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Calculation of dead space volume

To the Editor:

We read with interest the article by Mora *et al.*¹ regarding sedative and ventilatory effects of midazolam. They used the following equation for the calculation of dead space volume:

$$V_d = (EPaCO_2 - PETCO_2) \times (V_t - \text{Valve dead space}) / EPaCO_2$$

The use of end-tidal partial pressure of CO₂ (PETCO₂) is questionable. It seems to us that the *mixed expired*, rather than end-tidal PCO₂, should be used.

The volume of CO₂ eliminated in the expired gas each minute (CO₂ production, V̇CO₂) equals the product of minute ventilation (V̇E) and mixed expired CO₂ concentration (F̄ECO₂):

$$\dot{V}CO_2 = (\bar{F}ECO_2) \times (\dot{V}E) \quad (\text{Eq. 1})$$

The volume of CO₂ eliminated from the body is also equal to the sum total of CO₂ volume in the alveoli and in the dead space:

$$\dot{V}CO_2 = (\dot{V}A) \times (FACO_2) + (\dot{V}D) \times (FDCO_2) \quad (\text{Eq. 2})$$

where FACO₂ is the CO₂ concentration in the alveoli, FDCO₂ is the CO₂ concentration in the dead space (which equals inspired CO₂ concentration, FICO₂), and V̇A and V̇D are alveolar and dead space ventilation, respectively.

Setting equation 1 against equation 2, and using the relationship between V̇E, V̇A and V̇D (V̇E = V̇A + V̇D), and substituting FICO₂ for FDCO₂, results in the equation

$$(\bar{F}ECO_2) \times (\dot{V}E) = (\dot{V}E - \dot{V}D) \times (FACO_2) + (\dot{V}D) \times (FICO_2) \quad (\text{Eq. 3})$$

Since FICO₂ is approximately zero, and since FACO₂ approximates arterial CO₂ (FaCO₂), and since ventilation (V̇) is the product of volume (V) and respiratory rate, further algebraic manipulation yields the equation:

$$V_D = (FaCO_2 - \bar{F}ECO_2 \times (V_T) / FaCO_2 \quad (\text{Eq. 4})$$

which is known as the Bohr equation.²

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- 1 Mora TC, Torjman M, White PF. Sedative and ventilatory effects of midazolam infusion: effect of flumazenil reversal. *Can J Anaesth* 1995; 42: 677–84.
- 2 Benumof JL. Respiratory physiology and respiratory function during anesthesia. In: Miller RD (Ed.). *Anesthesia*. 3rd ed. New York: Churchill Livingstone Inc., 1990: 505–49.

REPLY

We appreciate the comments of Drs. Sherkman, Crisnic and Avidan regarding the calculation of physiologic dead space.¹ We apologize for the typographical error in expressing the Bohr equation. Indeed mixed expired values (P̄ECO₂) were used for the calculation of physiologic dead space rather than PETCO₂ values.

Our instrumentation consisted of a metabolic cart (MGC 2001) which is primarily designed to measure V̇E, V̇O₂ and V̇CO₂ and, therefore, provides an F̄ECO₂ measurement from the waveform analyzer trace. Had we used PETCO₂ values for our calculations, we would have obtained measurements well below the normal physiological range since PaCO₂ and PETCO₂ values are similar in patients with normal lung physiology.

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- 1 Mora CT, Torjman M, White PF. Sedative and ventilatory effects of midazolam infusion: effect of flumazenil reversal. *Can J Anaesth* 1995; 42: 677–84.

Erratum

Orser BA. Medication labels: for whose benefit? (Correspondence). *Can J Anaesth* 1996; 43: 194.

Please note that in the above Letter to the Editor, Dr. R. Chen, the primary author, was inadvertently omitted. It should read:

Chen R, Orser BA.