INTRODUCTION: According to the uptake and distribution theory, rates of uptake of nitrous oxide and volatile agents are parallel. Therefore, the rate of N₂O uptake from a closed circuit by an individual patient could uniquely govern a constantly proportional delivery of halothane. This study tested the hypothesis that N₂O alone flowing through an out-of-circuit halothane vaporizer into a closed circuit system would regulate halothane delivery to the patient, steadily maintaining desired circuit concentration.

METHODS: Ten ASA class 1 or 2 patients undergoing elective procedures were anesthetized using halothane-N₂O-O₂ anesthesia in a closed circuit. Institutional approval for the study and individual informed consent were obtained. A Fluotec III vaporizer was purged with N₂O at 10 L/min for one minute and the vaporizer then shut off. The anesthesia circuit was primed with 100% oxygen and the patient's lungs denitrogenated with high O₂ flows. Following conventional thioental induction and endotracheal intubation, the patient was rapidly ventilated with 2% halothane and N₂O at 10 L/min until the oxygen analyzer, placed in the expiratory limb, measured a circuit concentration of 35% O₂. The system was then closed and the halothane vaporizer set at 5%, remaining at this setting thereafter (see Figure). Metabolic O₂ requirements, supplied through a low flow oxygen meter, was introduced to the system distal to the vaporizer output. Flows of N₂O and O₂ were adjusted to keep circuit volume constant and O₂ concentration at 35%. Expired halothane concentrations were measured with an Engstrom EMMA previously calibrated with a Perkin-Elmer mass spectrometer. The O₂ delivery rate closely followed predictions (10 Kg⁻¹ h⁻¹) and the N₂O flows were decreased according to patient uptake.

RESULTS: Converting gas composition in the circuit from 100% O₂ to 65% N₂O - 35% O₂ - 0.5% halothane was achieved in one minute. Uptakes of N₂O and halothane were synchronous. Thereafter expired halothane concentrations remained constant. Good surgical anesthesia was provided.

Vaporizer outputs of halothane were reliable at all flow rates of N₂O, provided steady state was first achieved by N₂O purging, as described. With the vaporizer dial set at 5%, the circuit halothane concentration always measured about 0.5%.

DISCUSSION: This technique accurately maintained a 1.3 MAC anesthetic in a closed circuit, with an end-tidal halothane concentration of 0.5% (0.63 MAC N₂O = 0.63 MAC halothane). Based on actual measurements of N₂O uptake and analysis of multicompartamental time constants and respective vascular transports for high concentrations of N₂O, a patient's rate of uptake is 70% of standard calculations. The uptake of halogenated anesthetics is proportional to the arterial concentration of the agent, without modification. By multiplying the arterial concentration of N₂O by 70% ratios of uptake of halogenated anesthetic vapor to uptake of N₂O in a 0.63 MAC N₂O - 0.63 MAC halogenated anesthetic are accurately predicted (halothane 5%; isoflurane 6%; enfurane 10%).

The vaporizer is the means of coupling the delivery of these two agents in a fixed volume - percentage relationship during closed circuit anesthesia. Even at very low gas flow rates, contemporary vaporizers give linear output. In this system halothane delivery is biologically servo-controlled by N₂O flow rates, governed by the patient's actual N₂O uptake from the closed circuit.

\[ \text{rate of halogenated uptake} = \frac{\text{Ca halogenated agent}}{\text{rate of N}_2\text{O uptake}} = \frac{\text{Ca N}_2\text{O}}{0.7} \]

\[ \text{Ca} = \text{arterial concentration} = f \times \text{MAC} \times \text{B/G} \]

where \( f \) = fraction of MAC, MAC = minimal alveolar concentration and \( \text{B/G} = \text{Oswald blood/gas partition coefficient} \)

REFERENCES:

Fig. Schematic of system, pop-off valve closed.