Original Articles

Lung function measurement in general practice: a comparison of the Escort spirometer with the Micromed turbine spirometer and the mini-Wright peak flow meter

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It is important that new types of spirometer for widespread clinical use are pragmatically evaluated in primary care. This study compared measurements taken by a new portable Fleisch pneumotachograph spirometer (known as the Escort) with those of the commonly used mini-Wright peak flow meter and the Micromed Pocket turbine spirometer. A pragmatic study was conducted in two phases during routine surgeries at Aldermoor Health Centre, Southampton. Phase 1 compared the new spirometer with the mini-Wright peak flow meter and Phase 2 compared the new spirometer and the turbine spirometer. One hundred patients aged 5-88 years (56 patients with a history of chronic respiratory complaints and 44 patients without) entered Phase 1, and 100 patients aged 6-82 years (62 patients with a history of chronic respiratory complaints and 38 patients without) entered Phase 2. Each patient contributed only once to each phase, but some entered both phases on separate occasions. Ninety-five percent limits of agreement (mean ± 2 std) were wide for all comparisons. Graphical plots revealed trends towards higher Escort values as mean values rose compared with both mini-Wright and turbine readings for peak expiratory flow rate and forced expiratory volume in one second. Possible over-reading of peak expiratory flow rate with the mini-Wright meter at low mean values was also seen. Readings taken with these different types of meter cannot be interchanged with confidence in clinical practice. The clinical significance of the theoretically more accurate measures of lung function produced with the new meter, and indeed of spirometry itself, needs further investigation.

Introduction

After a long campaign conducted by a number of different agencies, the placing of mini peak flow meters onto the Drug Tariff in the U.K. in September 1990 was heralded as a major advance in the management of asthma within general practice. Since there is evidence that up to 90% of patients with asthma are managed entirely within this sector of health care (1,2), it could thus be hoped that major alterations in morbidity might follow and the rise in prescribing expenditure incurred by the provision of meters in primary care easily justifiable. Indeed, self-management plans based on home peak flow monitoring have been shown to be beneficial in a small uncontrolled study in a hospital outpatient department (3), and at least as useful as a symptom-based plan in general practice (4). However, more recent evidence has not confirmed these benefits (5).

Peak flow measurement has become commonplace in general practice whereas the use of spirometry, much used in hospital-based chest medicine, is much more sporadic and not well standardized. Comparisons of peak flow measured on different types of instruments have demonstrated that readings cannot be directly equated (6-11), making the whole issue of the role of spirometers in general practice problematic. Some evidence suggests that the additional measurement of forced expiratory volume in 1 s (FEV,1) makes little difference to therapeutic decision-making in a primary care based asthma clinic (12).

The specified required accuracy of peak flow meters placed on the Drug Tariff is ±10% of the value generated on the original dial-type Wright spirometer.
meter (13), but American standards for spirometry (which do not mention peak flows) insist on \( \pm 5\% \) of true laboratory values (14). Subsequent American guidance on peak flow meters require \( \pm 10\% \) accuracy and \( \pm 5\% \) reproducibility (15). Recent evidence comparing a whole range of spirometers and peak flow meters against laboratory-generated known peak flow rates has shown major discrepancies will all prescribable meters in their adult versions and in most of the low range versions (16). In particular, the mini-Wright peak flow meter, which is likely to be the most commonly used instrument in general practice, was shown to over-read at lower true values and under-read at high values. The same effect was demonstrated, though less severely, with the dial-type Wright on which British standards are currently based. Only peak flow measurements derived from a pneumotachograph fulfilled the American criteria for accuracy across the whole range of likely peak flow values.

The clinical effectiveness of using mini peak flow meters, especially at home where good technique and compliance may be questionable (17,18) has thus been called into question and alternative methods of ascertaining accurate peak flow records need to be considered. A new, hand-held, portable spirometer known as the Escort which incorporates a Fleisch pneumotachograph is now being marketed by Vitalograph at a cost of around £500. This instrument is not only more likely to be accurate on theoretical grounds, but also can be easily calibrated in clinical practice and can be adjusted for temperature. It has been tested against a wedge-bellows spirometer and a dial-type Wright in a hospital setting and found to yield comparable results (19).

