ORIGINAL CONTRIBUTION
asthma, bronchial, determinants of admission

Comparison of Peak Expiratory Flow and FEV_1 Admission Criteria for Acute Bronchial Asthma

One hundred nine episodes of acute bronchial asthma were studied utilizing PEFR and FEV_1 measurements to determine objective patient disposition criteria. Of patients with both a pre-treatment PEFR < 100 L/min, and a post-treatment value < 300 L/min, 92% required admission or had an unsuccessful OPD course. Of patients with a pre-treatment PEFR < 100 L/min and an improvement < 60 L/min after initial terbutaline, 85% were admitted or had problems after discharge. PEFR correlated well with FEV_1 at all stages of treatment. [Nowak RM, Pensler MI, Sarkar DD, Anderson JA, Kvale PA, Ortiz AE, Tomlanovich MC: Comparison of peak expiratory flow and FEV_1 admission criteria for acute bronchial asthma. Ann Emerg Med 11:64-69, February 1982.]

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INTRODUCTION

The dynamic reversible airflow obstruction of acute bronchial asthma offers a formidable challenge in establishing criteria for patient disposition. The goal is to complement clinical judgment with rapidly obtained, accurate, and easily interpreted objective measurements.

We previously reported the usefulness of spirometry in the evaluation of the severity of acute asthma.[1] Other investigators have commented on the value of the peak expiratory flow rate (PEFR) in this situation.[2] Peak flow measurement is more effort-dependent than the forced expiratory volume in one second (FEV_1), and might be a source of greater error. However, because the peak flow meter is portable and less expensive, and because the test requires less work during acute respiratory distress, we prospectively compared the mini-Wright peak flow meter with standard spirometry. Guidelines using absolute PEFR were developed for determining the proper disposition of asthmatic patients from the emergency department.

MATERIALS AND METHODS

Patients between the ages of 16 and 40 with acute bronchospasm who fulfilled the criteria for asthma as defined by the American Thoracic Society[3] were eligible for admission to the study. Those who presented in acute respiratory distress, and who agreed to the protocol, were included. Patients with any other cardiac or lung disease were excluded. Prior to treatment, peak expiratory flow measurements were made using a mini-Wright peak flow meter (Armstrong Industries, Inc, Northbrook, IL), and then spirometry was performed using a Vitalograph single wedge bellows spirometer (Vitalograph Medical Instrumentation, Lenexa, KS).

Initial therapy consisted of terbutaline 0.25 mg subcutaneously. The PEFR and FEV_1 were repeated after 15 minutes. Subsequent uniform treatment, if necessary, consisted of intravenous aminophylline with 5.6 mg/kg loading dose administered over 20 minutes (downwardly adjusted with recent oral theophylline therapy) and a 0.9 mg/kg/hr maintenance infusion.[4] Although serum theophylline levels were drawn, results were not available for assisting in treatment judgments.

Further therapy was left to the discretion of the emergency physician, and thus varied in individual patients. These discrepancies in further treatment protocols were not analyzed, as this study addressed airway obstruc-

tion and its reversibility in predicting outcome regardless of method used to attain this improvement. PEFR and FEV_1 were measured prior to the patient's discharge or admission to the hospital. Whenever possible, three PEFR and FEV_1 measurements were obtained and the best value was recorded.

Decisions to admit or discharge patients were based on clinical assessment and/or FEV_1, as most treating physicians chose not to follow our previously recommended guidelines.[1] PEFRs were not utilized in decision making. All percent-predicted normal values[5,6] were calculated after the study was completed.

At the conclusion of the study, the patients were divided into three categories. Group I included all who were hospitalized. Groups II and III included those who were sent home. Each discharged patient was evaluated 48 hours later with a questionnaire (Figure 1) in order to determine outcome. Group II patients had two or more affirmative answers, while discharged patients with fewer than two affirmative answers were placed in Group III. Nine of 21 (43%) patients in Group II and 30 of 56 (54%) patients in Group III also had pulmonary function testing done at the 48-hour follow-up.

