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CME CREDIT HOURS

A practical guide for peak expiratory flow monitoring in asthma patients

KEY POINTS:

As many as 15% of patients cannot perceive severe airflow obstruction, and studies show that physicians often misjudge the severity of asthma attacks.

Peak flow monitoring at home is indicated for patients older than 5 years with moderate to severe asthma, and gives physicians an objective assessment of airflow obstruction.

A reading of 50% or less of the patient's personal best peak flow reading indicates quick action is needed, while a reading of 50% to 80% indicates a potential problem.

Patient education is crucial and must include specific instructions on what to do in case of low peak flow readings.

ABSTRACT: The peak expiratory flow rate is an objective measure of airflow obstruction that patients can learn with little difficulty, and which provides physicians objective information for assessing a patient's condition. We outline how to use peak flow monitoring as part of an asthma treatment plan.

In assessing and treating asthma, the signs and symptoms are not enough: many patients and physicians alike underestimate the severity of airway obstruction. To obtain objective information, we advocate measuring the peak expiratory flow (PEF, or peak flow) rate. Our patients with moderate to severe asthma measure their peak flow at home using inexpensive, compact meters and record the readings in an asthma diary, which we review at follow-up visits.

WHY MEASURE PEAK FLOW?

Recent advances in understanding the pathogenesis of asthma have shifted the emphasis of treatment. Instead of controlling the symptoms of bronchospasm only with inhaled $beta_2$ agonists and methylxanthines, we also try to control the underlying chronic airway inflammation with inhaled anti-inflammatory agents.[1]

However, these advances have not translated into improved control in the general asthmatic population. Approximately 5% of adults and 10% of children in the United States have asthma, and its prevalence seems to be increasing, especially in children. From 1982 through 1991, the rate of death due to asthma increased by 62% in the United States.[2] Hospital admissions for asthma have increased in recent years. Possible reasons for these trends are inadequate access to health care, suboptimal maintenance pharmacotherapy, and delay in starting appropriate therapy because patients, relatives, and physicians fail to recognize the severity of an asthma attack.

TABLE 1

RATIONALE FOR PEAK EXPIRATORY FLOW MONITORING

At home

To detect worsening airflow obstruction early in patients, who may perceive symptoms poorly

To guide patients in taking medications

To improve asthma control

To reduce asthma-related morbidity

To improve perception of acute airflow obstruction

In the emergency department

To objectively assess the severity of asthma attacks

To assess response to therapy

To predict early the need for hospital admission

To identify need for arterial blood gas analysis

To predict relapse after discharge from the emergency department

In hospitalized patients

To assess therapeutic response

To document clinical improvement at discharge

In occupational asthma

To demonstrate airflow obstruction at the workplace

To identify asthma triggers

Patients' perceptions of symptoms are unreliable

The patient's own perceptions of chest tightness, cough, wheezing, and shortness of breath strongly influence the treatment he or she receives. When patients seek advice over the telephone, these perceptions are often the only kind of information available to the physician.

Unfortunately, these symptoms are unreliable. Numerous clinical and experimental studies show that many asthma patients cannot accurately evaluate the severity of airflow obstruction. As many as 15% of patients cannot perceive even severe airflow obstruction—a forced expiratory volume in 1 second (FEV_1) that is less than 50% of predicted.[3] No demographic or clinical feature can help the physician predict which patients will be "good perceivers" or "poor perceivers."

Clinical signs are also unreliable

Hyperinflation and wheezing that is high-pitched, loud, and biphasic are thought to be signs of severe airflow obstruction. However, several studies have shown that even experienced physicians often misjudge the severity of an asthma attack,[4,5] and data suggests that patients can gauge the severity of an attack better than their physicians can.[6]

Underestimating asthma severity leads to undertreatment

Physicians and patients need an objective measure of airflow obstruction to guide them in managing asthma attacks promptly, because underestimating the severity of airflow obstruction can delay appropriate therapy. Such delay may allow lung function to worsen progressively, predisposing patients to near-fatal asthma attacks and placing them at higher risk of asthma-related death.

Peak flow monitoring is practical

The peak flow rate is the most practical measure in outpatients,[7–9] as the monitoring devices are inexpensive (costing from $15 to $40), portable, and easy to use. Patients as young as 5 years can master the technique with minimum training and keep an accurate record.

