

## REFERENCES

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(Accepted for publication May 1, 1990.)

Anesthesiology  
73:354, 1990

*In Reply:*—A filling error such as that described by Riegle and Desertspring has never been reported. It is true that if the keyed collar on the halothane bottle should be accidentally installed upside down it would be physically possible to place an enflurane adaptor over the threads of a halothane bottle, but without a threaded connection because of diameter differences. Even in such a situation the practitioner would be made aware of the error by four different warnings: 1) no threaded connection could be made; 2) the mismatch would cause noticeable leakage during filling; 3) the color coding between bottle and filler would not match (enflurane's color is orange; halothane's is red); and 4) the bottles are prominently labeled as to content.

Anesthesiology  
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Even so, we regret any possibility of inversion of the collar, and we have redesigned the process of putting the collar on the bottle, with the use of the keyed system itself to insure proper orientation of the collar.

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(Accepted for publication May 1, 1990.)

## Capnometer Readings at High Altitude

*To the Editor:*—This letter is to alert those who work at altitudes much above sea level to a potential problem in misinformation generated by carbon dioxide analyzers not properly calibrated for altitude. While evaluating a prototype clinical mass spectrometer (Paradygm, Boulder, CO) in parallel with our Datascope Multinex 4300 (Datascope, Paramus, NJ), it became obvious that the Datascope unit gave consistently high values, even after field service personnel checked the calibration of the device. During moderate hyperventilation, the mass spectrometer showed end-tidal CO<sub>2</sub> values of 31 mmHg, whereas the Multinex 3400 indicated 38 mmHg. At the end of one case the mass spectrometer indicated an end-tidal CO<sub>2</sub> concentration of 48 mmHg, and the Multinex indicated a value of 64 mmHg.

Further investigation revealed that the manufacturer provided no procedure for altitude compensation when converting from per cent values to mmHg.<sup>1</sup> Specifically:

$$P_{\text{CO}_2} \text{ mmHg} = F_{\text{CO}_2} \times (P_B - P_{\text{H}_2\text{O}})$$

where  $F_{\text{CO}_2} = \% \text{CO}_2 / 100$ . The Multinex 4300 calibration instructions call for a 5% CO<sub>2</sub> calibration gas to be injected while an output voltage is adjusted to a fixed level, subsequently displayed as 38 mmHg, *i.e.*:

$$P_{\text{CO}_2} \text{ mmHg} = F_{\text{CO}_2} \times (760 - 0)$$

The Multinex 3400 measured a series of calibration gases (Scott Medical Products, Plumsteadville, PA) at a barometric pressure of 630 mmHg (dry gases) (table 1). This error is different from, and at our altitude larger than, the problem of correction for water vapor pressure discussed recently by Severinghaus.<sup>2</sup> Neither the Datascope unit nor the Paradygm unit corrected for alveolar water vapor, although the Paradygm unit now permits either dry or wet gas data presentation.

Severinghaus's summary of the conventions observed by respiratory physiologists surely is correct, with mmHg being reserved for wet gas readings and per cent reserved for dry gas readings. In addition, he

TABLE 1. Calibration Gases Measured by the Multinex 3400 at a Barometric Pressure of 630 mmHg

Calibration Gas %	Calculated Partial Pressure	Measured Partial Pressure (%)
2.0	12.6	14 (2.22)
3.0	18.9	22 (3.49)
4.0	25.2	30 (4.76)
5.0	31.5	38 (6.03)
6.0	37.8	47 (7.46)
7.0	44.1	54 (8.57)

is correct that those of us measuring end-tidal CO<sub>2</sub> clinically wish to measure the alveolar (wet gas) partial pressure. Nonetheless, correcting for alveolar water vapor with the somewhat arcane analog-era practice of forcing a measuring instrument to "misread" a dry calibration gas is confusing to many of the clinicians and engineers now concerned with these measurements.<sup>2</sup> There is merit to solving the complex problem of correcting for changes in water vapor content at the time patient data are computed. Clearly, 5% CO<sub>2</sub> in Boulder has a partial pressure of 31.5 mmHg; it is only when the sample has been dried between the alveolus and the measuring instrument that reporting the result as 31.5 mmHg instead of 29.4 mmHg incorrectly estimates the alveolar partial pressure of the gas.

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