Therefore, the Escort spirometer has an acceptable performance both in the hospital and the laboratory. However, since so much asthma care takes place in general practice, where use of spirometers is likely to be sporadic and non-standardized, it is important to compare peak flow recordings in clinical use of the new meter with those of the mini-Wright peak flow meter, as the most commonly used prescribable peak flow meter, and other measures with the Micromed Pocket turbine spirometer, as the most commonly used type of spirometer in primary care (20), in order to assess the pragmatic use and usefulness of the new device in that setting.

Methods

The study was conducted in two phases between July and October 1992 at the urban shared-list general practice of approximately 8400 patients incorporated within our academic department. In the first phase, the best of three peak flow rate recordings using forced vital capacity (FVC) manoeuvres on one Escort spirometer was compared with the best of three peak flow rate recordings using peak flow manoeuvres on one previously unused mini-Wright peak flow meter. The type of expiration employed has been shown not to make a significant difference to recorded values (9). In the second phase, the better of two FVC manoeuvres on the Escort spirometer was compared with the better of two similar manoeuvres on a single turbine spirometer. In addition to peak expiratory flow rates, comparisons in this phase were also made of measurements of FEV\(_1\) and FVC. The difference in numbers of manoeuvres is explained by the need to avoid undue fatigue in some subjects, some of whom had severe airflow obstruction.

All patients aged 5 years and over with a past or present clinical history of asthma or chronic obstructive airways disease, and an approximate one in three other attendees at the routine surgeries of KJ were invited to undergo lung function testing in order to evaluate the new spirometer. All subjects were coached in the proper use of the lung function equipment by KJ and their measurements were recorded under his supervision. The order of use of the instruments being tested was randomized. Repeatability was assessed using a subset of 28 of the subjects in the first phase and using all of the subjects in the second phase according to the methods of Bland and Altman (21).

The new spirometer was calibrated at the start of each surgery session using a standard 11 syringe and corrected for temperature in the consulting room. The accuracy of the turbine spirometer (which cannot be calibrated in routine use) was also tested at the start of each session. Neither instrument was more than 5% out at any time.

Data were entered on an IBM compatible personal computer using Data Entry and analysed using the SPSS-PC+ (version 4.0) software package (22). Graphical comparisons between the two instruments were made using Harvard Graphics (23) according to the methods of Bland and Altman (21).

Results

Forty-eight males and 52 females, with a mean age of 36.7 years (SD 21.2 years, range 5–88 years), completed Phase 1 and 56 males and 44 females, with a mean age of 41.6 years (SD 20.8 years, range 6–82 years), completed Phase 2. There was no significant difference between the two phases in terms of either age (t=1.64, d.f.=198, P=0.10) or gender (χ\(^2\)=1.28, d.f.=2, P=0.26). There were 56 subjects with a
history of chronic respiratory complaints and 44 patients without in Phase 1; the corresponding figures for Phase 2 were 62 and 38, respectively.

The mean differences between the instruments (Escort-mini-Wright/turbine), together with the 95% limits of agreement (plus or minus twice the SD of the differences) and the coefficients of repeatability (twice the SD of the repeatability data) are shown in Table 1. Figure 1 shows the ‘line of equality’ plots for each of these four comparisons and Fig. 2 shows the ‘Bland and Altman’ difference vs. mean plots for each comparison. The 95% limits of agreement are seen to be wide for all comparisons, but not significantly greater than the coefficients of repeatability. With the comparison between the peak expiratory flow readings on the Escort and the mini-Wright peak flow meter, there is an apparent tendency for the mini-Wright to exceed the Escort at values below 400 l min⁻¹ and an increasing trend for the opposite to be seen above 500 l min⁻¹. However, this relative bias is only marked at high values. With the comparison between the Escort and turbine spirometers, the bias in FEV₁ seems to increase with mean value but remains fairly small. The differences in FVC are negligible. The differences between the two spirometers for peak expiratory flow are more substantial, but appear to be consistent and thus could be adjusted for.

