The Mini-Wright Peak Flow Meter for Evaluating Airway Obstruction in a Family Practice

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This work reports an investigation of the usefulness of the Mini-Wright Peak Flow Meter in a family practice. The Mini-Wright Peak Flow Meter, an economical and simple tool for measuring peak expiratory flow rate, was developed in Great Britain but has found little clinical application in the United States. Its employment in quantifying airway obstruction and accurately reflecting changing patterns of obstruction over time is described. Recurrent patterns of airway obstruction in asthmatic patients are discussed. These patterns are used to individualize drug treatment regimens.

The Mini-Wright Peak Flow Meter is portable and can easily be used in an office setting or lent to patients for home use. Some patients may benefit by purchasing the meter themselves and self-adjusting the time and dose of their medication based on objective measurements of airway obstruction.

Although asthma has been recognized as a disease since ancient times, its treatment continues to evolve. In the second century AD, Aretaeus described persons suffering from it as experiencing "... heaviness of the chest; sluggishness to one's accustomed work, and to every other exertion; difficulty of breathing and running; they are hoarse and troubled with cough ... and as the symptoms increase, they sometimes produce suffocation."[1] Later, with the advent of the stethoscope, auscultated wheezing was accepted as an important sign of the asthmatic syndrome. More recently, the advent of pulmonary testing has refined the definition of asthma on a physiologic basis. The ability to measure airway obstruction has resulted in the definition of asthma as "hyperactive airway disease" or as a disease of "reversible airway obstruction."[1,2] The evolution of the definition of asthma reflects a growing understanding of its pathophysiology and of improving therapeutic capabilities.

In a review of current classifications of asthma, Turner-Warwick[3] discussed the value of subdivid-

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Figure 1. Patient using Mini-Wright Meter. She is instructed to blow as hard and as fast as she can

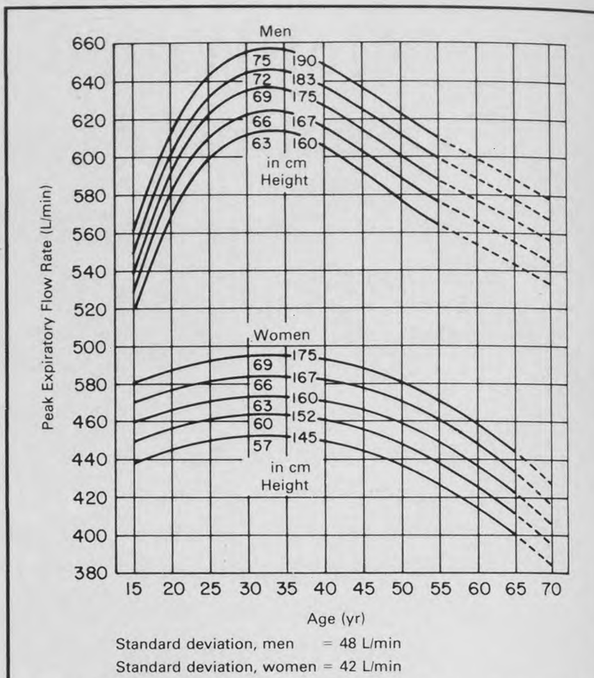

Figure 3. Normal values of PEFR for men and women by height and age.[10] (Courtesy Armstrong Industries, Inc, Northbrook, Illinois)

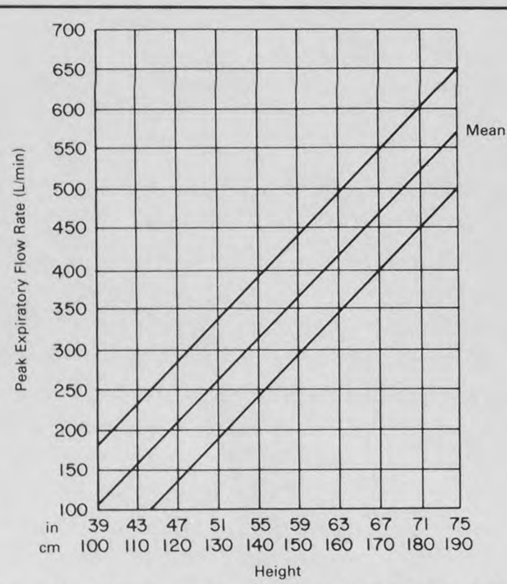

Figure 2. Nomogram of normal children (boys and girls) aged 5 to 18 years. (Reprinted, by permission of the *British Journal of Diseases of the Chest,* from Godfrey et al[9])

ing patients on the basis of host responsiveness. Using measurements of peak expiratory flow rate (PEFR), she was able to demonstrate the recurrence of three predictable patterns of airway obstruction in some asthmatic patients: "brittle asthmatic," "morning dipper," and "irreversible asthmatic." She suggests that the measurement of PEFR to detect these patterns can be used to individualize the timing and dose of bronchodilator medications to the needs of individual patients.

