Accuracy of mini peak flow meters in indicating changes in lung function in children with asthma

Peter D Sly, Patricia Cahill, Karen Willet, Paul Burton

Abstract

Objective—To assess whether mini flow meters used to measure peak expiratory flow can track changes in lung function and indicate clinically important changes.

Design—Comparison of measurements with a spirometer and different brands of mini flow meter; the meters were allocated to subjects haphazardly.

Subjects—12 boys with asthma aged 11 to 17 attending boarding school.

Main outcome measures—Peak expiratory flow measured twice daily for three months with a spirometer and at least one of four brands of mini flow meter.

Results—The relation between changes in lung function measured with the spirometer and those measured with the mini flow meters was generally poor. In all, 26 episodes (range 1-3 in an individual child) of clinically important deterioration in lung function were detected from the records obtained with the spirometer. One mini flow meter detected six of 19 episodes, one detected six of 15, one detected six of 18, and one detected three of 21.

Conclusions—Not only are the absolute values of peak expiratory flow obtained with mini flow meters inaccurate but the clinical message may also be incorrect. These findings do not imply that home monitoring of peak expiratory flow has no place in the management of childhood asthma but that the values obtained should be interpreted cautiously.

Introduction

Monitoring of peak expiratory flow is an integral part of the management of asthma. Plans for managing asthma are used in many countries and include regular monitoring of peak expiratory flow to indicate when patients should increase their drug treatment.^{1,2} This approach has been adopted because many patients with asthma, especially children, are not able to perceive their degree of airway obstruction adequately.³ An objective measure of the severity of asthma should allow more effective management of asthma with a reduction in both mortality and morbidity.

Studies with explosive decompression devices and computer controlled pumps have clearly shown that the mini flow meters used for monitoring peak expiratory flow are inaccurate and substantially overestimate flow in the range of 200-400 l/min.⁴ This range is commonly encountered in paediatric practice. The inaccuracy may be due to non-linear characteristics of the critical orifice in the meter (O F Pederson, personal communication). When we measured peak expiratory flow in subjects aged 6 to 19 with a mini flow meter and compared the results with those obtained with a spirometer we found a pattern of errors similar to that found by Miller *et al.*⁵ In theory, the scale on the flow meter can be adjusted to correct these inaccuracies.^{4,6}

Inaccurate absolute values of peak expiratory flow may not matter if the recordings track changes in lung function. The potential value of monitoring peak expiratory flow is that it allows such changes to be detected early so that treatment can be increased to

abort exacerbations of asthma. If the peak expiratory flow recorded with a mini flow meter is an overestimate of the true value the estimated variability may differ from the true variability. This may not matter, however, if the correct clinical message is evident. We investigated whether monitoring peak expiratory flow with mini flow meters adequately reflected clinically important changes in lung function.

Methods

Twelve boys with asthma aged 11 to 17 at a boarding school measured their peak expiratory flow twice daily, before using a bronchodilator, for three months. On each occasion they measured their peak expiratory flow with a Welch-Allyn spirometer and at least one of four brands of mini flow meter (the mini-Wright, Ferraris, Vitalograph, and Breath-Taker (a local copy of the mini-Wright)). They had all been using a mini-Wright meter regularly before the study. The measurements were supervised by one of the school's trained nurses, and the boys used a standardised technique: they were instructed to inhale maximally and exhale maximally while standing up, not using a nose clip. They repeated this procedure three times with each device, and the highest measurement was recorded.

All peak flow meters were new at the beginning of the study, and each boy was given one of each brand of meter, which he used throughout the study. The boys did not know the values of peak expiratory flow recorded at previous sessions. To disguise the flow values the spirometer displayed them as litres per second.

We recorded the peak expiratory flow on a chart for each mini flow meter and each boy. We included data on a chart only if the boy had used both the spirometer and the mini flow meter on the same occasion. The records on the charts omitted gaps in data that arose when only a mini flow meter or the spirometer was used. We inspected each completed chart to determine how closely the pattern of peak expiratory flow recorded with each mini flow meter matched the pattern recorded with the spirometer. Each chart was reviewed separately by a paediatrician who was not participating in the study and did not know which device had been used or which child had produced the record (data recorded with a mini flow meter were not on the same chart as data recorded with the spirometer). From visual inspection of the chart the paediatrician identified important episodes, basing his decision on clinical judgment rather than on any statistical criteria. This method was intended to mimic clinical practice. In all comparisons we used the peak expiratory flow recorded on the spirometer as the gold standard. A record for a mini flow meter was deemed to match the record for the spirometer if the clinically important event on the record for the mini flow meter occurred within two data points (namely, within 24 hours) of that on the record for the spirometer.

