Contamination of In-series Vaporizers with Halothane–Methoxyflurane

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Halothane was suspected to be a contaminant in a methoxyflurane vaporizer when unusual anesthetic depth was evidenced in a patient during induction with methoxyflurane. Liquid in the vaporizer chamber contained 7 per cent halothane. Such contamination might have occurred by inadvertent filling of the vaporizer with halothane. However, the question of contamination by transfilling of vaporizers in series also had to be considered. Therefore, a study was conducted to determine 1) the concentrations of component vapors delivered by a contaminated vaporizer, and 2) the amount of anesthetic contamination which could occur when vaporizers in series were opened simultaneously.

Methods

Outputs of individual calibrated Pentomatic and Fluomatic vaporizers containing varied proportions of halothane and methoxyflurane were determined at dial settings of 1.0 per cent with an oxygen flow of 6 l/min. Vaporizers were half-filled (visual fluid level indicator) with the appropriate mixtures and allowed to stand overnight.

The vaporizers were also connected in series in alternate sequence and the rates of contamination of liquid anesthetic in the downstream vaporizer (6 l/min oxygen carrier gas) determined with the following dial setting combinations: 1) 0.25 per cent for both vaporizers, 2) Fluomatic, 2.0, and Pentomatic, 1.5 per cent; 3) Fluomatic, 4.0 per cent, and Pentomatic, MAX. Liquid was sampled at intervals during a 60-minute period (0.5 μl § was withdrawn from the filler inlet while the dial was turned off approximately 15 seconds).

Repeated sampling of the gas in the downstream vaporizer (input and output) during an uninterrupted 60-minute period permitted estimation of the contaminating anesthetic deposition in the downstream vaporizer. This experiment was also conducted with Pentec and Fluotec vaporizers.

Determination of the anesthetic concentrations was carried out by gas chromatography as previously described.[1] Between experiments the vaporizers were drained, rinsed with ethyl ether, and flushed with air until halothane and methoxyflurane were not detectable. All data are expressed as volumes per cent of gas or liquid.

Results

A contaminated Pentomatic (dial setting 1.0 per cent) vaporized concentrations of halothane above 1 per cent during the first five minutes of operation, even with a concentration of 0.1 per cent halothane in the liquid phase (fig. 1). In contrast, methoxyflurane concentrations delivered by a contaminated Fluomatic did not exceed 0.07 per cent even with a liquid methoxyflurane concentration of 95 per cent (fig. 2).

When operated in alternate series, higher concentrations of liquid halothane were found in the Pentomatic vaporizer (fig. 3) than methoxyflurane in the Fluomatic vaporizer (fig. 4). In the Pentomatic more than 8 per cent halothane was present after 30 minutes at the

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§ Fixed-needle Hamilton Microsyringe.

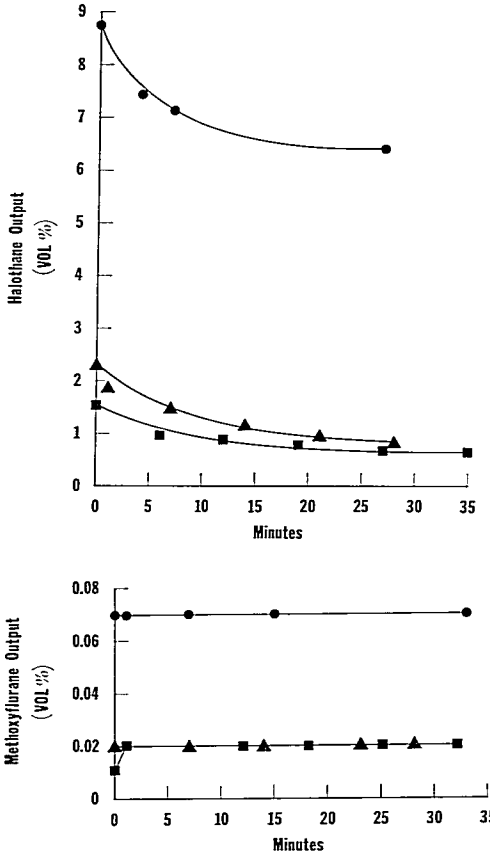

FIG. 1. Halothane delivery by a contaminated Pentomatic at a dial setting of 1.0 with 6 l/min oxygen flow. The vaporizer was charged with methoxyflurane–halothane mixtures containing the following halothane proportions: ●—●, 93.4 per cent; ▲—▲, 13.8 per cent; ■—■, 0.1 per cent. Each point represents one sample.

FIG. 2. Methoxyflurane delivery by a contaminated Fluomatic at a dial setting of 1.0 with 6 l/min oxygen flow. The vaporizer was charged with halothane–methoxyflurane mixtures containing the following methoxyflurane proportions: ●—●, 95.4 per cent; ▲—▲, 18.4 per cent; ■—■, 1.9 per cent. Each point represents one sample.

highest dial settings, with less than 0.05 per cent methoxyflurane present in the Fluomatic chamber after the same interval (fig. 4). After 60 minutes almost 10 per cent liquid halothane was present in the Pentomatic chamber.

The total amounts of contaminating anesthetic deposition in the downstream vaporizer during an hour at settings of 2.0 per cent for the Fluomatic and 1.5 per cent for the Pentomatic were: 27.8 per cent (10.6 ml liquid) of halothane input to the Pentomatic; in the opposite sequence, only 11.5 per cent (3.0 ml liquid) of the methoxyflurane input was taken up by the Fluomatic. Results obtained using Pentec and Fluotec vaporizers in this type of experiment were similar: 30.5 and 11.0 per cent deposition, respectively.

