Gas Chromatographic Analysis of Helium in Nitrous Oxide

Robert F. Hickey, M.D.,* Robert G. Hajny, M.D.,† Warner E. Betz,‡
Edmond I. Eger, II., M.D.§

Gas chromatographic analysis of helium in nitrous oxide by peak height measurement may produce erroneously high values if the standard peak height is obtained with helium-oxygen mixtures. This results from concentration of helium by the absorption of an appreciable volume of nitrous oxide by the chromatograph column. This error can be eliminated by calibration with standards of helium-nitrous oxide or by measurement of area rather than peak height. (Key words: Measurement (techniques): gas chromatography: helium; Measurement (techniques): gas chromatography: nitrous oxide; Anesthesics, gases: nitrous oxide: gas chromatography; Gases, nonanesthetic: helium; gas chromatography.)

INITIAL MEASUREMENTS of functional residual capacities of patients anesthetized with nitrous oxide and halothane by the helium-dilution technique produced unreasonably low values. When the aberrant readings were investigated, we found that calibration of the gas chromatograph with helium in oxygen produced erroneously high readings for helium in nitrous oxide. The cause of this error became apparent on examination of peaks produced by helium in oxygen compared with helium in nitrous oxide.

Method

One and two per cent helium in nitrous oxide or in oxygen were obtained by addition of known amounts of these gases measured by a 9-liter Collins spirometer. These gases

† Assistant Professor.
‡ Research Trainee and Resident in Anesthesia.
§ Research Laboratory Associate.
§ Professor.

 divides were then analyzed by gas chromatography. A sample was injected via an 0.4-ml gas-sampling loop. Separation was achieved with a Porapak column and detection by thermal conductivity. Nitrogen was used as the carrier gas. The temperature of the detector was 80 C and that of the Porapak column, 55 C.

Results

Peak heights produced by a given concentration of helium in nitrous oxide were 10 per cent greater than peak heights produced by the same concentration in oxygen (fig. 1). However, the areas under these peaks were equal. Calibration curves for either helium in nitrous oxide or helium in oxygen were linear (fig. 2).
Discussion

We believe these results can be explained by a "second-gas effect." As the bolus of nitrous oxide and helium enters the column, the nitrous oxide is preferentially absorbed. Evidence for the preferential absorption is the large differential in retention times for helium (1 min) and for nitrous oxide (9 min). The result is a decrease in bolus volume which concentrates the less absorbed (less soluble) helium. In contrast, there is no large-volume absorption of oxygen in the helium-oxygen mixture (respective retention times 1 min and 1¾ min). The concentrated helium resulting from the absorption of nitrous oxide produced a higher, narrower peak than the unaltered helium in oxygen (fig. 1). The effect of the absorption is constant for any given concentration of nitrous oxide, as evidenced by the linearity of the calibration curves (fig. 2). Erroneous estimates of helium concentration in nitrous oxide result if peaks from helium in oxygen samples are used as standards. Measurement of peak height to determine concentration is a usually-accepted approximation. In this case, however, accurate helium concentrations can be obtained by measurement of areas, or calibration with helium in nitrous oxide.

These results, then, apply to any combination of a low concentration of a poorly soluble gas and a high concentration of a soluble gas. Thus, the same potential error would result with either nitrogen or oxygen in combination with nitrous oxide. Other anesthetics likely to produce similar second-gas effects include cyclopropane, ethylene, and xenon. The definition of a highly soluble gas varies with the column characteristics. The magnitude of the effect seen would also relate to the nature and length of the column. A more absorbent material might make a gas such as nitrogen relatively soluble and therefore lead to the same error as occurs in the helium-nitrous oxide combination.

Reference