The data were analyzed by analysis of variance with pairwise contrasts to examine the differences among the three groups at selected stages of treatment. Chi-square was used for analysis of any categorial data. Relationships between PEFR and FEV_1 measurements for all patients were examined using correlation coefficients.

RESULTS

Ninety patients were treated for a total of 109 episodes of acute asthma. There were 56 women and 34 men. Each episode was considered a separate patient in the analysis. The mean age was 25.3 years, and the mean duration of therapy in the emergency department was 4.7 hours, with no statistically significant group differences. Thirty-two patients (29.3%) were admitted (Group I); 21 patients (19.3%) were discharged, but had further respiratory problems (Group II); and 56 (51.4%) were discharged and had no subsequent problems (Group III). All 109 patients had spirometry (FEV_1) performed, whereas 105 had PEFR measurements taken (4 of the Group III patients did not). The mean Group II absolute PEFR and FEV_1 at 48 hours follow-up were 233 L/min and 1.4 L, and the mean Group III values were 350 L/min and 2.43 L (all $P < 0.01$). This provided objective verification of the accuracy of the questionnaire.

The mean absolute and percent-predicted normal PEFR and FEV_1 measurements for each group at various stages of management are shown (Figures 2 and 3), and the actual means and standard deviations are shown (Table 1).

The mean values separate the three groups in a similar fashion. However, the PEFR did not significantly differentiate between Groups I and II at the post-terbutaline stage (Figure 2).

A comparison of the post-treatment percent-predicted PEFR and the post-treatment percent-predicted FEV_1 (Fig-

Fig. 1. *Questionnaire used in evaluating patients 48 hours after discharge from the emergency department.*

Fig. 2. *Mean absolute (A) and percent-predicted (B) PEFR values at various stages of management (Δ Group I, ○ Group II, □ Group III).*

Fig. 3. *Mean absolute (A) and percent-predicted (B) FEV_1 values at various stages of management (Δ Group I, ○ Group II, □ Group III).*

1. Is your asthma worse now than when you left the emergency department?	YES	NO
2. Have you had to return to any emergency department/ see another doctor?	YES	NO
3. Has your asthma kept you awake at night since you left our emergency department?	YES	NO
4. Has your breathing prevented you from resuming your usual activities?	YES	NO

