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Temperature Correction of the Calculated Alveolar Oxygen Tension

To the Editor:—Determination of partial pressure of alveolar oxygen ($P_{A_{O_2}}$) is necessary in several pathophysiologic conditions, including evaluation of alveolar-arterial oxygen gradient ($\Delta_{(A-a)O_2}$) and calculation of shunt fraction. The equation by which the $P_{A_{O_2}}$ is calculated, the alveolar air equation,¹ is

$$P_{A_{O_2}} = F_{I_{O_2}}(P_B - P_{H_2O}^*) - \frac{P_{A_{CO_2}}}{R} + P_{A_{CO_2}} \cdot F_{I_{O_2}} \cdot \frac{1 - R}{R} \quad (1)$$

where, $F_{I_{O_2}}$ is the inspiratory oxygen fraction, P_B is the inspiratory air pressure, $P_{H_2O}^*$ is the alveolar saturated water vapor pressure, $P_{A_{CO_2}}$ is the alveolar carbon dioxide tension, and R is the respiratory exchange ratio ($\dot{V}_{CO_2}/\dot{V}_{O_2}$, normally 0.8).

The alveolar air equation (equation 1) necessitates a knowledge of $P_{H_2O}^*$. In most texts of physiology, $P_{H_2O}^*$ is designated to be 47 mmHg.¹ This value, however, is a function of alveolar (body) temperature and varies markedly from approximately 13 mmHg at 15°C to approximately 72 mmHg at 45°C.² The values for $P_{H_2O}^*$ at different temperatures are readily available in handbooks of physical chemistry and in texts of anesthesia and respiratory physiology.² At a particular absolute temperature T , $P_{H_2O}^*$ may also be calculated by the following empirical equation:³

$$P_{H_2O}^* = e^{\left(\frac{18.3036}{T} - \frac{3816.44}{T - 46.13} \right)} \quad (2)$$

To facilitate the calculation of $P_{H_2O}^*$, based on equation 2, we developed a simple nomogram by which derivation of $P_{H_2O}^*$ at different temperatures can be performed easily within a few seconds. The accuracy of this nomogram (fig. 1) is sufficient for routine clinical practice. The corresponding $P_{H_2O}^*$ can be found easily at any particular temperature, which ranges from 15 to 45°C. As an example, to find out the $P_{H_2O}^*$ at 30°C, the corresponding point to the 30°C on the temperature axis (left side values) should be located first. Then, at the same ordinate, the value for the desired $P_{H_2O}^*$ can be read from the $P_{H_2O}^*$ axis (right side values), which, in this case, is approximately 31.6 mmHg. Assuming the following scenario, the importance of this simple correction could be evident.

Assume a body temperature of 30°C, the $P_{H_2O}^*$, as was found out earlier, is therefore 31.6 mmHg. Now assume $P_B = 760$ mmHg, $F_{I_{O_2}} = 21\%$, $P_{A_{CO_2}} = P_{a_{CO_2}} = 40$ mmHg, $P_{A_{O_2}} = 103$ mmHg, and $R = 0.8$. Using equation 1, then $P_{A_{O_2}} = 105.06$ mmHg, and, as a consequence, $\Delta_{(A-a)O_2} = 2.06$ mmHg.

If instead of using the correct value of 31.6 mmHg for $P_{H_2O}^*$, the usual value of 47 mmHg is utilized, the result then becomes $P_{A_{O_2}} = 101.83$ mmHg, and, subsequently, $\Delta_{(A-a)O_2} = -1.17$ mmHg < 0.

Arterial P_{O_2} could never be higher than that of the alveolar pressure, therefore, a zero or a negative $\Delta_{(A-a)O_2}$, in any case, reflects an error. In the aforementioned case, although the calculated value of $P_{A_{O_2}}$ differs by only 3% from its actual value, the resultant $\Delta_{(A-a)O_2}$ became negative and, therefore, meaningless.

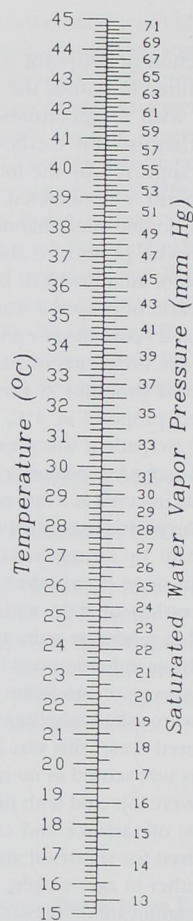


Fig. 1. A nomogram for temperature correction of saturated water vapor pressure.

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