Recognition Thresholds for Diethyl Ether and Halothane

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Operating room personnel are chronically exposed to anesthetic gases polluting their environment.¹⁻⁴ Some dangers of this exposure have been documented and published and efforts to scavenge the pollutants promoted.⁵⁻⁷ Some investigators have suggested that inability to smell halothane indicates an efficient and safe scavenging system.⁸ We created an apparatus for the production of trace concentrations of inhaled anesthetics with which to investigate whether halothane concentrations that are commonly found in the operating rooms and can significantly impair intellectual function are less than most people can detect by their sense of smell. We also established whether ether or halothane vapor is more easily detected by human olfaction.

METHODS

Generation of Traces of Inhalational Agents

1. The Long Calibrating Vapor Still. Air laden with vapor of halothane or diethyl ether was drawn slowly through a long coiled glass tube immersed in an ice and water bath. Anesthetic liquid condensed, leaving the vapor saturated at 0°C, at which temperature the calculated concentrations are 12.7 per cent halothane and 24 per cent ether.⁹ Gas chromatographic analysis showed these concentrations to be reproducible to within 0.5 vol per cent.

2. The Diluting Tube (Figure 1). The concentrated vapor was discharged from a 50 ml glass syringe at a rate governed by a motorized syringe pump, through a 7-inch plastic connector and a 25-gauge needle soldered into the sealed end of a copper tube, 91 cm long and 3.8 cm in diameter. The vapor was diluted by compressed air injected tangentially into the same end of the tube, to encourage rotation and mixing. The injection ports were carefully adjusted prior to soldering to eliminate venturi-type effects on the flow from the syringe pump. The total gas flow was approximately 10 l/min as measured by a calibrated dry gas meter and the final concentration of vapor was calculated as follows:

Final concentration

\[ \text{Final concentration} = \frac{\text{syringe concentration} \times \text{syringe flow rate}}{\text{total gas flow}} \]

The concentrations of diluted vapor were measured by gas chromatography using a flame ionization detector. The barrel output was reproducible to within ±5 per cent and the concentrations produced were greater than predicted by a factor of 1.3 within the ranges used in this study. Such equipment requires calibration against known standards. The washout time—the time elapsing before vapor was undetectable by chromatography (0.1 ppm halothane) after the concentrated vapor input had been discontinued—was 15 seconds.
We assumed that mixing was adequate because of the uniformity of measured concentrations—better than 0.5 per cent over a 5-minute period.

3. Evaluation of Smell Thresholds. Standard texts of smell theory describe a concentration at which an odor can be detected but not recognized and another at which it can be recognized. This study was concerned with recognition threshold because pilot studies showed it to be a more positive endpoint. We determined those of the recognition thresholds in the following manner.

On two different days, volunteer adults sat and sniffed ether or halothane from the vapor dilution tube. Several were cigarette smokers, although none had overt nasal or sinus disease. Ether was studied on the first day using 18 volunteers, and halothane on the second, using 20 volunteers. Sixty per cent of the first day's volunteers were tested the second day. First the volunteers sniffed air, to familiarize themselves with the apparatus. Then they sniffed a concentration that we had previously found to be recognized by most people (100 ppm halothane; 9 ppm ether) in order to familiarize themselves with the odor of the agent. Then, starting with 1 ppm halothane or 0.1 ppm ether and increasing concentrations stepwise, the threshold at which each subject could definitely recognize each anesthetic was established. The concentrations were then reduced until recognition was lost. Subjects were tested only once for each agent. The subjects were unaware that a set pattern of concentrations was being followed.

RESULTS

Figure 2 is a probit plot of the cumulative totals of subjects able to recognize various concentrations of ether and halothane. The best line was estimated by eye. From it we deduce that the recognition threshold for ether for 50 per cent of our volunteers was 1.6 ppm and that for halothane 33 ppm. Only five of 20 subjects could recognize less than 15 ppm halothane. In this study the recognition threshold was the same as the loss-of-recognition threshold.

DISCUSSION

Evidence that traces of anesthetic agents are harmful under field conditions is circumstantial because prospective data are not available. Bruce and colleagues determined that under experimental conditions, 15 ppm halothane would deleteriously affect psychomotor performance and intellectual skills. In our experiment, 75 per cent of subjects were unable to recognize this concentration. This indicates that the human sense of smell is inadequate to establish that scavenging techniques are entirely satisfactory when halothane is in use.

For 50 per cent of our subjects, the recognition threshold for halothane was 33 ppm and that for ether was 1.6 ppm. When the sense of smell is the only resource available for checking the adequacy of scavenging techniques, ether should be the test anesthetic agent.

REFERENCES