No trend is seen in the comparisons of FVC in Phase 2, but there is a trend towards higher Escort readings for both FEV₁ and peak expiratory flow rate as mean values rise. No significant effects were noted when order of use or temperature were examined.

Discussion

As with previous comparisons of different types of spirometer and peak flow meters (6-11,24,25), it is clear from our data that values gleaned from one type of machine cannot be compared with confidence with those from another. However, almost all the lack of agreement is due to lack of repeatability, a problem with all lung function measurements whatever the instrument, probably due to shortcomings in the users of the devices rather than to the devices themselves. Before Miller et al. (16) produced their data questioning the accuracy of portable peak flow meters (including the turbine spirometer), this would have led us to repeat our comment at the end of a previous exercise comparing the turbine and the mini-Wright (9) that ‘the mini-Wright is likely to remain the preferred instrument in general practice’.

General practitioners currently make frequent use of peak flow readings both indirectly, in nurse-run asthma clinics and in home diaries often for self-management (2,26), and directly in routine consultations. Different types of peak flow meter may be used on separate occasions and, even with different samples of the same type of meter, reproducibility of results is far from guaranteed. This use of peak flow readings is likely to result in therapeutic decisions which could be rendered questionable by the inaccuracies of the instruments on which they rely. For instance, a patient with a mini-Wright best ever peak flow rate of 600 l min⁻¹ might produce a mini-Wright reading of 380 l min⁻¹ during an attack, when their true reading was only 300 l min⁻¹. An inappropriate decision to withhold oral steroids could result from the higher erroneous figure. It is possible, therefore, that better and thus safer management could arise from the use of more reliable equipment.

The new Escort spirometer is portable, easily charged, and very easy to use with patients of all ages above 4 years. Its facility for automatically recording the best values from a series was certainly convenient.

<table>
<thead>
<tr>
<th>Instrument compared with Escort</th>
<th>Measurements compared</th>
<th>Mean difference</th>
<th>Standard deviation</th>
<th>95% limits of agreement</th>
<th>Coefficient of repeatability</th>
</tr>
</thead>
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<tr>
<td>Mini-Wright</td>
<td>PEFR</td>
<td>-8 l min⁻¹</td>
<td>58 l min⁻¹</td>
<td>-108-+124 l min⁻¹</td>
<td>Escort: 95 l min⁻¹; Mini-Wright: 89 l min⁻¹</td>
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<tr>
<td>Turbine</td>
<td>PEFR</td>
<td>66 l min⁻¹</td>
<td>45 l min⁻¹</td>
<td>-24-+156 l min⁻¹</td>
<td>Escort: 113 l min⁻¹; Turbine: 66 l min⁻¹</td>
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<td></td>
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<td>Escort: 0.46 l; Turbine: 0.37 l</td>
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<tr>
<td>Turbine</td>
<td>FEV₁</td>
<td>0.21 l</td>
<td>0.19 l</td>
<td>-0.17-+0.59 l</td>
<td>Escort: 0.69 l; Turbine: 0.48 l</td>
</tr>
<tr>
<td>Turbine</td>
<td>FVC</td>
<td>0.04 l</td>
<td>0.33 l</td>
<td>-0.62-+0.70 l</td>
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</tbody>
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PEFR, peak expiratory flow rate; FEV₁, forced expiratory volume in 1 s; FVC, forced vital capacity.
Fig. 1 Line of equality plots for: (a) forced vital capacity, Micromed turbine spirometer vs. Escort spirometer; (b) forced expiratory volume in 1 s, turbine vs. Escort; (c) peak expiratory flow rate, turbine vs. Escort; (d) peak expiratory flow rate, Escort vs. mini-Wright peak flow meter.

