

of length squared (L^2). Similarly, if the graph was, say, flow versus time, then the area under the flow curve would have units of volume; flow \times time (T) = (volume/time) \times time = volume, which has dimensions of length cubed (L^3). Now, if a volumetric CO_2 graph has its vertical axis labeled as P_{CO_2} (a pressure) and its horizontal axis labeled as volume, then any area has units of pressure \times volume = (force/area) \times volume = (force/ L^2) \times L^3 = force \times L, which has dimensions of mass (M) \times acceleration \times distance, or ML^2T^{-2} , representing *work*, not *volume*.⁵

The correct labeling for the volumetric CO_2 graph shows the fractional concentration of CO_2 on the vertical axis (F_{CO_2} not P_{CO_2}).⁶ Area in units of a fraction times volume yields the units of volume, as required. This was illustrated as early as 1948 in a paper by Fowler,⁷ where the vertical axis is labeled “ CO_2 concentration” expressed as a fraction. Fletcher et al⁴ seem to have written the original article describing volumetric CO_2 monitoring. They showed several graphs of volume versus fraction of CO_2 . Tusman et al⁸ even state explicitly, “The advantage of using fractions of carbon dioxide compared with partial pressure is that each area represents a volume of carbon dioxide, real or theoretical.”

You may think this issue is a trivial matter, not worth mentioning. But if you are a clinician who is struggling with inconsistencies in the literature, a researcher trying to analyze actual raw data, an educator trying to make a simulation with a spreadsheet, or an engineer trying to design software for a monitor, this kind of error could be quite confusing.

**Robert L Chatburn MHHS RRT-NPS
FAARC**
Respiratory Therapy Department
Cleveland Clinic
Cleveland, Ohio

Mr Chatburn has disclosed relationships with IngMar Medical and DeVilbiss/Drive Medical.

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A Shout Instead of a Whisper: Let's Get the Graphics Right— Reply

In reply:

After politely conceding to his original objections back in 2013, and thanking him for “his compulsion for accuracy and obsession to detail,”^{1,2} I am now amused and a bit annoyed by Mr Chatburn’s letter, which expresses his incessant intellectual banter and expert opinion on how the axis of the volumetric capnogram should be labeled in a peer-reviewed publication.³

In the pure technical sense, Mr Chatburn is absolutely correct in that fractional CO_2 is essential to the accuracy of the volumetric CO_2 calculation and for the calculation of areas representing the dimension of volumes of CO_2 . However, I would like to point out to Mr Chatburn that there are numerous examples of journal articles, presentations at educational meetings, ventilator graphics, and volumetric capnography monitors that depict or display the vertical axis of the volumetric capnogram in the manner that appears throughout my paper³ in Figures 4, 5, 6, 13, 14, 15, 18, and 19.

Certainly, a scientist or engineer studying, designing, or building a volumetric capnography device would understand this and

create the appropriate calculations. However, for the rest of us folks, it makes more sense to view the vertical axis labeled P_{CO_2} because that is how it is normally seen in the real world.

Maybe it would help if Mr Chatburn could imagine that everywhere P_{CO_2} appears in the vertical axis of the figures in question, inside invisible brackets next to P_{CO_2} is the equation, [$P_{CO_2} = F_{CO_2} \times (P_B - 47)$], where F_{CO_2} = fractional concentration of CO_2 , P_B = barometric pressure, and 47 = water vapor pressure at 37°C. I should hope this might be enough to justify my author’s prerogative instead of being seen as an egregious and confusing violation of depicting dimensionless and erroneous graphic illustrations.

To his credit, if not for Mr Chatburn’s scrutiny, I would have overlooked the error in the lower right corner of Figure 13 that was missed during the review and editing process. In place of the infinity symbol (∞) should have been the proportional to symbol (\propto).³ I am surprised that this missed Mr Chatburn’s scope of intense review and his quest for policing perfection and that I wasn’t reprimanded again for another error.²

Perhaps instead of shouting about getting the graphics right, Mr Chatburn should put some thought into the maxims of professional etiquette in constructive criticism.

Mark S Siobal RRT-ACCS FAARC
BSRC Program
Skyline College
San Bruno, California

Mr Siobal has disclosed a relationship with Aerogen.

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