The present study is a description of several uses of the Mini-Wright Peak Flow Meter, a portable, inexpensive instrument that measures PEFR. It has a 98 percent correlation with the highly accurate, but more expensive, Wright Peak Flow Meter, which is a standard instrument of PEFR measurement.[4] This instrument has found limited use in the United States as a clinical and research tool, although it is widely used in Great Britain.[3-7] Several case histories describe the introduction of this instrument into the care of ambulatory asthmatic patients in a family practice setting, exemplifying its use in diagnosing occult asthma and evaluating therapeutic regimens.

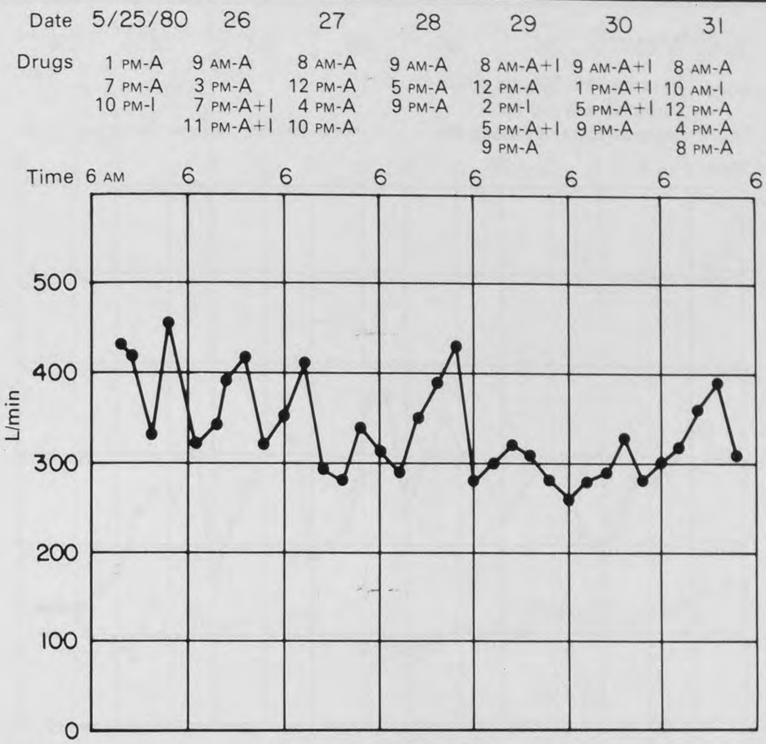

Figure 4. Brittle pattern: Home PEFR recordings of 30-year-old woman with "brittle" asthma since the teenage years on aminophyllin (A) and an isoproteronol (I) inhaler. It is notable that during the last three days charted here she was ill, with symptoms of fever and cough

Methods

The Mini-Wright Peak Flow Meter* was introduced in February 1979 (Figure 1). The device is a simple spring-loaded piston that is calibrated to record a single measurement of peak expiratory flow rate in liters per minute. After taking a deep breath, the patient is instructed to exhale the "biggest, fastest huff you can achieve." The patient makes two such measurements, and the higher flow rate is recorded as the PEFR for that occasion.

PEFR is defined as the maximum or peak expiratory flow rate during a forced expiration.[3] Figures 2 and 3 display the norms for PEFR adjusted for age, sex, height, and weight available in the current literature.[8-10] Age- and sex-associated norms are available for adults and children, although those for children have not been verified in a large normal population.

*Armstrong Industries, Inc, PO Box 7, 3660 Commercial Avenue, Northbrook, IL 60062 (approximate price, $68)

The study practice site is located in a rural California town having a population of 7,000. No pulmonary function testing is available in the town, but a community hospital eight miles away has complete pulmonary function testing, including diffusion studies, at a cost of $122. The charge is $5 for a single PEFR measurement and $25 for one week's rental. Single measurements are performed in the office an average of six times per week. Extended home recordings of PEFR by patients (every six hours for a week) are obtained on an average of once a month. Patients are selected for extended home recordings when the presence or reversibility of airway obstruction is uncertain.

