

## PERFORMANCE CHARACTERISTICS OF VAPORIZERS FOR ADMINISTRATION OF FLUOTHANE

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CLINICAL administration of Fluothane has established that this volatile anesthetic is a potent compound. Concentrations no greater than 2.0 to 3.0 volumes per cent in the inhaled atmosphere usually are sufficient for induction anesthesia, and concentrations of 0.4 to 1.5 volumes per cent will maintain in most patients light surgical planes of narcosis. In several clinical reports<sup>1-7</sup> investigators have emphasized the necessity of accurate, precise means of vaporizing this drug in order to avoid overdosage and danger to the patient.

The following factors are of importance in considering the safety and usefulness of a vaporizer for Fluothane: (1) There should be provision for assuring delivery of known, accurate vapor concentrations over the range of clinical usefulness and safety, from 0.0 to 3.5 volumes per cent. Preferably, concentrations in fractional divisions of 0.1 per cent should appear on the face of a control dial. (2) Any chosen vapor concentration should be constant and unaltered irrespective of varied rates of gas flow through the vaporization chamber. (3) Any particular vapor concentration should be constant and unaltered irrespective of environmental temperature alterations or temperature changes occurring within the liquid during vaporization. (4) If automatic compensations for gas flows and temperature changes are not provided, the instrument should be precalibrated for all reasonable circumstances of use.

Several vaporizers are now being recommended for the administration of Fluothane. A study of their performance characteristics was undertaken utilizing a liquid nitrogen condensation method. This technique involves the quantitative condensation of a vapor from

a gas-vapor mixture in which the gas is a known quantity.<sup>8</sup> The vaporizers to be described have been used clinically in a satisfactory manner.

### DESCRIPTION OF VAPORIZERS

*Vaporizers Designed Specifically for Use with Fluothane.* (A) The Fluotec (Cyprane) vaporizer approaches most closely the criteria outlined above. Compensation is provided for both temperature changes and rate of gas flows, with accuracy being maintained for flow rates between 4 and 16 liters per minute. Diagrammatic representation of the essentials in construction has been published.<sup>9</sup> The figures on the control dial represent concentrations of Fluothane vapor delivered. The range varies from 0.5 to 3.0 volumes per cent and the calibration allows concentrations to be altered in tenths of one per cent. The increases in concentration are linear (fig. 1).

In figure 2 the Fluotec is shown attached to a Heidbrink anesthetic gas machine. The T-valve assembly to which the instrument is connected serves to shunt desired gas flows

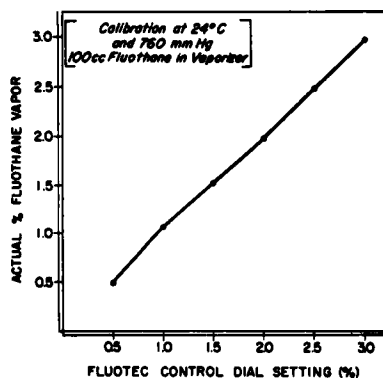


FIG. 1. Graph illustrating the linearity with which the Fluotec delivers vapor concentrations over a range of gas flows from 4 to 16 liters per minute. A wide range of temperature compensation is incorporated into this vaporizer.

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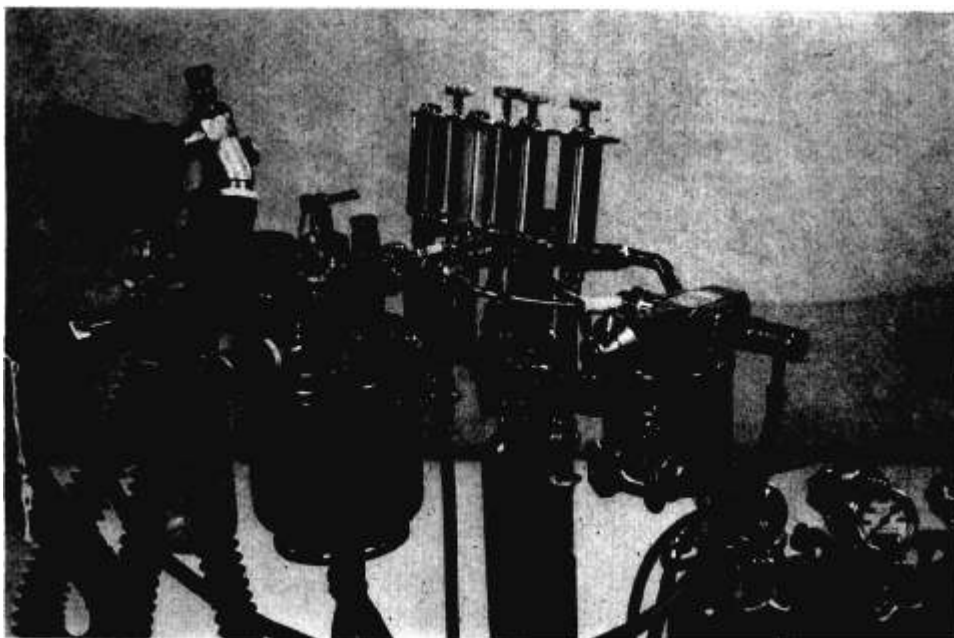


