

CORRESPONDENCE

Lung volumes and ventilatory flows: Report of Working Party

To the Editor:

The report of the Working Party on Lung Volumes and Ventilatory Flows [1] has been very much welcomed by all workers in the field. It is an excellent source for both clinicians and researchers. I would nevertheless present a few questions and comments.

Spirometer and temperature

In § 3.5.1.6. the authors emphasize the importance of adequate temperature measurement in the spirometer. However, temperature stability is also important. When a patient breathes in a spirometer, heat is dissipated due to various sources, the heat of reaction in the CO₂-absorber being the most important. The resulting increase in temperature is counteracted by the heat capacity of the instrument and by natural heat transfer to the ambient air, and is, therefore, dependent on the construction of the instrument and the materials used. Consequently, the spirometer volume increases, and this may lead to substantial errors in FRC-determinations, since it would lead to undetected imperfect oxygen supply, and incorrect helium meter readings. This effect is very prominent when dry rolling seal spirometers are used for FRC-measurements. Does the Working Party have a recommendation regarding temperature stability?

Heat conductivity meters

It is a known fact that heat conductivity meters for helium show a cross-sensitivity for oxygen and appendix B.2 deals with this problem. However, not only the thermal conductivities of the gases present in the sample determine the cross-sensitivity, but also the flow through the analyzer, its heat capacity, and the temperature. Therefore, it is not possible to estimate the cross-sensitivity for oxygen by such a simple calculation. Besides that, the values given in table 13 may be in error: the ratios calculated from more recently published values [2] for thermal conductivities differ substantially, depending on the temperature. I suggest that a recommendation could be that manufacturers explicitly state how the meter reading should be corrected for different oxygen concentrations. An important point in this respect is that in many commercially available equipment the result (FRC) is directly displayed and no check or correction on the gas concentration meters is possible. How could

a recommendation for such instruments be formulated?

Error analysis

The given definitions of accuracy and precision in § 3.2.1 do not follow conventional definitions [3]. A clear distinction should be made between systematic, random, probable, accuracy and precision errors. A detailed overview of error analysis, including the Law of Propagation of Errors, can be found in standard references [3, 4]. The basic idea of error analysis is that both measurements and errors are estimates of the "true" values, and can be considered as stochastic variables. In particular, when the desired quantity is calculated from different measurements, each with its own random error, the resulting probable error is the square root of the sum of squares of all individual errors. This value can be regarded as an estimate of the standard deviation of the desired quantity, thus permitting the calculation of confidence intervals. In contrast, herewith, is the handling of systematic errors: the resulting systematic error is the sum of individual errors, including the sign. The "worst case" analysis, given in appendix B.2 is inappropriate, because a systematic error in the helium meter (here defined as "accuracy error", cf. §3.2.1) also affects the spirometer volume, and may partly compensate the effect of the systematic error in the final helium concentration. This is easily verified by inspection of eq. 2, § 3.7.1.1. The conclusion that a large spirometer volume adversely affects the accuracy with which the FRC is assessed, only applies to random errors. It would be informative to carry out error calculations of the various lung function parameters, based upon the principles mentioned above, with the recommended instrument specifications as input values. This pertains to both normal and pathological conditions.

Water vapour pressure and temperature

In § 3.3 an approximation is given for the relation between the water vapour pressure and temperature. However, this relation is not founded on physical laws. A more correct expression is Young's relation [5]:

$$\ln P = -\frac{A}{T} + B$$

in which P denotes the vapour pressure, and T the absolute temperature. A and B are constants, to be determined empirically depending on the temperature range.

For the physiologic temperature range (16–37°C) the result becomes:

$$\ln P = - \left(\frac{5290.81}{t+273.15} \right) + 18.8974$$

with P in kPa and t in °C. This expression is considerably more accurate than the relation given in § 3.3 in comparison with published values [6] (rms error 0.0039 kPa, range -0.0115 to +0.0037 kPa). The main advantage, however, is the more solid foundation on classical thermodynamics.

Heated pneumotachometer

In appendix A.2.2. the effects of heating of a pneumotachometer are discussed. Apart from the fact that a Fleisch-type pneumotachometer is well capable of heating 1 l of ambient air to 33°C in a short time, this will not influence the calibration. Pneumotachometers measure an amount of gas passing per unit time, not a volume per unit time, and the amount of gas will not change, whether it is heated or cooled. Therefore, the temperature correction factors 0.9671 and 0.9579 for inhalation and exhalation respectively, should not be applied. The only correction to be taken into account is the change in viscosity. This applies only to Fleisch-type pneumotachometers, where the flow is artificially laminarized. For Lilly-type pneumotachometers a different approach

should be used, since the density of the gas plays an important role and the heat transfer characteristics are quite different.

References

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