Results

Examples of home PEFR recordings are presented in Figures 4 through 7. The absence of any

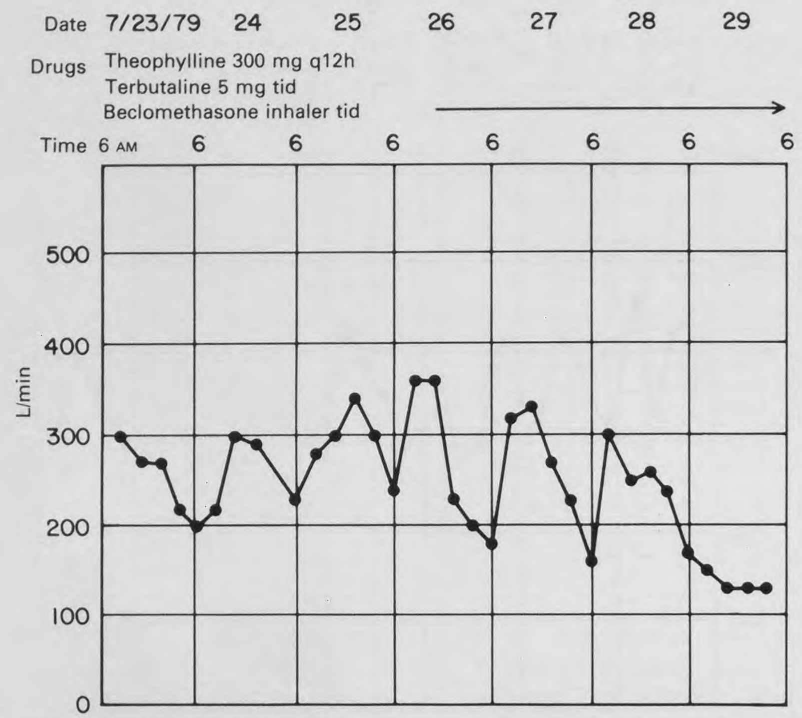

Figure 5. Morning dipper pattern: Home PEFR recordings of 35-year-old woman whose first known episode of airway obstruction, which resulted in hospitalization for respiratory failure, occurred two months prior to the tracing. Since discharge, she has been stabilized on theophylline (Theo-Dur) in a twice-a-day dosage, oral terbutaline, and beclomethasone inhaler. The pattern of early morning airway obstruction, "morning dipper," was ameliorated by doubling her bedtime dose of theophylline

regular pattern in Figure 4 demonstrates the "brittle asthmatic," as described by Turner-Warwick. Frequent extreme variations of PEFR are characteristic of this type of patient. The extreme variability and randomness of the measurements are reminiscent of blood glucose records of "brittle" diabetics.

Figure 5 demonstrates a "morning dipper" pattern, which is the most common pattern of airway obstruction seen in this practice. The pattern characteristically shows the lowest PEFRs and greatest obstruction in the early morning, in this case occurring between 10:00 PM and 6:00 AM.

Figure 6 demonstrates an "irreversible" pattern of airway obstruction with minimal variability of PEFR.

Figure 7 demonstrates the use of the PEFR measurement to evaluate the need for chronic bronchodilator therapy. This child had been on slow-release theophylline (Theo-Dur) on a twice-a-day schedule for 12 months. Home PEFR measurements were obtained for five days while on theophylline and for five days following discontinuation of the medication. The patient's theophylline was discontinued and has since been used only during episodes of airway obstruction.

Discussion

Measurement of PEFR can be very helpful in both diagnosis and management of airway obstruction. In addition to the history and physical exam-