Results

Measurements obtained with a mini flow meter that could be compared with measurements obtained with

Division of Clinical Sciences, Western Australia Research Institute for Child Health, PO Box D184, Perth 6001, Australia
Peter D Sly, head
Karen Willet, research assistant
Paul Burton, biostatistician

Christ Church Grammar School Medical Centre, Perth, Australia
Patricia Cahill, matron

Correspondence to: Dr Sly.

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FIG 1—Recordings of peak expiratory flow obtained with spirometer (solid line) and mini-Wright mini flow meter (dotted line) in 12 boys

the spirometer totalled 629 for the mini-Wright, 359 for the Ferraris, 511 for the Vitalograph, and 600 for the Breath-Taker. All meters were available for use throughout the three months, and no bias in the pattern of use of any particular brand was evident. We compared the mean values of peak expiratory flow obtained by each boy with the different types of mini flow meter with the mean values recorded with the spirometer over the same period: the mean values obtained with each of the mini flow meters were generally higher. Furthermore, the mean values

Mean peak expiratory flow (l/min) measured in 12 boys with four mini flow meters twice daily for three months compared with that measured with spirometer at same time

Subject	Mini-Wright		Ferraris		Vitalograph		Breath-Taker	
	Mean	Spirometer mean	Mean	Spirometer mean	Mean	Spirometer mean	Mean	Spirometer mean
1	525	437	547	403	438	438	498	428
2	351	312	360	310	326	320	352	314
3	345	269	355	270	315	268	324	267
4	406	352	447	347	412	353	401	353
5	252	307	310	246	296	251	310	251
6	489	391		706	393	467	392	
7	382	323	388	324	346	333	355	324
8	543	563	626	578	503	563	525	563
9	447	285	521	316	704	315	473	317
10	417	332	443	332			414	340
11	627	396			619	396	624	396
12	474	422	498	415	465	423	457	418

obtained for an individual boy differed substantially with the different mini flow meters (table).

In general, the relation between changes in lung function shown by the spirometer and those shown by the mini flow meters was poor. In all boys we detected in the records for the spirometer at least one episode of clinically important deterioration in lung function over the three months (individual range one to three episodes). None of the mini flow meters detected all such episodes: the mini-Wright detected six of 19, the Ferraris six of 15, the Vitalograph six of 18, and the Breath-Taker three of 21. The six episodes that were detected by the mini-Wright, Ferraris, and Vitalograph by the meters were not all the same episodes. In addition, all the mini flow meters showed false positive reductions in peak expiratory flow (reductions in lung function that were judged to be clinically important but were not indicated by the spirometer). The mini-Wright meter showed 10 false positive episodes, the Ferraris nine, the Vitalograph four, and the Breath-Taker 12.

The peak expiratory flow measured with the mini-Wright meter was on average closest to that measured by the spirometer. Figure 1 shows the records for each boy for the mini-Wright meter; close examination of the individual records showed several clinically important patterns. Figure 2 shows selected individual traces to highlight these patterns. Trace A is from a boy with mild asthma. Although the mean peak expiratory flow recorded with the mini flow meter (Ferraris) was generally higher than that recorded with the spirometer, the only important reduction in lung function was accurately captured by the mini flow meter. Trace B is from a boy with moderately severe asthma. Initially the peak expiratory flow recorded with the mini flow meter (mini-Wright) matched reasonably closely that recorded with the spirometer. The boy then experienced an episode of asthma, from which his lung function recovered, followed by another, from which his lung function did not recover. The mini flow meter missed these two episodes. Trace C shows that the mini flow meter (Vitalograph) indicated a reduction in peak expiratory flow but that the spirometer did not. The mini flow meter could be considered to have shown a false positive reduction in lung function. Finally, trace D shows no relation between the peak expiratory flow recorded with the mini flow meter (Vitalograph) and that recorded with

FIG 2—Selected data showing clinically important patterns of measurements of peak expiratory flow obtained with spirometer (solid line) and mini flow meter (dotted line) (see text (results) for details)

Clinical implications

- Studies have shown that mini peak flow meters used in the management of asthma can give inaccurate absolute values
- These inaccuracies may not matter if the values track changes in lung function
- This study examined whether mini flow meters can identify clinically important changes in peak expiratory flow in children with asthma
- Less than half of the important reductions in lung function detected by a spirometer were detected by four different mini flow meters
- Accurate tracking of lung function in children with asthma may not be possible with mini peak flow meters

the spirometer. The values recorded with this mini flow meter were almost certainly a result of the boy producing an explosive decompression of the gas in his upper airway with his tongue (the "spitting" manoeuvre).