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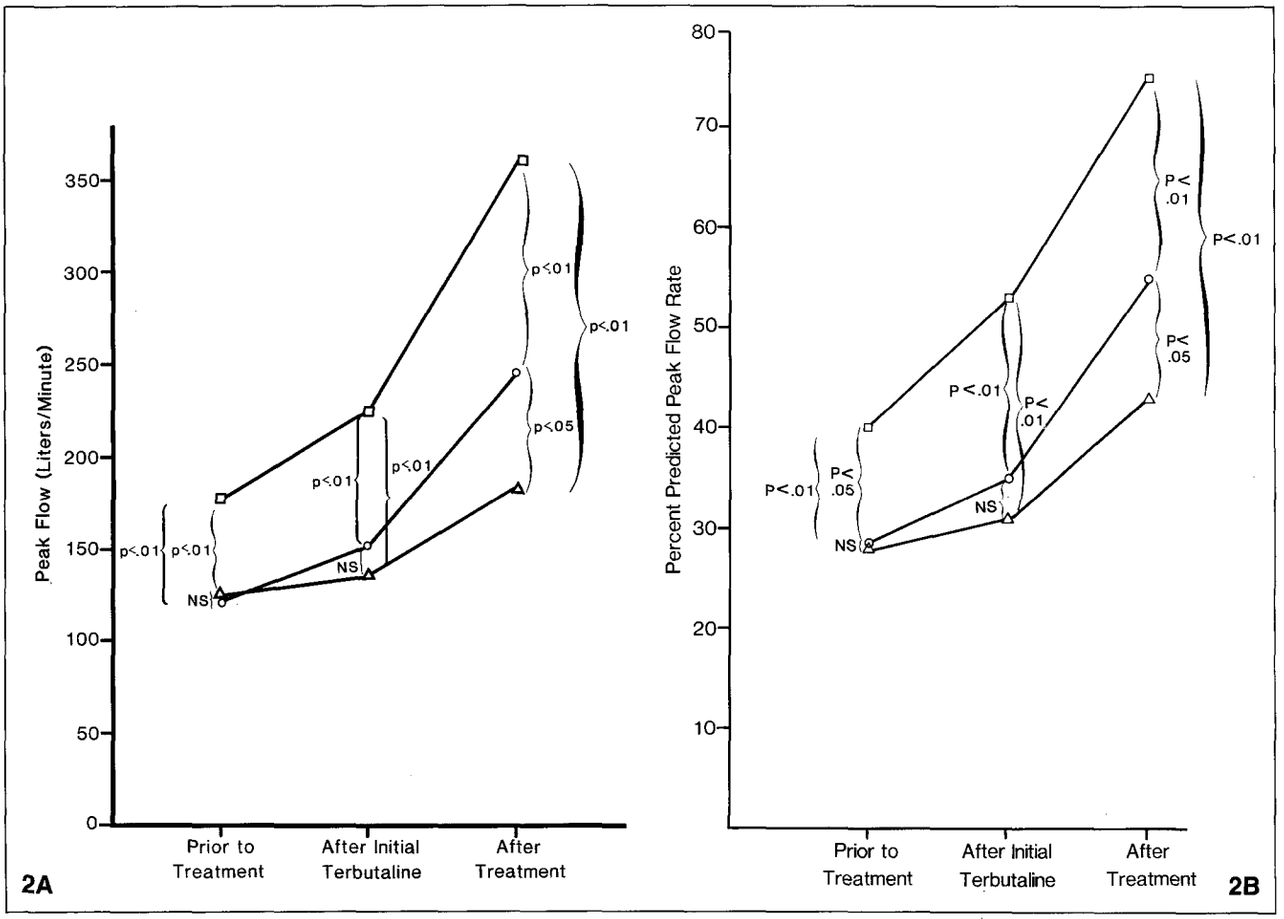
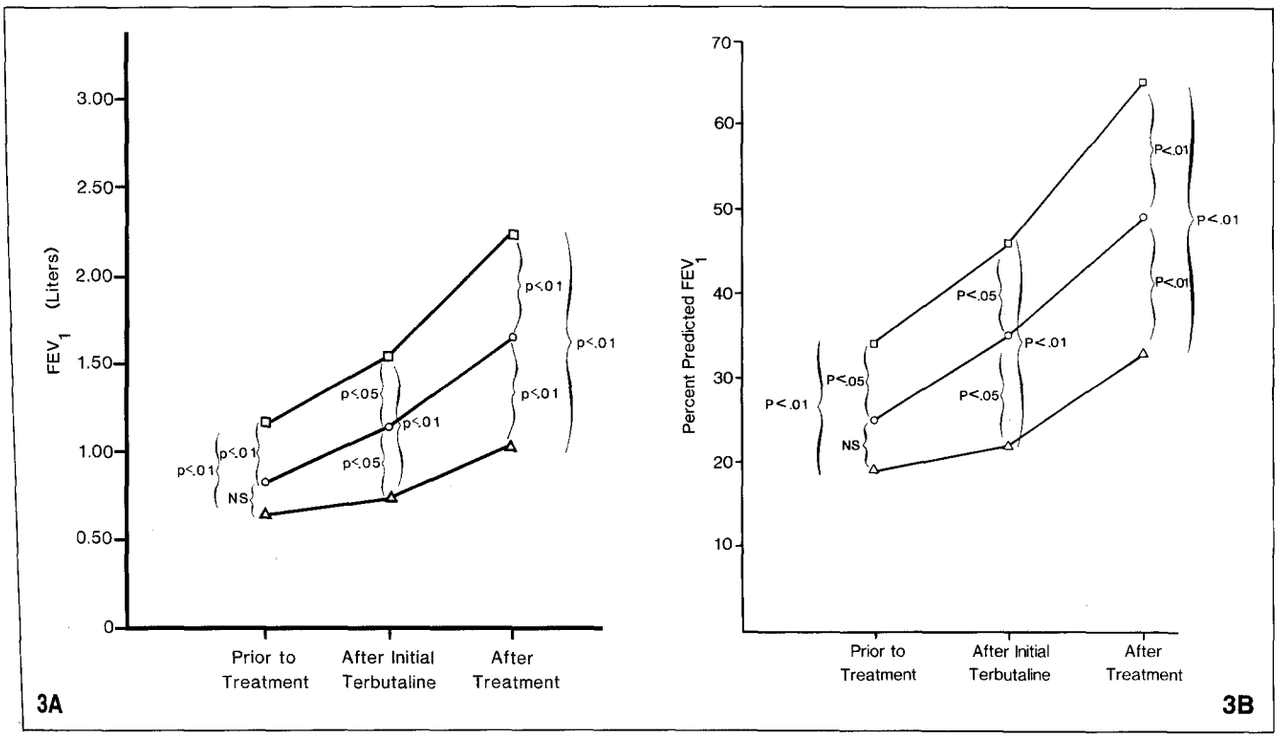
TABLE 1. *Mean ± standard deviation pulmonary function testing values at various treatment stages*