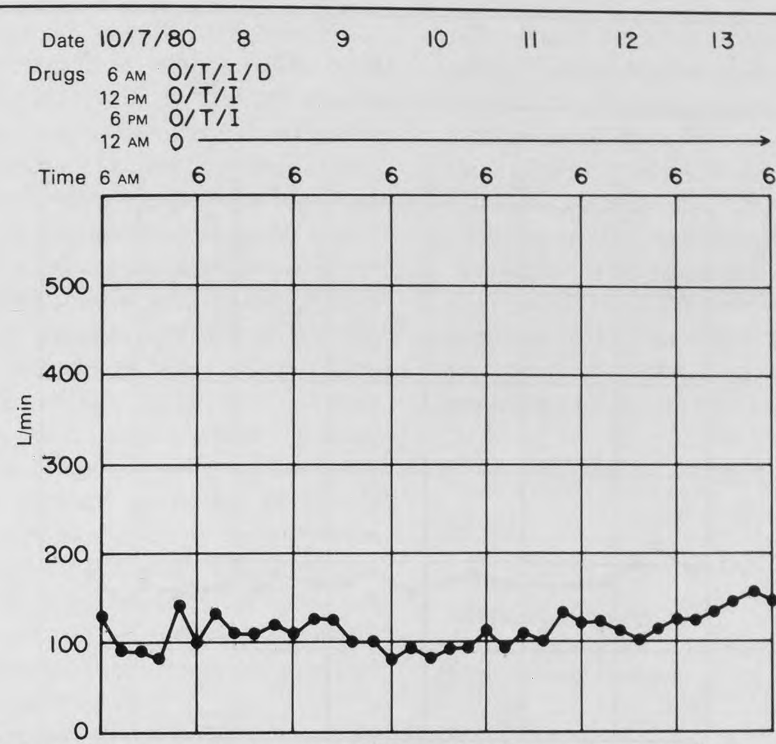

Figure 6. "Irreversible" pattern: Home PEFR recordings of 70-year-old man with end-stage chronic obstructive pulmonary disease. Without medication his peak expiratory flow was consistently less than 60 L/min. This graph demonstrates his PEFR on oxtriphylline (O), terbutaline (T), and isoetharine (I) by nebulizer and 20 mg of prednisone (P) each day. As can be seen, there is little improvement in the PEFR, although the patient was symptomatically improved on this regimen with 20 percent improvement in mean PEFR two months later, the pattern of obstruction remaining unchanged

ination, measurement of PEFR before and after bronchodilator therapy provides an objective measure of the reversibility of airway obstruction in the office or at the bedside when wheezing or respiratory distress is absent. Occult asthma is relatively common,[3,5,11,12] and PEFR measurement provides a firm basis for initiating a trial of bronchodilator therapy if it improves with such therapy in the office. Measurements of PEFR have been taken after a single dose of subcutaneous epinephrine (0.01 mL/kg up to 0.4 mL) for this purpose. Alternatively, a trial of therapy over several weeks with serial PEFR measurements may be used. An increase of 15 percent or more in the PEFR is interpreted as evidence that the airway obstruction is reversible. At times, a lesser degree of improvement is accepted as an indication for a longer trial of bronchodilator therapy if the patient improves symptomatically following administration of the bronchodilator. Once the diagnosis of asthma has been made, the initial PEFR values can be compared with subsequent PEFR measurements on medication to evaluate the effectiveness of therapy.

After the diagnosis is established, two major tasks of management in chronic asthma remain: (1) establishment of a therapeutic plan that meets the patient's individual needs, and (2) periodic reevaluation of this regimen. Classically, the therapeutic plan involves manipulation of the life environment to remove respiratory irritants and allergens and stepwise titration of pharmacological agents, including oral xanthines, sympathomimetics, cromolyn sodium, and steroids. In severe

