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Calculating F_{DO_2} for Mixtures of Air and Oxygen

The need to combine air and oxygen frequently arises during anesthesia and critical care. Primarily, the nitrogenous component of air functions to reduce the concentration of oxygen and to decrease the risk of oxygen toxicity.[1] This dilution is also mandatory during laser surgery because high concentrations of oxygen support combustion.[2-4] Use of 100% oxygen also can result in absorption atelectasis.[5] The oxygen concentration delivered (F_{DO_2}), when air and oxygen are mixed, is calculated by Equation 1

$$F_{DO_2} = \frac{(1.0)(\dot{V}_{O_2}) + (0.21)(\dot{V}_{air})}{\dot{V}_{O_2} + \dot{V}_{air}},$$

$$\text{where } \dot{V}_{O_2} = O_2 \text{ flowrate and}$$

$$\dot{V}_{air} = \text{air flowrate}.$$

If the flowrates of air and O_2 are known, the F_{DO_2} can be quickly calculated by Equation 2

$$F_{DO_2} = (0.79)\left(\frac{\dot{V}_{O_2}}{\dot{V}_{total}}\right) + 0.21,$$

where $\dot{V}_{total}$ = the total flowrate ($\dot{V}_{air} + \dot{V}_{O_2}$).

As shown in the Appendix, Equation 2 is just a simplified form of Equation 1. It is especially practical for rapid estimates and often can be used without a calculator. All flowrates must be in the same units (ordinarily $mL \cdot min^{-1}$ or $L \cdot min^{-1}$). F_{DO_2} is the fraction of the total gas flow that is oxygen. The coefficients of the equation, 0.79 and 0.21, correspond to the percentage of nitrogen and oxygen in air, respectively. Equation 2 can be easily rearranged to solve for $\dot{V}_{O_2}$. Example: With an air flowrate of $4.5\ L \cdot min^{-1}$ and oxygen flow of $0.5\ L \cdot min^{-1}$ (total flow, or $\dot{V}_{total} = 5\ L \cdot min^{-1}$, the resulting F_{DO_2} is

$$0.79\left(\tfrac{0.5}{5}\right) + 0.21 = 0.29,$$

ie, the oxygen fraction.

An estimate can be obtained by rounding off 0.79 to 0.80 and 0.21 to 0.20 and, in this example 0.5/5 = 0.1 and thus

$$(0.80)(0.1) + 0.20 = 0.28,$$

ie, the oxygen fraction.

By making use of simple arithmetic shortcuts, the reader can make this method work expeditiously. By Equation 1, it may be difficult to determine $\dot{V}_{O_2}$ for a given F_{DO_2}, but Equation 2 can be easily manipulated to solve for $\dot{V}_{O_2}$.

$$\dot{V}_{O_2} = \frac{(\dot{V}_{total})(F_{DO_2} - 0.21)}{0.79}.$$

Example: For an F_{DO_2} of 0.3 (30% O_2), with $\dot{V}_{total}$ of $8\ L \cdot min^{-1}$, the flowrate for O_2 will be

$$\frac{(8)(0.3 - 0.21)}{0.79} = 0.91\ L \cdot min^{-1}.$$

Again, rounding off and knowing that 8/0.8 = 10 and 0.3 - 0.21 = 0.09, the solution can be estimated

$$\left(\tfrac{8}{0.8}\right)(0.3 - 0.21) = 0.9\ L \cdot min^{-1}.$$

$\dot{V}_{air}$ can be determined by subtracting the flowrate of O_2 from the $\dot{V}_{total}$ ($\dot{V}_{air} = \dot{V}_{total} - \dot{V}_{O_2}$). In the preceding example, the flowrate for air would be $8.0 - 0.91 = 7.09\ L \cdot min^{-1}$. Use of these equations should reduce the 'trial and error' (and anxiety!) associated with setting air and oxygen flowrates.