Admittedly, the FEV_1 is more accurate, as it reflects changes in large and medium-sized airways, whereas the peak flow reading reflects changes in the large airways only. Peak flow readings correlate well with FEV_1 readings, but not uniformly. Therefore, a peak flow reading is not an adequate substitute for office spirometry. However, serial peak flow measurements are acceptable for monitoring lung function.

Studies have been equivocal

Studies that compared the outcomes of patients treated according to peak flow val-

ues vs symptoms have yielded conflicting results. The failure to show clear benefit of management based on peak flow readings compared with conventional management is very controversial, and may be the result of differences in "action points" used in the studies.

Most studies of outcomes used peak flow values of less than 70% of the patient's personal best as an initial indication to alter the treatment, or "action point." In a recent study, Gibson and colleagues[10] found a better peak flow-based action point: readings on 2 of 3 consecutive days that were between 2 and 3 standard deviations below the patient's mean value. This criterion was significantly more sensitive and specific than criteria based on a percentage of the patient's personal best reading and detected exacerbations several days sooner, at least in retrospect.

Nevertheless, we believe that peak flow monitoring has a sound and logical rationale (TABLE 1) and we will discuss our specific recommendations for action points in the section on practical recommendations, below.

On the basis of frequency of asthma symptoms, peak expiratory flow (expressed as a percentage of the patient's personal best score), and peak flow variability, asthma is classified as mild, moderate, and severe.

Patients with mild asthma do not need peak flow monitoring,[11–13] but patients with moderate to severe asthma appear to benefit,[13–15] because it facilitates close monitoring of lung function and may promote use of inhaled steroids and early institution of oral steroid therapy whenever appropriate.

In many randomized studies that compared peak flow-based management with conventional symptom-based treatment, the outcomes improved even in the control groups, probably because all patients in these studies received asthma education. These findings concur with those in previous studies of asthma education.[16–18]

Special uses of peak flow monitoring

In the emergency department. Patients frequently undergo peak flow monitoring during emergency care for acute asthma exacerbations. Objective monitoring of lung function leads to a change in treatment in up to 20% of patients with acute asthma exacerbations.[19] There is no evidence that the FEV_1, which requires more sophisticated and expensive equipment, has a greater clinical value than the peak flow reading. Studies showed that patients who needed hospital admission after receiving initial care in the emergency department had lower peak flow rates both at initial presentation and at the time of disposition from the emergency room.[20,21] Peak flow monitoring may reduce the need for arterial blood gas analysis in as many as 40% of patients receiving emergency therapy for asthma exacerbations.[22,23] Practice guidelines based on peak flow monitoring have been shown to reduce unnecessary hospital admissions.[24]

TABLE 2

INDICATIONS FOR PEAK EXPIRATORY FLOW MONITORING AT HOME

- Moderate to severe asthma
- Labile and poorly controlled symptoms
- Increasing need for rescue $beta_2$ agonists
- Repeated need for oral prednisone therapy
- Frequent emergency visits for asthma exacerbations
- Recent hospital admission for asthma
- Near-fatal asthma attack
- Poor perception of asthma symptoms

The National Asthma Education and Prevention Program recommends peak flow monitoring for all patients with acute asthma exacerbation and suggests that the peak flow value should be at least 70% of the predicted value at the time of discharge from the emergency department.[25] Unfortunately, many physicians do not measure the peak flow rate in this situation. Also, patients do not typically receive clear instructions about peak flow monitoring before discharge.[26]

Measure the peak flow rate before and 10 to 15 minutes after giving a $beta_2$ agonist

In these patients, the peak flow should be measured before starting therapy and frequently thereafter. Measuring the peak flow before and 10 to 15 minutes after giving a $beta_2$ agonist provides a fair assessment of how well bronchospasm responds to inhaled bronchodilators in the short term. In addition, the peak flow should be measured at the time of discharge from the emergency department, to document that airflow has improved.

In hospitalized patients. Peak flow monitoring is performed in 15% to 80% of patients admitted to the hospital with acute asthma exacerbations.[26–28] How physicians use the information is unclear. Pulmonary physicians follow the peak flow rate more often than do internists in hospitalized asthma patients.[29] Whether monitoring the peak flow rate improves the outcome in hospitalized patients is unknown.

