CORRESPONDENCE

Impact of leaks in sulfur hexafluoride and nitrogen multiple-breath washout systems

To the Editor:

A recent study by Lenherr *et al.* [1] helps quantify impacts of leaks on multiple-breath washout (MBW) systems for functional residual capacity (FRC) and lung clearance index (LCI) measurements. In my view, technical leaks (post-capillary and intra-capillary leaks) are avoidable by careful testing of the equipment before connecting to the patient. However, pre-capillary leaks (interface between the device and patient) will occur, even in carefully controlled tests. The study [1], based primarily on computer modelling, provides detailed data showing that LCI measurements are relatively insensitive to expiratory leaks, but quantitative data on errors due to inspiratory leaks are not reported. It is, however, important to note that inspiratory leaks have a much higher impact on nitrogen (N_2) MBW LCI and FRC measurements than expiratory leaks.

The study is relevant for a specific N_2 MBW system, but the authors mention that sulfur hexafluoride (SF_6) MBW measurements are prone to similar leaks. This is correct, but the impact of inspiratory leaks in SF_6 MBW systems is entirely different because SF_6 is washed out with air. Therefore, an inspiratory leak does not affect the SF_6 concentration but only inspiratory flow, which is not used to calculate FRC or LCI. Consequently, the SF_6 MBW method is insensitive to inspiratory leaks.

For N_2 MBW systems, even a small inspiratory leak causes an error in the N_2 washout curve with a substantial change in the LCI point. As an example, a continuous leak of only 1% with an alveolar ventilation of 6 $L \cdot min^{-1}$ (100 $mL \cdot s^{-1}$) causes a nitrogen leak flow into the lungs of 0.8 $mL \cdot s^{-1}$, which moves the N_2 concentration at the LCI point by 0.8%, corresponding to 40% (relative) of the concentration at the LCI point without a leak. A leak of this size is not easily spotted, but it causes an error of the same order of magnitude as the error caused by N_2 back diffusion [2], which has been shown to affect the LCI point significantly, changing it from 1/40 of the initial N_2 concentration to, on average, around 1/60 of the initial concentration. The impact on the LCI point of an isolated leak in a few respirations is not predictable as it depends on both timing and level of ventilation heterogeneity. However, the relative error in calculated FRC equals the ratio between the volume of the leak and true FRC. The consequence of an inspiratory leak in an N_2 MBW system is to abort the test and perform the N_2 wash-in procedure before restart of the test, increasing test duration.

Expiratory leaks affect LCI and FRC measurements by N_2 and SF_6 MBW systems similarly. Inspiratory leaks affect the wash-in phase of SF_6 MBW systems. For open-circuit SF_6 wash-in [3], the leak is easily detected by the failure to obtain complete equilibration during wash-in. In the closed-circuit wash-in system [4], an inspiratory leak is also easily detected as a transient dip in SF_6 concentration during inspiration. In both cases, it is possible to ensure a leak-free system before the washout by adjusting patient interface (nose clip, mouthpiece or face mask) with limited increase in test duration.

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Sulfur hexafluoride multiple-breath washout is insensitive to inspiratory leaks
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Conflict of interest: J.G. Nielsen is a Chief Medical Officer and indirect owner of the company PulmoTrace ApS that develops, produces and sells devices for measurement of lung clearance index by multiple-breath washout using sulfur hexafluoride.

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