		PEFR		FEV_1	
		Absolute (L/min)	% Predicted	Absolute (L)	% Predicted
I	Admitted				
	Pre-treatment	125.9 ± 77.4	28.4 ± 16.6	0.65 ± 0.35	19.2 ± 10.7
	Post-terbutaline	138.0 ± 72.5	31.2 ± 16.1	0.75 ± 0.36	22.4 ± 11.5
	Post-treatment	184.0 ± 82.7	42.6 ± 18.5	1.04 ± 0.41	33.1 ± 12.9
II	Problems				
	Pre-treatment	121.9 ± 82.1	27.9 ± 19.3	0.82 ± 0.58	24.7 ± 15.7
	Post-terbutaline	152.6 ± 86.6	35.0 ± 20.4	1.15 ± 0.71	34.6 ± 20.4
	Post-treatment	247.6 ± 94.8	55.2 ± 21.4	1.65 ± 0.76	49.0 ± 22.0
III	No Problems				
	Pre-treatment	178.8 ± 82.8	39.9 ± 21.1	1.16 ± 0.54	34.4 ± 18.1
	Post-terbutaline	237.5 ± 103.2	53.0 ± 25.5	1.56 ± 0.77	45.8 ± 23.6
	Post-treatment	336.0 ± 87.2	74.9 ± 24.8	2.24 ± 0.65	64.8 ± 20.7


Peak Flow (Liters/Minute)
350
300
250
200
150
100
50
0
p<.01
p<.01
NS
p<.01
p<.01
p<.01
p<.05
p<.01
Prior to Treatment
After Initial Terbutaline
After Treatment
2A
Percent Predicted Peak Flow Rate
80
70
60
50
40
30
20
10
P<.01
P<.05
NS
P<.01
P<.01
P<.05
P<.01
Prior to Treatment
After Initial Terbutaline
After Treatment
2B


FEV1 (Liters)
3.00
2.50
2.00
1.50
1.00
0.50
0
p<.01
p<.01
NS
p<.05
p<.01
p<.05
p<.01
p<.01
Prior to Treatment
After Initial Terbutaline
After Treatment
3A
Percent Predicted FEV1
70
60
50
40
30
20
10
P<.05
P<.01
NS
P<.05
P<.01
P<.05
P<.01
P<.01
Prior to Treatment
After Initial Terbutaline
After Treatment
3B