PRACTICAL RECOMMENDATIONS FOR HOME PEAK FLOW MONITORING

Successful asthma treatment requires that patients participate actively in their care. The essential components of a well-constructed therapeutic program are patient education, environmental control, and carefully tailored pharmacotherapy based on objective assessment of lung function.

Prescribing a peak flow meter without a well-constructed asthma management plan is unlikely to improve patient outcome. Rather, peak flow monitoring provides another piece of information that should be carefully interpreted in the overall clinical context.

Patient selection

Not all patients require or benefit from peak flow monitoring, but we believe it is useful for patients at higher risk of asthma-related morbidity and mortality (TABLE 2). The National Asthma Education and Prevention Program (NAEPP) guidelines recommend home peak flow monitoring for all patients older than 5 years with moderate to severe asthma.[25,30,31]

Peak flow monitoring is useful for patients at higher risk

Which peak flow meter to choose?

A variety of small, inexpensive peak flow meters are available for home use. All must meet NAEPP guidelines for accuracy and precision[32,33]: readings must be within 10% of those obtained with a standard Wright peak flow meter, and successive readings must come within 5% of each other if measured with the same device, and within 10% of each other if measured with different devices from the same manufacturer.

Because most of these inexpensive devices can detect a 2% to 5% change in peak flow, most experts agree that they are adequate for serial monitoring. However, because the variation between devices made by different manufacturers is unpredictable, once a patient has chosen a device, he or she should use the same brand for all subsequent monitoring.

Portable electronic meters have gained some popularity in recent years.[34,35] Although some can only measure the peak flow, most can also measure the FEV_1, forced vital capacity (FVC), and the forced expiratory flow, mid-expiratory phase ($FEF_{25\%-75\%}$). Their main advantage is the ease with which they can store and retrieve data, obviating the need for manual record-keeping. Some can download data over the telephone to the physician's computer for subsequent review.

On the other hand, electronic peak flow meters cost considerably more than mechanical ones. Even though the peak expiratory flow measured by hand-held electronic devices and office spirometers maintains a linear relationship over a wide range of observations, these electronic instruments are not accurate enough to substitute for office-based spirometry. We do not believe that electronic peak flow meters represent a major breakthrough or offer any major advantage in routine clinical practice.

Patient education is crucial

The FIGURE summarizes how patients should measure their peak flow, and what they should do if they have abnormal readings. Because the peak flow occurs within the first 100 milliseconds of the forced expiration,[36] a prolonged expiratory effort is unnecessary.

We ask patients to keep a simple asthma diary, which we review during each outpatient visit. The diary contains their peak flow readings and how many puffs of a $beta_2$ agonist they used each day.

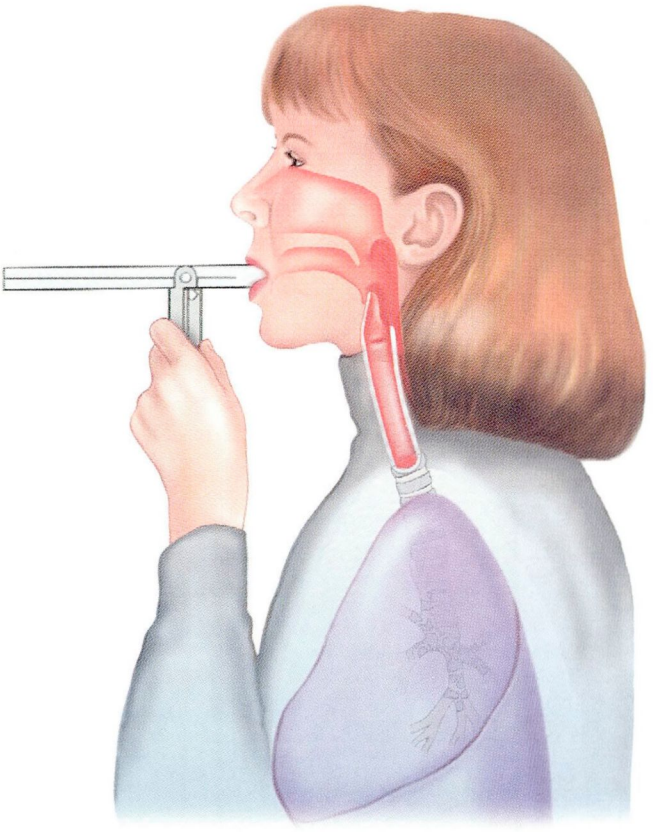
In the beginning, patients measure their peak flow rate twice a day, upon waking up and in the evening; all readings are taken before taking any inhaled bronchodilators. Once they achieve good asthma control, patients can measure their peak flow rate less frequently, such as once a day or even 2 to 3 times per week. If they do so, however, they should always measure it at the same time of day, preferably in the morning before taking any bronchodilators.

