Alveolar Air Equations

To the Editor — Story’s letter1 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 PaO2 in the calculation of venous admixture, for example. Perhaps the most satisfactory version for the anesthesiologist is that of Filley, Machnotsh, 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:

\[
P_{A\text{O}_2} = P_{a\text{dry}}(F_{\text{O}_2} + \frac{V_{\text{CO}_2}}{V_{\text{A}}})
\]

\[
P_{A\text{CO}_2} = P_{a\text{dry}}(F_{\text{CO}_2} - \frac{V_{\text{CO}_2}}{V_{\text{A}}})
\]

The first is accurate if expired minute volume is used to calculate VA, the second is only approximately.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 PAO2 is not really a function of PAO2 as Story explains, even though some versions of the alveolar gas equation give this impression. However, if inspired volumes and respiratory exchange ratio remain constant, then changes in alveolar ventilation alter PAO2 and PAO2, 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.

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.4 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 Pao2 alone that is responsible for the change in the relation between Svo2 and CMRb (percentage of maximal CMRO2) seen with hypothermia, but rather the interaction between that shift and the relation between interstitial oxygen tension (PtrO2) and CMRb. In brief, the target (or basal) CMRb determines the PtrO2 (and therefore the Pvo2) needed to support that CMRb. The authors chose a model (Michaelis-Menten kinetics, eq. 9)5 which requires relatively high PtrO2 to support high CMRb. As the Pvo2 shifts left with hypothermia, it is not surprising to find that the high Pvo2, which is determined

References


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