On the Ether Concentration of Inspired and Expired Air during Endotracheal Anesthesia

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There have appeared in Western countries a number of reports on the measurement of the ether concentration of inspired air during endotracheal anesthesia¹⁾⁻⁵⁾, while the literature on this problem is scanty in our country. We have already reported^{6),7)} on changes in ether concentration of inspired and expired air as measured by means of the Orzat's apparatus. The purpose of the present paper is to add those cases which have accumulated thereafter, and also to describe slight modifications made to the original method.⁸⁾

Apparatus. The Orzat's apparatus, made by the Glass Institute of our university, was used for gas analysis. Essentially the apparatus consists of a levelling cylinder N, a gas burette B, a stopcock A for gas outlet, absorption tubes I-III, and a stopcock h for introducing expired or inspired gas (Fig. 1). Instead of water as used in the original method, mercury was used to fill the gas burette, for water absorbs ether to some extent. To lessen the weight the burette with a volume of 50 cc was used, which was graduated in scale divisions of 1 cc. As in the original method, 50 per cent potassium hydroxide solution was used to absorb CO₂, 25 per cent pyrogallol-alkali solution to absorb O₂, and concentrated sulfuric acid solution to absorb ether.⁹⁾

Procedure. With stopcock A open, levelling cylinder N is raised to fill gas burette B with mercury, thus expelling the air inside. Stopcock A is closed, h is turned so as to introduce the gas to be tested into B by lowering N. This procedure is repeated 3 or 4 times. When the gas sample has been admitted into B up to mark 0 by adjusting h and N, h is closed. The stopcock of the ether absorber (I) is then opened to introduce the sample into I, where the ether contained in the sample is allowed to be absorbed. The gas is driven to B to take a burette reading,

Fig. 1. Respiratory gas analysis apparatus.

from which the volume decrease of the gas can be found. This process is repeated several times until all the ether has been absorbed and a constant reading is obtained. The stopcock of I is now closed and a burette reading is taken to calculate the volume decrease of the gas. The value twice this volume decrease corresponds to the content of ether in volume per cent of the gas sample.

Then, the stopcock of the CO_2 absorber (II) is opened to allow the sample from which ether has been absorbed to flow into II. The same procedure as above is followed and the CO_2 content of the sample is found. The O_2 content is then found by repeating the same procedure as before after opening the stopcock of the O_2 absorber (III).

Check of accuracy of the apparatus. To check the accuracy of this apparatus, measurement was made with samples of known ether concentration. For obtaining ether gas of known concentration an ether vaporization apparatus as shown in Fig. 2 was made, with which saturated ether gas was produced at a given temperature. Fig. 3 represents a vapor pressure curve for ether gas in a text book,¹⁰⁾ and Fig. 4 shows a theoretical curve between concentration of saturated ether gas and temperature at an atmospheric pressure of 760 mm. Hg, the value for each concentration being obtained by calculation from the curve in Fig. 3. A large number of points plotted in Fig. 4 represent observed values for ether

concentration at varying temperature. It will be seen that there are little differences between observed and theoretical values, thus showing the satisfactory accuracy of this apparatus.

Fig. 2. Ether vaporization apparatus.

Fig. 3. Vapor pressure curve for ether.

Fig. 4. Concentrations of saturated ether solution at varying temperatures at an atmospheric pressure of 760 mm Hg.

Fig. 5. Changes in ether content of inspired gas in individual cases (light-lined curves) and average ether contents at varying time (heavy-lined curve).

Fig. 6. Changes in ether content of expired gas in individual cases and average ether contents at varying time.

As for CO_2 and O_2 measurement, no special check of accuracy was made, for the methods used were the same as the original ones. The results obtained for CO_2 and O_2 of the expired air of normal subjects were 2–4 per cent and 14–18 per cent, respectively, which may be said to agree well with those found in the literature.

Application of the present method to clinical cases. By the use of the present apparatus the analyses of anesthetic atmosphere for the CO_2 , O_2 and ether contents were made during general anesthesia by ether. The cases studied consisted of 17 cases of thoracoplasty, 14 of gastrectomy, 4 of pulmonary lobectomy, 3 of nephrectomy, 2 of amputatio mammae, and 1 of resection

of the lower jaw. In these cases the patients were first subjected to the premedication by atropine or morphine, then to the induction by intravenous injection of pentothal sodium, followed by ether inhalation. Serial examinations of the ether content of expired and inspired gas were made at intervals of 10 to 15 minutes after administration of ether had begun. Figures 5 and 6 show the results obtained with these 41 cases (Fig. 5 for inspired air, Fig. 6 for expired air), where curves in light lines represent changes in ether content of individual cases during the course of anesthesia and a curve in heavy line in each figure shows a variation of the mean values of 41 cases. From Fig. 5 it will be seen that, though there were found wide variations of values according to cases, mean values fell within a range of 5 to 10 per cent in the induction and of 2 to 5 per cent in the maintenance, which results are in general agreement with those thus far reported in the literature. Changes in ether concentration of expired gas were not so great as those of inspired gas, as will be seen from Fig. 6; mean values fell within a range of 2 to 4 per cent.

From these finding it may be concluded that an ether concentration of 5 to 10 per cent (mean: 7 per cent) in the induction and of 2 to 5 per cent (mean: 3 per cent) in the maintenance, which have been reported in the literature,¹¹⁾ are the concentrations most suitable for Japanese also.

CONCLUSION

The ether concentration of inspired and expired air in 41 cases was measured by Orzat's apparatus modified by us. The mean value of the ether concentration of expired air in the induction was 7%, that in the maintenance 3%.

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