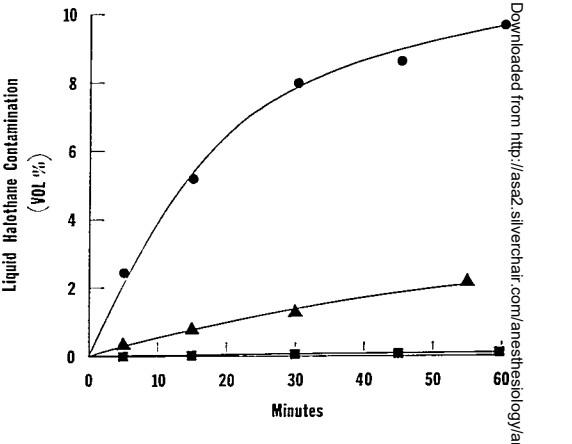

FIG. 3. Rates of appearance of liquid halothane in a Pentomatic charged with methoxyflurane and placed downstream from a Fluomatic. Both vaporizers were operated simultaneously with 6 l/min oxygen flow and the following dial settings for the Fluomatic and Pentomatic, respectively: ●—●, 4.0 per cent and MAX; ▲—▲, 2.0 and 1.5 per cent; ■—■, 0.25 and 0.25 per cent. Each point represents one sample.

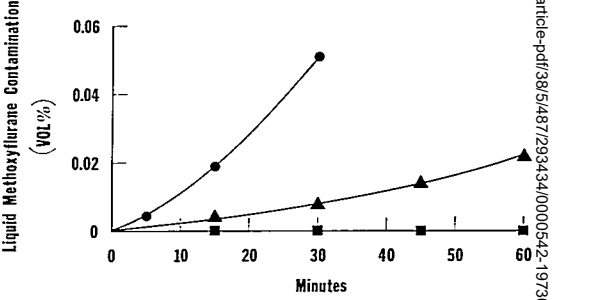

FIG. 4. Rates of appearance of liquid methoxyflurane in a Fluomatic charged with halothane and placed downstream from a Pentomatic. Both vaporizers were operated simultaneously with 6 l/min oxygen flow and the following dial settings for the Pentomatic and Fluomatic, respectively: ●—●, MAX and 4.0 per cent; ▲—▲, 1.5 and 2.0 per cent; ■—■, 0.25 and 0.25 per cent. Each point represents one sample.

Discussion

Measurement of the rate of liquid contamination in the downstream vaporizer gave a low estimate of the total amount of contaminating anesthetic absorbed. For example, during a one-hour experiment with medium dial settings, 10.6 ml liquid halothane were deposited in a Pentomatic vaporizer which initially contained 125 ml methoxyflurane. At a 6-l/min oxygen flow, 28 ml of methoxyflurane should have vaporized during the hour, and the halothane in the remaining methoxyflurane should have been 9.9 per cent; yet, as is evident in figure 3, only 2.0 per cent was observed in the chamber. This discrepancy might be explained by the suggestion of Dorsch that halothane (the contaminant) dissolves first in the liquid on the wick and slowly equilibrates with the liquid in the chamber.[2]

Regardless of the source of contamination, it is now evident that a methoxyflurane vaporizer containing even small amounts of halothane can deliver anesthetic concentrations of this agent in addition to the expected methoxyflurane output at a 1.0 per cent setting.

A vaporizer designed to volatilize a low-vapor-pressure liquid (methoxyflurane) should not be placed in a downstream series position

relative to higher-vapor-pressure anesthetic vaporizers (halothane). Also, every precaution should be taken to avoid charging a vaporizer with a higher-vapor-pressure liquid than it was designed for. If either of these recommendations is violated, a clinically dangerous situation may rapidly develop.

References

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A Method for Ultrasonic Measurement of Blood Pressure in the Adult Leg

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Measurement of the popliteal blood pressure frequently has clinical significance. In many patients with extensive burns or multiple fractures, and during operations on upper extremities, indirect measurement of the brachial arterial blood pressure is not always feasible. Coarctation of the aorta and aortic-valve insufficiency are associated with disproportionate systolic pressure differences between arm and leg which should be determined to help confirm the diagnosis of either condition. It is advocated that the blood pressures in both the arms and the legs be determined in patients with hypertension or peripheral-artery disease.[1, 2] However, indirect measurement of the systolic and diastolic blood pressures in the leg has heretofore been unsatisfactory. The Korotkoff method is grossly inaccurate,[3] the palpatory technique difficult, and the oscillometric approach unreliable.[4]

Ultrasonic kinetoarteriography is a new technique of indirect blood pressure measurement. Detection of arterial-wall motion forms its basis. When brachial arterial pressures were determined, it rivalled the intra-arterial technique and exceeded the Korotkoff method in accuracy.[6, 7, 8] The aim of the present study was to develop and evaluate ultrasonic kinetoarteriography of the popliteal artery as a method for the measurement of blood pressure in the leg.

MATERIAL AND METHODS

An ultrasonic distance-measuring device § was used to determine the depth of the popliteal artery below the skin. All measurements were made in the popliteal fossa of the right leg. The depths ranged from 3.0 to 6.0 cm, with a mean of 4.3 cm, in 17 adults, 20 to 59 years old. In nine children and adolescents, 4 to 13 years of age, the depths ranged from 2.5 to 4.0 cm, and averaged 3.4 cm. This information was necessary for the design of ultrasonic crystals with an appropriate energy focus. Two piezoelectric crystals, one a transmitter and the other a receiver, operating at a frequency of 2 MHz, are sealed separately into a plastic housing. The beam pattern of the transmitting crystal and the signal acceptance aperture of the receiving crystal are of a wide-angle design to provide effective signal reception from the area of the popliteal artery.

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§ Ultrasonic Ranging Device (prototype), Roche Medical Electronics Division, Hoffmann–La Roche Inc., Cranbury, New Jersey.