How to interpret the readings

The normal range for peak flow is 500 to 700 L/min for men, and 380 to 500 L/min for women. Peak flow rates vary with age, sex, race, height, smoking history, respiratory mus-

FIGURE

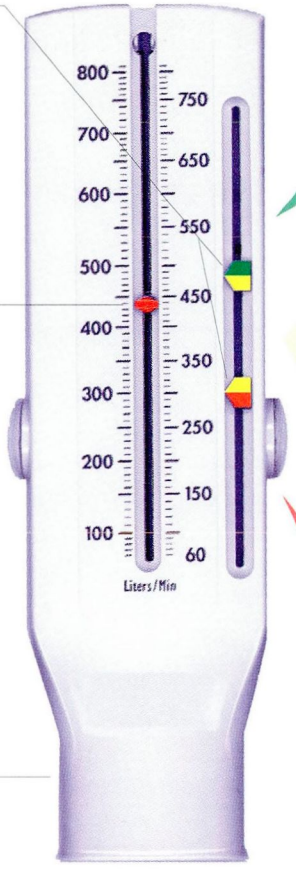
How to use a peak flow meter



1. Slide the marker to the bottom of the scale (close to the mouthpiece).
2. Stand or sit upright.
3. Take a deep breath.
4. Place the meter in your mouth.
5. Make your lips tight around the mouthpiece.
6. Blow as hard and as fast as possible.
7. Take the meter out of your mouth, look at the reading, and write it down.
8. Repeat the same steps two more times.
9. Record the highest of the three readings in your Asthma Diary.

Tabs
Your doctor will set these to mark the three zones at 80% and 50% of your personal best reading.

Marker



Mouthpiece

If your highest of the three readings is in the:

Green zone:
Congratulations. Keep up the good work.

Yellow zone:
Take two to four puffs from your bronchodilator inhaler (for example, Alupent, Proventil, Ventolin, or a similar product) every 15 to 20 minutes for 1 hour, and then measure your peak flow three times again.

If the best of the second three readings is in the green zone:
Continue taking the inhaler every 3 to 4 hours for the next 24 hours.

If the best of the second three readings is still in the yellow zone:
Call your doctor.

Red zone:
Take your bronchodilator inhaler, and call your doctor immediately.

TABLE 3

AN ASTHMA TREATMENT PLAN BASED ON PEAK EXPIRATORY FLOW RATE

Step	Severity	Symptoms	Peak flow*	Variability	Treatment
1	**Mild, intermittent**	Any: < 1/week At night: < 2/month	> 80%	< 20%	Inhaled $beta_2$ agonists as needed
2	**Mild, persistent**	Any: 1/week–1/day At night: > 2/month	> 80%	20%–30%	Inhaled steroid (200–800 µg/day) Long-acting inhaled $beta_2$ agonist or sustained release theophylline at bedtime for nocturnal symptoms Inhaled $beta_2$ agonists as needed
3	**Moderate, persistent**	Any: daily At night: > 1/week Need for daily $beta_2$ agonists	60%–80%	> 30%	Inhaled steroid (800–2000 µg/day) If symptoms persist, add long-acting inhaled $beta_2$ agonist or sustained release theophylline or both Inhaled $beta_2$ agonists as needed
4	**Severe, persistent**	Any: continuous At night: frequent Frequent exacerbations Limitation of physical activity	< 60%	> 30%	Inhaled steroids (800–2000 µg/day) Add inhaled long-acting $beta_2$ agonist Add sustained-release theophylline Add inhaled nedocromil sodium Inhaled $beta_2$ agonists as needed Oral steroids as rescue therapy

*Peak expiratory flow as a percent of the patient's personal best value

cle strength, and effort. If the patient always gives the same effort, a change in the peak flow rate reflects a change in the caliber of the large airways; however, the peak flow rate may be normal in patients with significant small-airway obstruction.