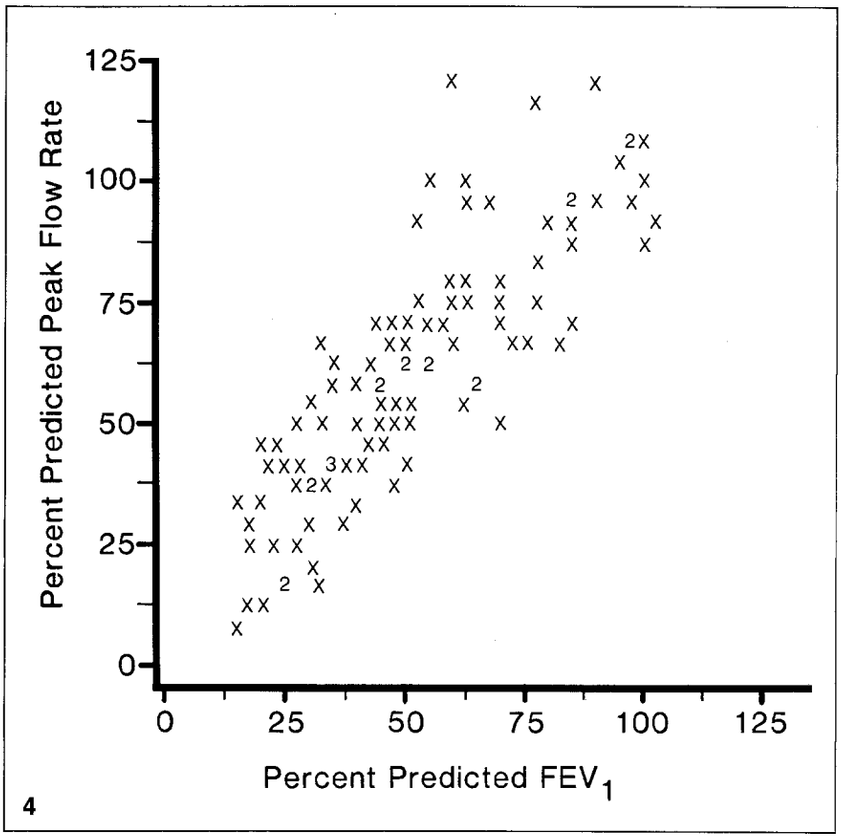


Fig. 4. *Percent-predicted PEFR plotted against percent-predicted FEV_1 ($r = 0.8416$, $P < 0.01$) at completion of therapy. (Numbers indicate more than one x at same location.)*

ure 4) yielded a correlation coefficient of 0.8416 ($P < 0.01$). Furthermore, correlation coefficients between PEFR and FEV_1 at each stage of treatment were excellent (r-values ranged between 0.7370 and 0.8615, all $P < 0.01$).

The optimal pulmonary function testing values to establish appropriate disposition criteria, based on our patients' outcomes, are shown (Table 2). There was no advantage to the use of percent-predicted normal values. A pretreatment PEFR or FEV_1 < 20% and a post-treatment < 60% were associated with similar patient outcomes ($P < 0.001$ chi-square).

The mean absolute response to the first dose of terbutaline is shown (Table 3). The Group I, II, and III mean (± standard deviation) absolute FEV_1 (L) and PEFR (L/min) responses are 0.10 ± 0.24, 0.33 ± 0.42, 0.40 ± 0.43, and 12.0 ± 29.8, 30.7 ± 65.8, 58.8 ± 64.4. The admitted patients had significantly lower mean PEFR and FEV_1 improvements after this initial treatment than did the other patients. The optimal pulmonary function testing values utilizing the initial absolute PEFR or FEV_1 and this response to terbutaline in establishing early predictive disposition criteria are shown (Table 4).