FIG. 2. The Fluotec (cyprane) vaporizer attached in proper position to a stand model Heidbrink anesthetic machine. Note the T-valve assembly interposed between the absorber head and the flowmeters.

through or away from the vaporizer. The outlet tube from the vaporizer may be connected to the inspiratory accordion tube of the circle system or may proceed directly to a nonrebreathing or a to-and-fro system.

(B) The Ohio Chemical (Heidbrink) Fluothane vaporizer is similar in basic design to the Heidbrink Trichloroethylene vaporizer. However, the numbers on the control dial represent concentrations of Fluothane vapor which are delivered at a gas flow rate of 4 liters per minute and at a room temperature of 25 C. The concentrations of vapor increase in a gradual but nonlinear fashion from 0.0 to 4.0 volumes per cent. The vaporizer is attached to the anesthetic gas machine in a manner similar to that described for the Fluotec vaporizer. A water bottle surrounds the vaporizer bottle to reduce the possibility of temperature fall within the liquid Fluothane during vaporization.

(C) The F. N. S. Fluothane vaporizer<sup>9</sup> is a simple and accurate instrument which is adaptable easily to all types of Heidbrink and Foregger anesthetic machines, and to the Boyle anesthetic apparatus. It provides vapor con-

centrations ranging from 0.0 to 4.4 volumes per cent. The percentages on the control dial are accurate at gas flow rates of 4 liters per minute and at ambient temperature of 25 C. With other rates of gas flow the concentrations delivered are determined by means of a graph (fig. 3). As seen on this graph, the increase in concentrations is gradual but nonlinear.

The alterations in vapor concentration which are associated with decreases in the tempera-

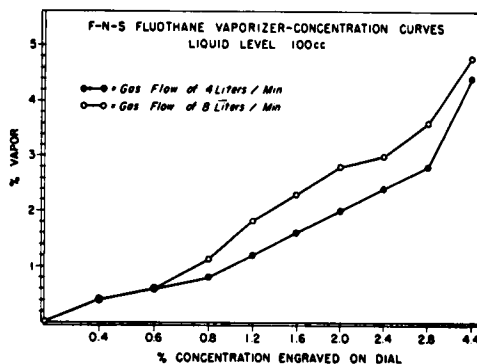


FIG. 3. Graph illustrating vapor concentrations delivered at 25 C. by gas flows of 4 and 8 liters per minute through the F.N.S. vaporizer.

ture of liquid Fluothane at gas flows of 4 and 8 liters per minute are illustrated in figure 4. In these graphs, the altered vapor concentrations are depicted at 10-minute intervals for periods totalling 40 minutes. No significant change in temperature occurs in the vaporizing liquid when concentrations of 1.2 volumes per cent or less are being delivered. Relatively little heat is required for such vaporization. Therefore, these lower vapor concentrations will maintain uniform levels. When higher concentrations are required, the decrease in vapor concentration, which develops gradually with the decrease in temperature of the liquid, serves actually as a safety factor to prevent excessive concentrations of Fluothane vapor being delivered continually to the patient.

*Vaporizers Designed Originally for Other Drugs but Recalibrated for Use with Fluothane.* The Foregger Copper Kettle and Heidbrink Vernitrol, although not the same in basic design, deliver similar quantities of Fluothane vapor with a given flow of oxygen through them. Each vaporizer provides maximum vapor pressures of Fluothane at room temperature. At 25 C., for example, approximately 34 volumes per cent of the mixture delivered from the vaporizer (before dilution with other metered gases) is Fluothane vapor. Vapor concentrations of Fluothane after dilution with various gas flows are represented graphically

