotracheal tube (ETT), transparent ETT connector, elbow and Ayres's T-piece. There was no leak in the system. FGF was delivered by a calibrated flow meter to the Ayre's T-piece. The test lung was filled with smoke created by vaporization of mineral oil. The model was ventilated with both a Sechrist Infant Ventilator and an Air-shields Ventimeter. A high-speed shutter video camera (30 frames/second) was used to visualize the site of mixing of fresh gas and smoke labeled expired gas. FGF of 2 to 15 l/m, respiratory rate of 20 and 30/minute, I:E ratio 1:2 and tidal volume of 30 to 100 cc were evaluated.

Results: Pictures of the site of mixing of fresh gas and expired gas were generated from individual frames of the videotape (fig. 2). Each picture was obtained at the end of the expiratory cycle immediately before the delivery of the next breath. The site of mixing advanced distally as FGF increased, but was always proximal to the point where the ETT connector narrows to the diameter of the ETT. This was independent of all variables studied.

Conclusions: The need for distal sampling of end-tidal CO2 in small children has recently been questioned.[1] The results of this study demonstrate that at FGF of up to 15 l/m, the site of mixing of fresh gas and expired gas in the Mapleson D circuit is always proximal to the point of narrowing of the ETT connector, and suggests that sampling end-tidal CO2 at the point of narrowing of the ETT connector is as accurate as distal sampling.

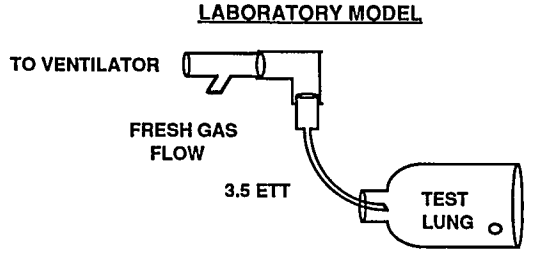

Figure 1.

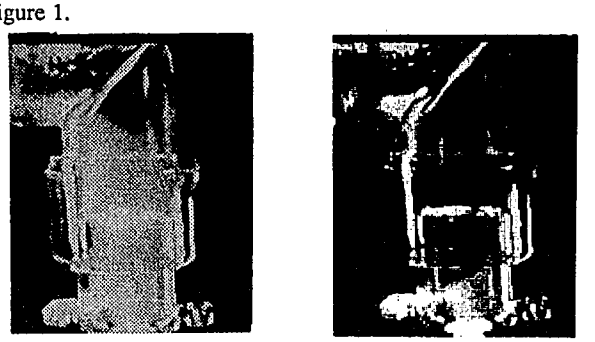

Figure 2. Left photo, FGF 3 l/m, Right photo, FGF 15 l/m.

References:
1. Anesthesiology, 73:265, 1990.

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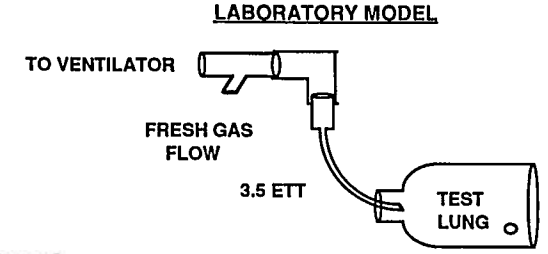

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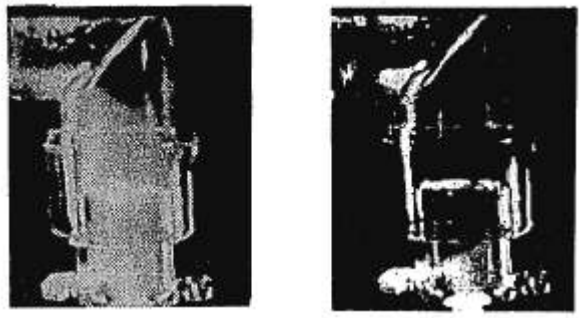

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