Establish the "personal best" value. Although nomograms based on age, height, weight, and sex are available, the most useful value that needs to be established at the outset is the "personal best"—the highest peak flow reading that a patient can achieve during an asymptomatic period. We recommend calculating each peak flow reading as a percentage of the patient's personal best value: (observed value / personal best value) × 100.

Watch for "morning dip." For reasons that are not understood, peak flow values are lower in the morning than in the evening, both in asthma patients and in normal subjects.[37] Morning and evening values may vary as much as 10% in normal subjects and even more in asthma patients, especially those with poor asthma control.[38,39]

Some sudden deaths have occurred in patients with diurnal variations greater than 20%, suggesting that excessive diurnal variation indicates an unstable situation and possibly identifies patients at higher risk of fatal or near-fatal asthma attacks. Recent studies suggest that a morning dip in peak flow is a reliable marker of nocturnal bronchospasm and poor asthma control.[40]

We tell our patients to watch for any excessive drop in their morning peak flow value, or "morning dip." The diurnal variation is calculated as: [(maximum value – minimum value) / 0.5 (maximum + minimum value)] × 100. Long-term therapy with inhaled steroids can reduce the morning dip in peak flow.[41]

Using peak flow readings in managing asthma

TABLE 3 shows a typical stepped-care approach to asthma treatment in which the treatment intensity is based on symptom severity and on peak flow monitoring.

To help patients to manage their asthma more effectively at home, the NAEPP guidelines suggest using a system of three color-coded peak flow zones:

- Green—80% to 100% of the personal best score.
- Yellow—50% to 80% of the personal best score.
- Red—less than 50% of the personal best score.[25] Some peak flow meters have sliding tabs, which the physician can set to mark these three zones (FIGURE); on others we use pieces of tape or colored felt-tipped markers.

If readings remain in the green zone and the patient has no symptoms for a sufficient period, a reduction in the medication dosage can be attempted. Unfortunately, no definite recommendation about dosage reduction can be given.

If readings are in the yellow zone and symptoms are worsening, the patient should use an inhaled beta$_2$ agonist (two to four puffs every 15 to 20 minutes for up to 1 hour) and then measure the peak flow again. If the repeat reading is in the green zone, we tell the patient to continue taking the inhaled beta$_2$ agonist every 3 to 4 hours for the next 24 hours, and together we try to identify the "trigger" that caused the attack. Failure of peak flow to improve after 1 hour of intensive bronchodilator treatment indicates a more severe asthma exacerbation. In that event, we start a course of oral prednisone and advise the patient to continue taking the inhaled bronchodilator every hour. We advise patients to go to the emergency department if the asthma attack does not reverse within 6 hours of this treatment.

Readings in the red zone require prompt treatment with bronchodilators and oral prednisone, and a visit to the emergency department if no response occurs within 1 hour.

Follow-up

The patient's technique for measuring the peak flow should be reassessed at regular intervals. Although most peak flow meters function adequately for 1 to 2 years, they sometimes fail prematurely. Therefore, their accuracy should be validated against office spirometry on a periodic basis. Because the peak flow changes with age, the personal best value must be re-established every year, especially in young patients.

TABLE 4

LIMITATIONS OF PEAK FLOW MONITORING

Technical
Effort-dependent
Does not reflect small-airway obstruction
Potential for unrecognized device malfunction
Clinical usefulness
Cannot substitute for spirometry in initial diagnosis
No role in mild asthma
Inaccurate measurement may promote overmedication
Overreliance may delay seeking medical advice
Other
May contribute to noncompliance
Potential for fungal contamination of device

Limitations of peak flow monitoring

Peak flow monitoring has several limitations (TABLE 4). Perhaps the most serious of these is the potential for inappropriate therapeutic action based on an inaccurate peak flow record. A consistent trend of change in peak flow is more convincing evidence for altering therapy than an isolated finding.

Because regular peak flow monitoring and record-keeping requires considerable commitment, patient compliance is a substantial problem.

Re-establish the personal best value every year

Safety

Peak flow monitoring is generally safe. Perhaps the most harm it can do is to mislead patients and physicians if the readings are inaccurate, although there is no evidence to suggest this actually happens. In a few patients, the forced expiratory maneuver may precipitate bronchospasm; these patients should not perform peak flow monitoring.

Fungal contamination of peak flow devices sometimes occurs.[42] Therefore, patients should gently wash the device with soap and warm water regularly, according to the manufacturer's recommendations.

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