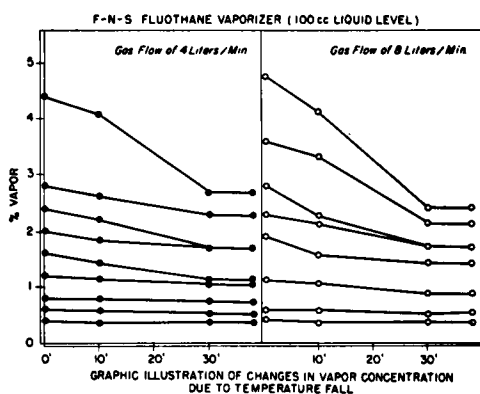


FIG. 4. Graphs illustrating decreases in vapor concentration occurring during 40 minute period of vaporization as a result of gradual decreases in temperature of the liquid Fluothane. Note insignificant changes occurring within safe anesthetic range of 1.2 per cent concentration and less.

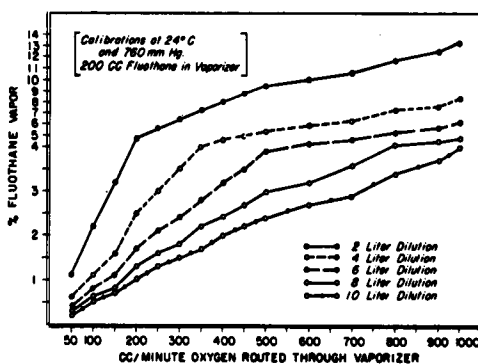


FIG. 5. Graphic illustration of vapor concentrations of Fluothane delivered at various oxygen flow rates through Copper Kettle or Vernitrol vaporizer after dilutions of these mixtures with other gas flows of from 2 to 10 liters per minute.

in figure 5. Due to the conductivity of the metals used in the construction of these vaporizers, temperature compensation is not a problem during the administration of Fluothane.

Careful note should be made in figure 5 of the low flows of oxygen through the vaporizer and the high flows of diluting gases necessary to maintain safe vapor concentrations. It is possible for these vaporizers to deliver unsafe and lethal concentrations of Fluothane vapor.

Fluothane vapor is capable of causing swelling and deterioration of the rubber gasket in the Copper Kettle. Polyethylene gaskets are not affected. Fluothane has no deleterious effect on copper.

## DISCUSSION

Of the three vaporizers designed especially for Fluothane, the Fluotec is unique in that it contains a mechanism which compensates for different gas flows in such a manner, that at any flow between 4 and 16 liters per minute, the concentration of Fluothane vapor delivered remains the same.

The Heidbrink and F. N. S. vaporizers do not possess such a flow compensation mechanism. As a general principle, with temperatures remaining constant, the greater the flow of gas passing over the Fluothane surface, the greater will be the concentration of Fluothane vapor delivered. This statement holds true

for all the "flow-over" vaporizers available for volatile drugs.

A lack of compensation for varying rates of flow creates certain problems if a potent drug like Fluothane is to be used in a rebreathing or "circle" system. If the vaporizer is placed within the circle system, where the standard Heidbrink ethyl ether vaporizer is found, for example, the total amount of gas flow, and its rate of flow, per minute will be unknown. The total flow will depend principally on the minute volume respiration of the patient and the rate of flow will vary markedly with each respiration. Under these conditions, utilizing this type of vaporizer, the concentration of Fluothane vapor delivered each minute is unpredictable and has been shown to be unsafe.<sup>10</sup>

For these reasons it is believed that Fluothane can be administered safely only when the vaporizer is placed in the anesthetic machine somewhere between the flowmeters and the inlet to the rebreathing or "circle" system (fig. 2). Under these circumstances the flow of gas over or through the vaporizer is known and constant and therefore vaporization can be accurate. The placement of the Fluothane vaporizer on the anesthetic machine is important in relation to its performance characteristics.

In the Copper Kettle and Vernitrol vaporizers oxygen is bubbled through the vaporizing liquid and the ensuing mixture is saturated with Fluothane vapor. Dilution of this mixture is necessary in order to reduce the Fluothane vapor concentration to safe levels. This dilution factor can be controlled adequately in modern anesthetic machines.

#### SUMMARY

Overdosage with Fluothane anesthesia, as with other potent anesthetic drugs, can lead to severe hypotension and cessation of cardiac action. To administer Fluothane vapor safely, precisely calibrated vaporizers which deliver concentrations of vapor within the range of

clinical usefulness are necessary. The performance characteristics of several suitable vaporizers are detailed. The Fluotec vaporizer most nearly approaches the ideal conditions necessary. For safe administration it is believed important to place the Fluothane vaporizer on the anesthetic machine between the flowmeters and the inlet to the rebreathing or "circle" system.

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