Accuracy and Reproducibility of the ASSESS Peak Flow Meter

I have had the opportunity to read "Accuracy and Reproducibility of the ASSESS Peak Flow Meter", which appeared in the European Respiratory Journal, March, 1990, 338-341 [1]. As a pulmonary physiologist and biotechnologist, I have serious concerns that this study has a poorly conceived research plan and is vague in its conclusions. The following statements elucidate my concerns regarding the research presented in the aforementioned article:

1. The author sets out to do an ANOVA analysis, i.e., an analysis of variance, to separate out the contributions of the instrument, patients, readers and other factors to the accuracy of the peak flow measurement; however, his conclusions reflect on the accuracy and precision of the ASSESS® peak flow meter.

2. In the methods section, a reference is made to Discord 14 while the bibliography contains only 12 references. The author further states that "the Fleisch #4 pneumotach is a very accurate apparatus" and cites [2]. This study shows (Table 1) that these pneumotachs require as much as a 13% gain factor to improve their linearity. My experience has been that this equipment can be off as much as 10%. Reference [2] recommends a correction equation to improve the linearity of the Fleisch.

3. I agree with the author in regard to his placing the peak flow meter in series with the pneumotach. This methodology was recommended by Eichenhorn et al., who the author references. In a study that will be published in CHEST, February, 1991, [3], Shapiro et al. points out that placing the peak flow meter in series alters the direction of flow, causing turbulence, and thereby introduces a source of error in the pneumotach. Van Schayck overlooks this point in the experimental setup. The Duvier study refers to this error as impedance. The significance to the present study, is that, in spite of referring to the Duvier study, the author ignores this salient point.

4. I believe that the entire calibration verification procedure, either implied or real, is suspect. The author dismisses the most important aspect of experimental protocol. In this study, the author calibrates the pneumotach with a one (1) litre syringe. The usual procedure is to calibrate with 1% rotameters and use a volumetric syringe as a verification. The author fails to use the correction factor outlined in the Duvier study. Furthermore, the author states that the respective levels of flow were produced by the second author (ED) at different levels of lung inflation. Additionally, correct procedure dictates that gas temperature be uniform, i.e., in equilibrium. Author (ED) could not provide temperature equilibrium while blowing through the pneumotach. This factor, alone, could account for the variability noted (-20.37%). The accepted method is to use a three (3) litre syringe as a known volume to generate a flow. In this way, the flow is verified by its integral, i.e., volume.

5. The study, despite its experimental design, demonstrates a linear response (y=0.86x - 0.23) and, therefore, precision of the ASSESS peak flow meter. The conclusion supports the Shapiro study in that the device works well using the subject as his own control, especially at flows below 300 litres per minute, the bellweather of airway patency. The author recommends that the accuracy will equal that of his "calibrated" pneumotachs simply by adjusting the scale. This cannot be done to the Wright meter, since the scale isn't large enough to square the flow [47].

In conclusion, the author did not establish a means of reproducing accurate increments of flow to test the reproducibility of the device. Therefore, the variability was that of the flow generator (author ED) and not the device itself.

References


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We would like to thank Dr Imbruce for his interest in our study. We shall reply point by point.

1. Our analysis was not on ANOVA procedure. In an ANOVA procedure variances and means of different distributions of a variable are compared and tested. We explained in the Introduction section that the aim of this study was to gain a better insight into the contribution of the variability caused by the peak flow meter to the total variability of peak flow measurements. In the Methods section it was explained that in order to calculate this contribution, both the total variability of 5 measurements of 24 patients and the standard deviations of several flow rates of 12 peak flow meters were assessed. The sum of the squared deviations from the mean peak flow rate is the random error of the instrument (measure of precision). The systematic error of the instrument (measure of accuracy) was calculated by means of regression analysis. Therefore the conclusion (in abstract and discussion) did not only reflect the accuracy and precision of the meter, but also mentioned the contribution of the Assess to the total variability in peak flow measurements.

2. Discom 14 (not Discin 14) does not refer to reference 14 (which indeed does not exist) but to the type number of the Fleish No. 4 pneumotachograph. Table 1 of the study of DUVOIVIER et al. shows that the maximal change in gain does not exceed 3.3% when the upper end of the flow range is 11.0 l/s. The maximal peak flow of the Fleisch in our study was 11.0 l/s, as the highest value that can be read of the Assess is 660 l/min (≈11 l/s). When the flow range of the Fleisch is extended to 22.0 l/s, a 13% gain factor is required to improve linearity.

3. The problem of turbulence, caused by the in-series connection of a pneumotachograph and peak flow meter, is quite realistic. This is a local turbulence at the site of the mouthpiece of the peak flow meter. The magnitude of the error due to this connection has not been assessed in our study. However, in the Discom 14 apparatus, the pneumotachograph has a truncated cone attached to both sides in order to keep the flow in the pneumotach laminar. The base of the cone has the dimension of the Fleisch No. 4 (2.5 cm radius), the height is 10.5 cm, the top of the truncated cone has an opening with a radius of 1.25 cm. Consequently, the source of the turbulence is 10.5 cm away from the pneumotach. We assume that it is highly unlikely that the turbulences at the peak flow meter will extend over such a distance.

4. Not only EICHENHORN et al. recommended in-series connection but the study of SHAPIRO et al. used exactly the same methodology as our study: the calibration verification of the pneumotach was performed with a one-litre syringe and a normal subject produced several flow rates with maximum effort. The calibration of the pneumotach was performed at three levels of flow: 1, 7 and 10 l/s, and verified by its integral. It is well-known that rotameters also deviate, if connected in series with a pneumotach. As already explained, the correction factor of the pneumotach calculated in the study of DUVOIVIER et al. is almost negligible in the lower flow range. The ECCS recommends calibration of pneumotachs by means of a syringe of at least one litre (Bull Eur Physiopathol Respir, 1983, 19 (Suppl. 5), 7–10). In the standardization of spirometry of the American Thoracic Society (Am Rev Respir Dis, 1987, 136, 1285–1298) it is also not advised to calibrate with a three-litre syringe or with rotameters, but to use a computer-controlled mechanical syringe, in order to imitate the in vivo situation of the forced expiratory manoeuvre as well as possible. Performing FVC-maneouvres by a subject will probably most clearly resemble the in vivo situation. The temperature problem is only partially compensated for by heating the pneumotach. This temperature effect probably affects the reading of the pneumotach and of the peak flow meter in the same direction.

5. We are glad to see that the study of SHAPIRO et al. is in agreement with our conclusion on the use of the peak flow meter when the patient is his own control.

Our recommendation to adjust the scale in order to improve the reproducibility was directed to the Assess peak flow meter and not the Wright meter, as we did not study this meter. Moreover, we never suggested to square the flow. We do not understand the reference to the study of SHAPIRO et al. in this respect. In that study it was suggested to describe the peak flow of the Miniwright as a function of the square root, but it was concluded that the data of the Assess meter were best described by means of a linear function, which confirmed our study. Our recommendation to adjust the value scale was a suggestion for the manufacturer of the Assess peak flow meter.

Dr Imbruce's final conclusion actually rephrases our own: the variability of the peak flow measurement is more due to patient variability than to instrument variability.

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