Peak flow measurement

Lord Kelvin wrote: "When you can measure what you are speaking of and express it in numbers, you know that on which you are discoursing. But when you cannot measure it and express it in numbers, your knowledge is of a very meagre and unsatisfactory kind." The introduction of the Wright peak flow meter in 1959[1] transformed lung function testing from measurements carried out on a few patients in hospital laboratories to a measurement made on many in primary care, workplaces, and the community. The measurement of peak flow, particularly in the early morning, transformed the assessment of asthma severity from a series of anecdotes, which were easy to dismiss, to hard data needing to be addressed. The current third generation of mass produced peak flow meters are cheap and results are surprisingly reproducible—to within 10 litres a minute—throughout the range. Measurements from them are used to make diagnoses and alter treatment.[2 3]

The peak flow meter has formed the basis of respiratory chronobiology, the study of circadian rhythms of airflow obstruction.[2] With current peak flow meters a diurnal variation below 20% in adults[2 4] or 31% in children[4] is normal. The main reason for increased diurnal variation is asthma, though increased diurnal variation is also seen in non-asthmatic chronic airflow obstruction, partly because of the usual practice of using mean peak flow as the denominator in the calculations. Individual patient management plans are often based on peak flow readings, increases in treatment and instructions to call for help being based on defined percentage falls in peak flow.[3 5] We are therefore making important decisions in the light of the variation of peak flow in individual patients.

The calibration of lung function equipment is a fundamental part of respiratory physiology, being carried out in all laboratories; few workers, however, ask themselves about the calibration of their peak flow meters. Are they accurate? Are they linear—in other words, is any error equal throughout the range? Are they stable? Part of the problem has been the difficulty of calibration. The original Wright meter was biologically calibrated in a group of volunteers whose peak flow was measured both with the meter and with a pneumotachograph. The pneumotachograph was calibrated by using a constant flow of gas, which produces results different from those obtained with a rapidly increasing flow rate, as in a forced expiration. Modern peak flow meters have been designed to reproduce the original Wright meter—indeed, the British drug tariff specification requires the readings of a meter to be within 10% of those of the Wright meter.

Methods are now available for reproducing expiratory flow patterns from computer driven syringe pumps to a high degree of accuracy.[6 7] A computerised forced expiratory manoeuvre (profile 24) has been introduced as a standard by the American Thoracic Society.[8] On page 904 of this issue Miller and colleagues[9] describe results obtained with such devices for calibrating currently available peak flow meters. There is a consistent non-linearity in the original Wright meter, which has been reproduced in the modern variable orifice meters. The calibrations of Miller *et al* showed that meters overread by 40–80 l/min in the mid range and underread by 30–80 l/min in the high range. This results in systematic bias in the calculation of diurnal variation and percentage change. The importance of this non-linearity depends on the range over which variation is seen. Most meters are at their most accurate around 100 and 600 l/min. The overreading, which peaks at around 300 l/min, will increase calculated diurnal variation in those in the 100–300 l/min range. This may explain some of the increased diurnal variation in children and patients with non-asthmatic chronic airflow obstruction. The underreading, which is maximal at the top of the scale, will tend to reduce the diurnal variation in the 600–800 l/min range. This may explain some of the low diurnal variation seen in workers who have other features of occupational asthma. The non-linearity is large and clinically relevant. At the recent summer meeting of the British Thoracic Society (see October issue of *Thorax*) several authors presented the effects of linearising peak flow measurements by using correction factors from the calibrations of Miller *et al*. In a group of asthmatic patients diurnal variation changed by more than 5% on 110 of 280 days, and by more than 10% on 32 of 280 days (Miles *et al*, p 891); in a group with suspected occupational asthma mean diurnal variation increased by 4%, 25 of 274 records changing from below 20% to 20% or more (Gannon *et al*, p 891); and in a group of 103 patients with chronic obstructive airways disease the mean peak flow fell from 211 to 155 l/min (Weir *et al*, p 865).

Not all agree with using mechanically driven syringes to calibrate flow measurement devices. Possibly the meter itself, and its resistance in particular, alters the actual peak flow, and this may not be the same when a mechanical device is used. Miller *et al* provide reasonable evidence that this is if anything a minor problem. I believe that the evidence is now sufficient for us to act. All our peak flow meters should be calibrated and should be linear (this requires only a change in the printing of the scale). A commercial calibration device should be produced and installed in lung function laboratories so that we can have as much confidence in our measures of flow as we do in those of volume. So far the innovation of the equipment manufacturers has led the clinicians; the reverse should now be true.

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