Discussion

The results of this study suggest not only that the absolute values of peak expiratory flow obtained with mini flow meters are inaccurate but that the clinical message may also be incorrect. The worldwide trend to use management plans for asthma has led to the suggestion that most people with asthma requiring maintenance treatment should monitor their peak expiratory flow twice a day and judge their drug dosages accordingly. Our results suggest, however, that this approach may not always be appropriate for children. Paediatric respiratory physicians in Australia and New Zealand have been cautious in recommending routine monitoring of peak expiratory flow, suggesting that the patients most likely to benefit are those with persistent asthma and those who require continuous treatment with inhaled steroids.⁷ Perhaps this conservative approach is more rational.

LACK OF SKILL MAY AFFECT ACCURACY

Under conditions of standard clinical practice a child uses only one mini flow meter for many months and therefore becomes expert in using that meter. This skill could result in a reduction in the random variability of individual measurements with that meter. Because the children in our study had to use several different meters they may have lost, or not increased, their skill, and this may have led to greater random variability. Any reduction in skill, however, is unlikely to account wholly for a clinical performance as poor as that observed in the present study. Also, even the mini-Wright meter, which all the boys were experienced in using, gave misleading clinical messages at times.

GAPS IN DATA UNLIKELY TO HAVE INFLUENCED FINDINGS

The removal of the gaps in our data when we compiled the record charts is unlikely to have distorted the interpretation of the data. Almost all the gaps arose when children returned home from school because of a school holiday or a weekend visit. These gaps may reasonably be viewed as having occurred at random and should not therefore have distorted the analysis. Furthermore, any significant change in the recording obtained with the spirometer that was not reflected in the recordings obtained with the mini meter (or vice versa) over a series of measurements not spanning a gap must indicate an important difference in the clinical message given by the results of these two measuring methods. Moreover, most of the important changes observed did not span gaps. We asked the paediatrician who had identified important changes in lung function in the main charts to re-examine some of the charts but with the gaps left in; his conclusions were the same.

TESTING IN THE COMMUNITY

Most mini flow meters are used in the community rather than in a laboratory, where most tests have previously been conducted. We found that the meters performed remarkably poorly in the community: many of the results were either meaningless or misleading and therefore potentially dangerous. Although the meters were chosen in a formally haphazard way rather than randomly, the way they were chosen is not likely to have introduced any important bias to the results. We accept that this poor performance of the meters may reflect some deficiency in clinical practice in Western Australia. As far as we are aware, however, our clinical practice is similar to that elsewhere in the world; moreover, as the boys in our study measured their peak expiratory flow under the supervision of a trained school nurse the meters might be expected to have produced more accurate results than they would among the general population of children with asthma. We do not believe that there is any deficiency in the fundamentally simple design of our study that could explain why important changes in peak expiratory flow measured with a spirometer were so unrelated to those measured with several mini flow meters.

TECHNIQUE IS IMPORTANT

Despite the shortcomings of our study some important messages about monitoring peak expiratory flow emerge. Measurements of peak expiratory flow in an asthmatic child are likely to differ depending on the brand of mini flow meter used. The same is probably true for different meters of the same brand. Thus children using a mini flow meter should have a personal meter. Furthermore, they should be encouraged to take their own meter with them when visiting their doctor. In a consultation with a doctor lung function is best measured with a spirometer, but if it is measured with a mini flow meter the patient should use the meter that he or she normally uses. Also, doctors should check the technique used by patients; substantial discrepancies between the values of peak expiratory flow measured at home and in the surgery with the same meter should alert the doctor to poor techniques. The spitting manoeuvre is more likely to occur with mini flow meters that have a mouth piece with a small diameter; the technique used by patients with these meters should be carefully checked. Finally, as all mini flow meters used in this study were new at the beginning the effects of "use and abuse" of mini flow meters in clinical practice were not addressed. Any effects, however, are likely to decrease the accuracy of the instruments.

In conclusion, mini flow meters for measuring peak expiratory flow may produce clinically misleading results when used by children in the community. These meters should be investigated further: if the poor results obtained in the present study are replicated in other studies the precise role of mini flow meters in the routine management of childhood asthma should be reviewed.

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