CORRESPONDENCE

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Alveolar Air Equations

To the Editor:—Story's letter[1] raises interesting questions about the alveolar gas equations. Essentially, these indicate the alveolar partial pressures of oxygen and carbon dioxide in terms of barometric pressure, uptake (or output), and alveolar ventilation. They are simply based on conservation of mass.

Alveolar gas equations exist in many versions for different purposes: some versions are accurate, some less accurate, and some only approximate. Accurate versions are required for determination of alveolar P_{O_2} in the calculation of venous admixture, for example. Perhaps the most satisfactory version for the anesthesiologist is that of Filley, MacIntosh, and Wright,[2] which does not require inert gases, such as nitrous oxide, to be in equilibrium.

Some approximate versions give a clearer indication of the quantitative relevance of clinically important variables and so are a valuable teaching aid. For this purpose, I favor the following:

$$P_{A_{CO_2}} = P_B(dry)(F_{I_{CO_2}} + \dot{V}_{CO_2}/\dot{V}_A)$$

$$P_{A_{O_2}} = P_B(dry)(F_{I_{O_2}} - \dot{V}_{O_2}/\dot{V}_A)$$

The first is accurate if expired minute volume is used to calculate $\dot{V}_A$, the second is only approximate.[3] Nevertheless, it is quite adequate as a basis for consideration of problems of gas exchange in such situations as high altitude, malignant hyperpyrexia, or ventilatory failure.

These versions of the "universal" alveolar air equation make it quite clear that $P_{A_{O_2}}$ is not really a function of $P_{A_{CO_2}}$ as Story explains, even though some versions of the alveolar gas equation give this impression. However, if inspired concentrations and respiratory exchange ratio remain constant, then changes in alveolar ventilation alter $P_{A_{O_2}}$ and $P_{A_{CO_2}}$ in different directions, the magnitude of the changes being related to the respiratory exchange ratio. Therefore, it is a case of *post hoc* rather than *propter hoc.*

It should be stressed that $\dot{V}_{CO_2}$ and $\dot{V}_{O_2}$ in these equations are output and uptake, respectively, and not production and consumption, as Story states. In the case of oxygen, uptake and consumption seldom differ greatly. However, for carbon dioxide, output may differ greatly from production in an unsteady state. This has considerable clinical relevance. Patients seldom die in a steady state.

Alveolar air equations are at their simplest when $F_{I_{O_2}} = 1.0$. Then:

$$P_{A_{O_2}} = P_B - P_{H_2O} - P_{A_{CO_2}}$$

and no corrections are required. An opening parenthesis is missing from Story's equation (1) immediately before P_B. This may have caused confusion.

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Cerebral Oxygenation during Deep Hypothermic Cardiopulmonary Bypass: Is Hemoglobin Relevant?

To the Editor:—I was fascinated by Dexter and Hindman's model of cerebral oxygen delivery.[1] To examine the behavior of their model in more detail, I loaded the equations into a Hewlett Packard HP-48GX programmable calculator and examined their behavior under a variety of conditions, using the calculator's Equation Solver application.

This examination led me to conclude that it is not the shift in P_{50} alone that is responsible for the change in the relation between Sv_{O_2} and CMR% (percentage of maximal $CMRO_2$) seen with hypothermia, but rather the interaction between that shift and the relation between interstitial oxygen tension ($PinO_2$) and CMR%. In brief, the target (or basal) CMR% determines the $PinO_2$ (and therefore the Pv_{O_2}) needed to support that CMR%. The authors chose a model (Michaelis-Menten kinetics, eq. 9)[2,3] that requires relatively high Pin_{O_2} to support high CMR%. As the P_{50} shifts left with hypothermia, it is not surprising to find that the high Pv_{O_2}, which is determined