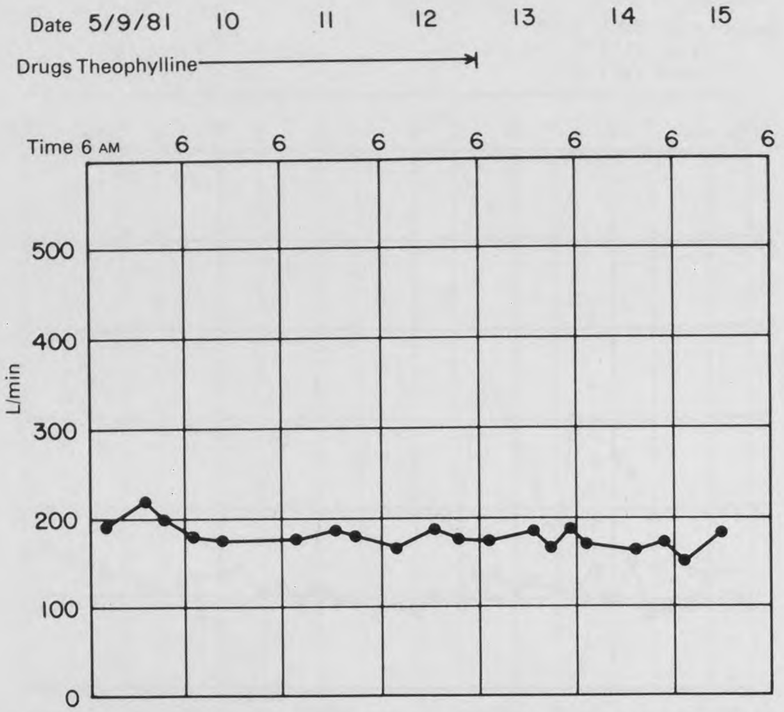

Figure 7. Reassessment of treatment regimen: Home PEFR recordings of seven-year-old girl with onset of cough as the only symptom of bronchospasm one year prior to this chart. Initially she required 5 mg/kg/d of theophylline (Theo-Dur) on a twice-a-day schedule tapered to a one-at-bedtime dose by the time of this measurement. After one year on therapy the need for bronchodilator medication was reassessed using home PEFR measurements. This chart demonstrates no difference between days on and off medication, and for this reason her medication was discontinued. She now uses it only for episodes of bronchospasm

cases home oxygen may be required. Education of patient and family as to the nature of the disease and its treatment is frequently helpful. Early attacks may be "nipped in the bud" by using self-treatment with home medications and prompt self-referral for medical care when an asthmatic episode becomes out of control. In each of these areas of management, the measurement of PEFR can be helpful.

Periodic re-evaluation of the patient labeled "asthmatic" will be necessary. In this re-evaluation two questions should be asked: (1) Is the patient truly asthmatic? and (2) If the patient is asthmatic, how and when should treatment be given? The first question requires data indicating that reversible airway obstruction was, and is still, present. These data are especially important for patients previously labeled asthmatic without the advantage of pulmonary function studies. Serial measurements of PEFR in the office or, better yet, every four to six hours at home can supply such data. In some cases airway obstruction that has not responded to therapy will be evident. In such treatment failures the diagnosis of asthma should be reconsidered. Some cases of reversible terminal airway obstruction may remain undetected by measurement of PEFR, requiring more sophisticated tests.[13,14] On the other hand, when some response to therapy is observed, further manipulation of therapeutic options can be undertaken with confidence that the diagnosis of reversible airway obstruction has been securely established.

The second management question is how and when to treat. To paraphrase Turner-Warwick,[6] asthmatic persons are not equally asthmatic all of the time. Airway obstruction may fluctuate over great and small time intervals. In addition to the diurnal patterns of airway obstruction reported by Turner-Warwick, it is well known that regular patterns of airway obstruction can occur in response to changes in weather conditions, seasons, travel from one region to another, participation in exercise, and occupational conditions.[1,11] Using PEFR measurements, both patients and physicians can learn to recognize patterns of airway responsiveness to the variables of host, time, and environment. For example, the "morning dipper" pattern may be reversed by using a long-acting bronchodilator at bedtime. Patients suspected of having seasonal asthma can be evaluated by measurement of PEFR both on and off medication. During seasons in which PEFR is unaffected by a change in medication, treatment can be decreased or eliminated with the knowledge that respiratory function is probably not compromised.

Medication dosages can also be titrated to achieve the highest possible PEFR with minimal side effects. Often patients themselves are unaware of mild reversible airway obstruction, and there are no physical signs to alert the physician to incompletely reversed bronchospasm.[4] However, using the Mini-Wright Peak Flow Meter to obtain maximal bronchodilation may result in an unexpected increase in exercise tolerance and sense of well-being. Finally the treatment modality can be adjusted or corrected using PEFR measurements. For example, long-acting theophylline preparations can be substituted for short-acting drugs if serial measurements of PEFRs indicate an inadequate duration of response to medication. In fact, measurement of PEFR has virtually replaced the use of serum theophylline levels in this practice. Measurement of physiologic airway response is usually adequate to evaluate effectiveness of treatment, unless the clinical setting suggests overdosage, in which case theophylline levels are obtained. Evaluation of the need for continuation of steroids can also be accomplished by comparing PEFR on optimal nonsteroidal therapy with that on corticosteroids.

An intriguing application for the Mini-Wright Peak Flow Meter now being tested is the continuous use of PEFR measurement for self-titration of asthmatic medication. This method might be equated with a diabetic's use of the insulin sliding scale based on urine testing. Guidelines for self-medication analogous to the diabetic sliding scale could be used by the patient to self-adjust the medication as needed. As in the diabetic, careful patient selection would be critical in such a program. However, many asthmatics already self-adjust their medication based upon subjective respiratory symptoms. For such patients, thorough knowledge of the use of medications and regular measurement of PEFR would allow both early home treatment of asthmatic episodes and objective guidelines as to when to consult a physician.

Acknowledgment

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