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Pollution Hazard of Spilled Liquid Anesthetic

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There has been much interest and concern regarding trace concentrations of anesthetics in the operating room air (AD HOC COMMITTEE 1974, CORBETT et al. 1974, GREENE 1974). Major sources of waste anesthetic gas are the pop-off valve and the ventilator, and other sources include poorly fitted components of the breathing system, worn out seals in high-pressure hose connectors and spilled liquid anesthetics. Although readily amenable to analysis, the quantitative pollution effect of spilled liquid anesthetic is neither intuitively obvious, nor, to our knowledge, published anywhere. Accordingly, this report quantitates the pollution hazard of breaking a 500-mL bottle of halothane in operating rooms which have both recirculating and non-recirculating air conditioning systems.

METHODS AND RESULTS

Assume the room size to be 3 m x 5 m x 5 m and that spilled liquid anesthetic vaporizes instantaneously and is dispersed uniformly throughout the room. The number of moles of halothane, n_H, initially present throughout the operating room is:

$$n_H = \frac{\{\text{density } (g/cm^3)\}(cm^3)}{\text{molecular weight } (g/mole)} = \frac{(1.86)(500)}{197.5} = 4.709 \text{ moles} \quad (1)$$

At room temperature the volume of vapor in cm^3 that this number of moles would occupy is:

$$\text{Volume of vapor} = (\text{moles}) \times \frac{cm^3}{mole} \times \frac{295^{\circ}K}{273^{\circ}K}$$

$$= (4.709)(22,400) \times \frac{295}{273} = 114 \times 10^3 \ cm^3 \quad (2)$$

The volume of the operating room is 75×10^6 cm^3. Dividing the volume of vapor by the volume of the operating room yields the relative concentration of anesthetic which can be stated in terms of ppm.

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$$\frac{114 \times 10^3 \ cm^3}{75 \times 10^6 \ cm^3} = 1.520 \times 10^{-3} = 1520 \text{ ppm} \qquad (3)$$

Thus, the initial concentration of halothane in the room is 1520 ppm after breaking a 500-mL bottle of halothane.

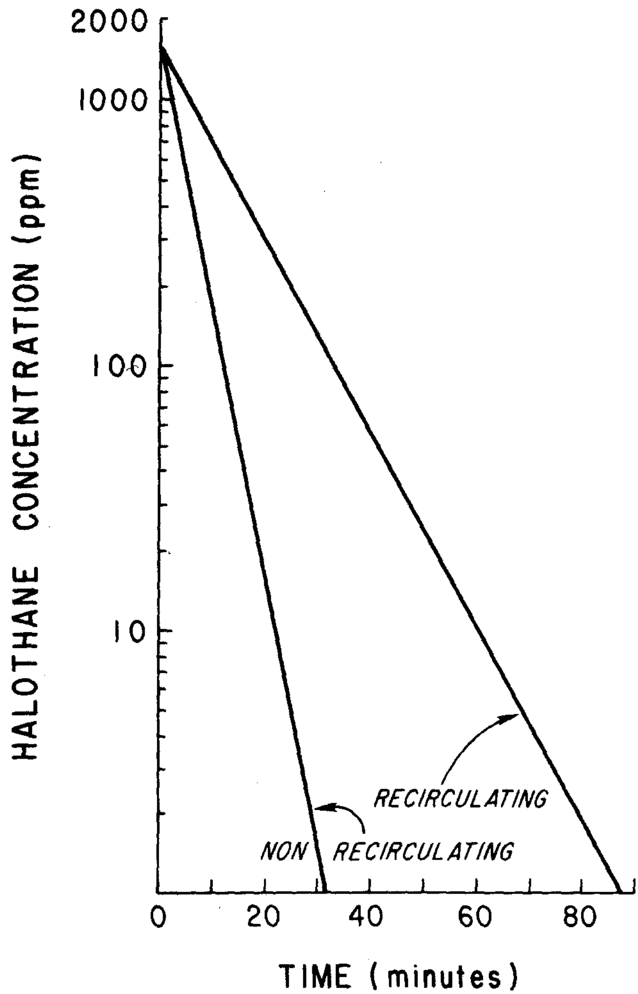

FIGURE 1: Operating room decay rates of halothane after dispersion of 500-mL for non-recirculating and recirculating air conditioning systems.

If the air conditioning system is operating and assuming no uptake by operating room personnel, the decrease in the concentration of halothane in the room is exponential and the half time ($t_{\frac{1}{2}}$) for this decrease is given by

$$t_{\frac{1}{2}} = 0.693/k \qquad (4)$$

where k = 5 exchanges of outside air/h for recirculating and 15 exchanges of outside air/h for non-recirculating air conditioning systems.

Consequently, the half life for recirculating systems is 8.3 min and for non-recirculating systems 2.8 min. Figure 1 shows this exponential decrease.

DISCUSSION

An unscavenged operating room contains halothane in the range of 10 ppm (GREENE 1974). With scavenging systems on anesthesia machines, the contamination can be reduced to 1 ppm (GREENE 1974). Values considerably higher than these are present for over 0.5 h should a bottle of halothane break assuming instantaneous vaporization. Since liquid anesthetic does not vaporize instantaneously, lower but still excessively high concentrations of halothane would be present in the operating room environment for a longer period of time. Even if only 1 mL of halothane is spilled, which commonly happens when anesthesia machine vaporizers are filled, the room concentration would be 3 ppm and would exceed 1 ppm for a minimum of 5 min. The importance of these considerations is obvious: unnecessary spillage of liquid anesthetic will cause more anesthetic vapor to be in the environment for short periods of time than occurs utilizing the presently available expensive scavenging system on the anesthesia machine.

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