A nomogram for obtaining the partial pressure of oxygen in alveolar air

Amod Karnik, Dilip R Karnad

The relation between the arterial and the alveolar partial pressure of oxygen (PAO₂) is used for estimation of venous admixture in critically ill patients for adjusting the inspired oxygen concentration to obtain the required arterial PO₂ in patients having mechanical ventilation as a basis for deciding whether to wean a patient from mechanical ventilation, and for calculating intrapulmonary shunting, and for predicting the extent of hypoxaemia during an air flight in patients with chronic obstructive lung disease. Whereas the arterial PO₂ is estimated by blood gas analysis, the partial pressure of oxygen in alveolar gas (PAO₂) is obtained from the alveolar gas equation:

\[ \text{PAO}_2 = (P_b - PH_2O) \times FIO_2 - \frac{\text{Paco}_2}{R}, \]

where PB is the barometric pressure in mm Hg, PH₂O is the water vapour pressure (which at 37°C is 47 mm Hg), FIO₂ is the fraction of oxygen in inspired air, PACO₂ is the partial pressure of carbon dioxide in arterial blood, and R is the respiratory quotient. To avoid the tedious task of repeatedly calculating PAO₂ by solving the alveolar gas equation, we attempted to produce a nomogram that takes all these variables into account.

The nomogram

The nomogram was drawn on the basis of the alveolar gas equation on the assumption that the value of R is 0.8. The barometric pressure (PB) is selected on the scale at the bottom of the left hand portion of the nomogram. A vertical line is plotted upwards from this PB until it intersects the desired FIO₂ line. For values of FIO₂ that lie between two drawn FIO₂ lines a measured or approximate point is selected. From this point a horizontal line is...
plotted, extending rightwards across the vertical scale for the partial pressure of oxygen in inspired air (P_{O_2}, kPa) into the right hand portion of the nomogram. The P_{O_2} value may be read off this vertical (kPa) scale or off the vertical scale on the right in mm Hg if desired, but is not essential for obtaining the P_aO_2. The horizontal line that is being plotted is extended until it intersects the desired P_aC_0 line. A vertical line through this point of intersection, drawn upwards (if the horizontal line is in the upper half of the nomogram) or downwards (if the horizontal line is in the lower half of the nomogram) will give the P_aO_2 value in kPa and mm Hg.

In most clinical circumstances the respiratory quotient is assumed to be 0·8\(^3\); we therefore assumed this value when preparing the nomogram. If, however, in a particular patient the respiratory quotient is measured and is not 0·8, a correction is provided (see legend below figure).

Validation

After some practice in using the nomogram and a non-programmable pocket calculator, 20 resident doctors were given 10 problems; in each case values were provided for P_b, F_iO_2, and P_aC_0, from which the P_aO_2 had to be derived first with the calculator and then with the nomogram. In problems 1–5 there was a constant P_b of 760 mm Hg, so these values could be plotted on the vertical line already drawn on the nomogram at 760 mm Hg. In problems 6–10 the P_b varied from 500 to 800 mm Hg. These doctors took an average of 13 seconds (95% CI 8·07–18·03 seconds) longer over each problem with the nomogram than with the calculator. The mean of the residuals (difference between actual and nomogram values) was 7·4 mm Hg or 1 kPa (95% CI 6·1–8·7 mm Hg or 0·8–1·2 kPa).

The nomogram is suitable for use up to an altitude of 11 000 feet (3353 metres). We recommend that users draw a vertical line corresponding to the barometric pressure at the altitude at which they are working. The line for use at sea level is the one already drawn at 760 mm Hg. Plotting values on a line that is already drawn increased accuracy.

Our nomogram therefore gave fairly accurate values of P_aO_2 within a reasonable time. Moreover, its ease of use makes it a convenient alternative to a pocket calculator.

We are grateful to the resident doctors from the department of medicine for their cooperation, and to Peter Gonsalves for helping us to prepare this nomogram.