for the clinician. Moreover, its use of the pneumotachograph makes it likely to be acceptably accurate [i.e. within American standards (15)], which the current mini meters and turbine appear not to be (16). The under-reading of the turbine at high flows shown by both Miller et al. (16) and suggested by our own data could be due to the inertia of the turbine vane and/or to high resistance to flow through the turbine swirl vanes. The Escort has no moving parts, samples pressures 100 times s⁻¹ and is well within American recommendations for back pressure. It does, however, need frequent re-calibration and adjustment for temperature. The theoretical advantages of the Escort are not clinically evident from our data since this instrument had higher coefficients of repeatability than both the other meters.

Which lung function parameters and which machine(s) are best for general practice? Firstly, what is the case for spirometry? As well as the recent questioning of the accuracy of mini peak flow meters, there are theoretical reasons why the measurement of FEV₁ is better at reflecting changes in small airway function than peak expiratory flow estimation (28). Measurement of FVC and the ratio of FEV¹/FVC may also allow other diseases as well as asthma to
Fig. 2 Bland and Altman difference vs mean plots for: (a) forced vital capacity, micromed turbine spirometer and Escort spirometer; (b) forced expiratory volume in 1 s, turbine and Escort; (c) peak expiratory flow rate, turbine and Escort; (d) peak expiratory flow rate, mini-Wright peak flow meter and Escort.
be diagnosed. Ratios showing normal, obstructive, restrictive, or mixed patterns may help in referral decisions.

American guidelines for the diagnosis and management of asthma state that 'all patients suspected of having asthma should have office spirometry performed, at minimum, for initial assessment. Most physicians' offices can successfully use an office spirometer...'. In addition, significant research from the Netherlands concerning declining lung function in patients with asthma and chronic obstructive lung disease on differing therapeutic regimes might not have shown such clear results without the recording of these spirometric variables.

Secondly, what is the case for peak flow measurement alone? The American guidelines reflect a longstanding U.S. preference for the measurement of FEV₁ which is not echoed so strongly in the U.K. The latest U.K. asthma management guidelines make no mention of spirometry rather than peak flow measurement even in the section on areas of uncertainty.

In practical use, Dekker et al. have found changes in peak expiratory flow to be sufficiently accurate for predicting changes in FEV₁. Peak flow meters are widely available by prescription to patients and thus their clinicians in U.K. primary care, but access to formal spirometry in general practice is sporadic and not centrally resourced. There is clearly room for further evaluation and discussion in this area. One aspect of this debate must be to examine the relevance of other spirometric variables in primary care. Some evidence suggests that general practitioners are making measurements of such variables, but their indications are not sufficiently well defined and their relevance for therapeutic decision-making in doubt.

There is thus a doubt about the accuracy of the commonly used mini peak flow meters, but also some debate concerning when and whether formal spirometry should be performed in the care of patients with respiratory complaints. Resolving the issue of the usefulness of spirometry vs. simple peak flow measurement in general practice needs to be part of the standard setting in asthma care requested by the U.K. government in its White Paper 'The Health of the Nation' (32), since the resource implications are considerable. The inaccuracies of mini peak flow meters could be fairly easily rectified by re-calibration and re-scaling, but this would necessitate the extensive exercise of providing new scales for or replacing many hundreds of thousands of meters. This process is being delayed by lack of worldwide agreement on scale standards. The cost-effectiveness and proper role of spirometers and spirometry in primary care should be delineated while agreement is being sought. The acceptability of doctors, nurses and patients of a range of devices for measuring lung function in general practice also needs to be investigated so that an informed choice of equipment can be made.

In conclusion, the Escort spirometer is a welcome addition to the range of portable instruments available for potential use in primary care, but does not appear to offer larger clinical benefits over other devices. Consistency of device, likely to be provided in prescribable peak flow meters, remains more important.

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References


