A SIMPLE METHOD FOR THE ESTIMATION OF CARBON DIOXIDE CONCENTRATION IN THE PRESENCE OF NITROUS OXIDE

BY

MICHAEL W. GLOSSOP

Wessex Region Respiratory Poliomyelitis Unit, Priorsdean Hospital, Portsmouth, Hampshire, England

SUMMARY

A modification of the Haldane technique, using potassium hydroxide as the absorbent, was devised to measure the concentration of carbon dioxide in the presence of nitrous oxide. It depends upon the principle that the amount of nitrous oxide absorbed is proportional to the duration of its exposure to the reagent. If the absorption of carbon dioxide from the gas mixture is completed within a fixed time, and is followed by blank analysis of the remaining gases within the same time limit, the loss of nitrous oxide during the period of carbon dioxide absorption can be readily estimated.

The Haldane method of gas analysis depends on measurement of the reduction in volume of a gas mixture after absorption of a specific gas by a specific reagent. When employed on gas mixtures containing nitrous oxide, this technique is subject to errors arising both from the solubility of the diluent gas in the absorbing agent and from its loss by diffusion through flexible connections in the apparatus. To overcome these errors Nunn (1958) recommended the use of an all-glass apparatus with saturated sodium hydroxide as the absorbing agent—the solubility of nitrous oxide in the latter being very small. Concentrated sodium hydroxide has the great disadvantage of being a viscous and corrosive fluid, and when used as an absorbent it produces insoluble substances which collect on the surface and distort the meniscus; the frequent need to drain and cleanse the apparatus does not make it a very practicable reagent for the casual user.

In order to calibrate an infra-red carbon dioxide analyzer for use during anaesthesia, when the "collision broadening" effect of nitrous oxide increases the apparent carbon dioxide concentration measured by the machine, a reliable method was required to estimate the concentration of this gas in the presence of nitrous oxide. A modification of the Haldane technique was devised to meet this need. It is based upon two simple principles which have been verified by observation:

(a) With a given exposure to 40 per cent potassium hydroxide, the amount of nitrous oxide lost is but a small fraction of the carbon dioxide absorbed.

(b) The amount of nitrous oxide dissolved in the reagent or lost by diffusion through plastic connections in the apparatus is directly proportional to the duration of exposure and to the concentration of the gas.

METHOD

A standard Haldane apparatus is used, with 40 per cent potassium hydroxide as the absorbing agent. The analysis is performed in two stages:

1. Full absorption of the carbon dioxide from the gas mixture by passing it from the burette to the absorption chamber and back a fixed number of times, and within a fixed time limit.

2. Determination of the amount of nitrous oxide lost during the carbon dioxide absorption by re-passing the gas mixture—now free of carbon dioxide—from the burette to the absorption chamber and back the same number of times and within the same time limit.

When the volume of nitrous oxide lost during the blank analysis (stage 2) has been determined and deducted from the total volume of gas removed during the initial period of carbon dioxide absorption (stage 1), the true volume of carbon dioxide absorbed is easily calculated.

There are a number of points concerned with this technique which require further explanation.
(a) Before starting the analysis the passage connecting the measuring burette to the absorption chamber must be primed with the carbon dioxide/nitrous oxide mixture to obviate dilution of the nitrous oxide in this space. This means that stage 1 of the analysis must be performed twice in quick succession with two samples of gas, measurement of carbon dioxide absorption being made on the second sample.

(b) It is necessary in stage 1 to absorb all the carbon dioxide within the fixed time limit. Therefore the number of times the gas mixture has to be passed into the absorbing chamber to achieve this must be determined beforehand. The timing can be worked out by using a mixture containing carbon dioxide in air or oxygen in approximately the same proportion as is expected in the unknown gas mixture. It is most important that all the absorptive “runs” be carried out at a steady speed, taking neither more nor less than the selected time. It was found empirically that four “runs”, completed within a period of 90 seconds, sufficed for complete absorption of the carbon dioxide from 10 ml of a 5 per cent gas mixture.

(c) Once the passage between the burette and the absorption chamber has been flushed with the nitrous oxide mixture, repeated timed blank analyses give constant diminutions of volume. It was found empirically that the loss of 100 per cent nitrous oxide during four absorptive “runs” completed within 90 seconds amounted to 0.03 ml from a total volume of 10 ml. With a 50 per cent nitrous oxide/50 per cent oxygen mixture the loss of volume was only 0.015 ml.

(d) Because the absorption of oxygen by pyrogallol takes very much longer than the absorption of carbon dioxide by potassium hydroxide, this technique probably cannot be effectively applied during the measurement of oxygen concentrations: far more nitrous oxide would be taken up by the reagents during the extended time required for full absorption of the oxygen, hence the likelihood of error would be greatly increased.

(e) After using the Haldane apparatus on gas mixtures containing nitrous oxide it is necessary to drain off and replace the potassium hydroxide before using it to analyze nitrous-oxide-free gas samples. Unless this is done, the nitrous oxide dissolved in the reagent is released during subsequent analyses and distorts the volume measurements.

Being dependent on the timing of the absorption “runs”, this method of analysis does not provide the same satisfying sense of completeness as the basic Haldane technique employed on mixtures of carbon dioxide in air or oxygen; but it yields very consistent results which were fully confirmed by the shape of the infra-red analyzer calibration curves. It enables a standard Haldane apparatus to be used with the standard 40 per cent potassium hydroxide absorbent for the occasional analysis, and hence may prove to be of value to the practising anaesthetist.

REFERENCE