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APPENDIX

Equation 2 can be derived from Equation 1 by simple algebra. First, $\dot{V}_{O_2}$ can be expressed as the sum of two fractions $(0.79)(\dot{V}_{O_2})$ and $(0.21)(\dot{V}_{O_2})$.

$$F_{DO_2} = \frac{(1.0)(\dot{V}_{O_2}) + (0.21)(\dot{V}_{air})}{\dot{V}_{O_2} + \dot{V}_{air}} = \frac{(0.79 + 0.21)(\dot{V}_{O2}) + (0.21)(\dot{V}_{air})}{\dot{V}_{O2} + \dot{V}_{air}}.$$

Because both $\dot{V}_{O_2}$ and $\dot{V}_{air}$ are multiplied by a factor of 0.21, they can be collected. The term $[\dot{V}_{O_2} + \dot{V}_{air}]$ then is eliminated from both numerator and denominator of that part of the equation:

$$F_{DO_2} = \frac{(0.79)(\dot{V}_{O_2})}{\dot{V}_{O_2} + \dot{V}_{air}} + \frac{(0.21)(\dot{V}_{O_2} + \dot{V}_{air})}{\dot{V}_{O_2} + \dot{V}_{air}}$$

$$= \frac{(0.79)(\dot{V}_{O_2})}{\dot{V}_{O_2} + \dot{V}_{air}} + 0.21$$

Replacing $[\dot{V}_{O_2} + \dot{V}_{air}]$ with the equation $\dot{V}_{total} = \dot{V}_{O_2} + \dot{V}_{air}$ yields the simplified result:

$$F_{DO_2} = (0.79)\left(\frac{\dot{V}_{O_2}}{\dot{V}_{total}}\right) + 0.21.$$

Professional Literacy Revisited

Last Fall Semester (1991), my students and I read with interest Robert Weilacher's editorial in RESPIRATORY CARE entitled "Professional Literacy."[1] I feel it professionally incumbent upon me to add some comments.

I have taught two advanced-level Respiratory Therapist reading courses (REST 2525 and REST 2526) in our Registry Curriculum every year for the past 19 years. In those courses, my students and I have read and evaluated practically every article published in RESPIRATORY CARE since 1972. I want to reassure my fellow Texan from Palestine that at least one academic educator not only uses but relies on RESPIRATORY CARE in his work!

I (and my students) have never seen the quality of articles in the Journal as good as they are at present. We are proud to be a part of a profession from whose peers such high quality, original, and scholarly work as that published in RESPIRATORY CARE this past year can be generated. The recent academic quality reflected in our monthly science journal should make each member of the Journal's Editorial Board proud —especially because it makes AARC members and respiratory care students proud.

I totally agree with Mr Weilacher that the Journal is *the* one tool always available to me and my students in that "constant struggle to remain professionally contemporary."[1] Permit me to illustrate: This Spring Semester (1992), one of the topics emphasized in my course is mechanical ventilation. What a quality synthesis of up-to-date information awaited us in the Journal papers by such internationally acclaimed authors as Richard Branson RRT, Robert Chatburn RRT, Roger Goldberg MD, Dean Hess MEd RRT, Robert Kacmarek PhD RRT, and David Pierson MD—just to name a few! In Volume 36 (1991), topics related to mechanical ventilation ranged from ventilator performance during hyperbaric compression to bronchodilator administration, circuit compression volume, and patient work of breathing, and numbered more than 35—not including letters! My students and I found the Chatburn paper[2] on ventilator classification to be the single, most helpful paper published in the past 10 years.

I think that sometimes we take our Journal too much for granted; too often we do not take the time to pat on the back those who continuously produce a high quality product year after year. I have certainly failed to do so in times past, and my students and I simply want to express our thanks to the Editorial Board and the Journal's authors for adding so much to our professional enrichment and pride.

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2. Chatburn R L. A new system for understanding mechanical ventilators. Respir Care 1991;36:872-874.