Technical note

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

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The relation between the arterial and the alveolar partial pressure of oxygen (P\(_{A\text{O}_2}\)) is used for estimation of venous admixture in critically ill patients,\(^1\)\(^2\) for adjusting the inspired oxygen concentration to obtain the required arterial P\(_{A_2}\) in patients having mechanical ventilation,\(^3\)\(^4\) as a basis for deciding whether to wean a patient from mechanical ventilation,\(^5\) for calculating intrapulmonary shunting,\(^6\) and for predicting the extent of hypoxaemia during an air flight in patients with chronic obstructive lung disease.\(^7\) Whereas the arterial P\(_{A_2}\) is estimated by blood gas analysis, the partial pressure of oxygen in alveolar gas (P\(_{A\text{O}_2}\)) is obtained from the alveolar gas equation:\(^8\)\(^9\)

\[
P_{A\text{O}_2} = (P_B - PH_2O) \times FIO_2 - \frac{P_{ACO_2}}{R}.
\]

where P\(_B\) is the barometric pressure in mm Hg, PH\(_2\text{O}\) is the water vapour pressure (which at 37°C is 47 mm Hg), FIO\(_2\) is the fraction of oxygen in inspired air, P\(_{ACO_2}\) is the partial pressure of carbon dioxide in arterial blood, and R is the respiratory quotient. To avoid the tedious task of repeatedly calculating P\(_{A\text{O}_2}\) 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 (P\(_B\)) is selected on the scale at the bottom of the left hand portion of the nomogram. A vertical line is plotted upwards from this P\(_B\) until it intersects the desired FIO\(_2\) line. For values of FIO\(_2\) that lie between two drawn FIO\(_2\) lines a measured or approximate point is selected. From this point a horizontal line is

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Reprint requests to:
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Received 20 August 1991
Returned to authors
18 December 1991
Revised version received
27 January 1992
Accepted 4 February 1992

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**Nomogram based on the alveolar gas equation for obtaining the alveolar partial pressure of oxygen (P\(_{A\text{O}_2}\)).** FIO\(_2\)—fraction of oxygen in inspired air; P\(_{ACO_2}\)—partial pressure of carbon dioxide in arterial blood. Correction for the respiratory quotient (R): The correction factor is obtained by rounding off P\(_{ACO_2}\) in kPa to the nearest whole number and then dividing this by 10, or by dividing P\(_{ACO_2}\) in mm Hg by 10 and rounding this off to the nearest whole number. If R = 0-9, no change in P\(_{A\text{O}_2}\) is required; if R = 0-7, 1·5 times the correction factor is subtracted from the P\(_{A\text{O}_2}\); if R = 0-9, 1·5 times the correction factor is added to P\(_{A\text{O}_2}\); if R = 1, twice the correction factor is added to the P\(_{A\text{O}_2}\).
plotted, extending rightwards across the vertical scale for the partial pressure of oxygen in inspired air (P[_O_2]ast, kPa) into the right hand portion of the nomogram. The P[_O_2]ast 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 PAO_2. The horizontal line that is being plotted is extended until it intersects the desired Pco_2 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 PAO_2 value in kPa and mm Hg.

In most clinical circumstances the respiratory quotient is assumed to be 0.8; 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 PB, FIO_2, and Pco_2, from which the PAO_2 had to be derived first with the calculator and then with the nomogram. In problems 1–5 there was a constant PB 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 PB 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 gives fairly accurate values of PAO_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.

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*Thorax* 1993 48: 89-90
doi: 10.1136/thx.48.1.89

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