DISCUSSION

The clinical assessment of the degree of physiologic impairment in acute asthma is known to be less accurate than pulmonary function testing.[7,8] The usefulness of the FEV_1 in the emergency department has been advocated.[1] Measurement of the PEFR has been suggested as an alternative,[2] but this test has never been compared to standard spirometry in this clinical setting. Our study demonstrated that correlation coefficients at various stages of treatment between the PEFR (as measured by the mini-Wright peak flow meter) and the FEV_1 (as measured by standard spirometry) were excellent and highly significant. Consequently, the PEFR may be substituted for the FEV_1 in the assessment of asthma severity in the emergency department.

Ninety-two per cent of those patients with an initial PEFR < 100 L/min and a post-treatment value < 300 L/min were either admitted or had respiratory difficulty after discharge. These two parameters are indicative of both severe initial airway obstruction and a lack of responsiveness to treatment. Furthermore, 84% of patients with values > 100 L/min initially and > 300 L/min after therapy had no problems on discharge. These patients presented with less severe asthma and had a good response to treatment. Most patients with severe but responsive asthma (< 100 and > 300) did well, while those with mild or moderate but non-responsive (> 100 and < 300) asthma generally did poorly (Table 2). An initial FEV_1 < 0.7 L and a post-treatment value < 2.1 L gave similar results (Table 2). There-

TABLE 2. *Pre- and post-treatment pulmonary function testing and group outcome (all $P < 0.001$ [chi-square])*

Absolute PEFR (L/min)				
Pre-Rx	Post-Rx	I & II	III	Patients
< 100	< 300	22 (92%)	2 (8%)	24
> 100	< 300	25 (66%)	13 (34%)	38
< 100	> 300	0 (0%)	5 (100%)	5
> 100	> 300	6 (16%)	32 (84%)	38
Absolute FEV_1 (L)				
Pre-Rx	Post-Rx	I & II	III	Patients
< 0.7	< 2.1	35 (86%)	6 (14%)	41
> 0.7	< 2.1	12 (40%)	18 (60%)	30
< 0.7	> 2.1	1 (14%)	6 (86%)	7
> 0.7	> 2.1	5 (16%)	26 (84%)	31

TABLE 3. *Mean absolute FEV_1 (L) and PEFR (L/min) response in each group after initial terbutaline*

	FEV_1		Peak Flow Rate	
I Admitted	0.10	$P < 0.05$	12	NS
II Problems	0.33	NS; $P < 0.01$	31	NS; $P < 0.01$
III No problems	0.40		59	

TABLE 4. *Pretreatment pulmonary function testing and terbutaline responsiveness as related to group outcome (all $P < 0.001$ [chi-square])*

Absolute PEFR (L/min)

Pre-Rx	Improvement Post-terbutaline	I & II	III	Patients
< 100	< 60	17 (85%)	3 (15%)	20
> 100	< 60	29 (51%)	28 (49%)	57
< 100	> 60	4 (57%)	3 (43%)	7
> 100	> 60	3 (14%)	18 (86%)	21

Absolute FEV_1 (L)

Pre-Rx	Improvement Post-terbutaline	I & II	III	Patients
< 0.7	< 0.3	28 (80%)	7 (20%)	35
> 0.7	< 0.3	12 (45%)	15 (55%)	27
< 0.7	> 0.3	8 (67%)	4 (33%)	12
> 0.7	> 0.3	5 (14%)	30 (86%)	35

fore, a pretreatment PEFR of < 100 L/min and a post-treatment value < 300 L/min indicate the need for inpatient therapy or very closely monitored outpatient management. Values for the FEV_1 are < 0.7 L and < 2.1 L. It is suggested that, in spite of subjective well-being and/or improvement as measured by clinical assessment, patients generally should be treated in order to attain a PEFR > 300 L/min or an FEV_1 > 2.1 L before discharge from the emergency department.

The utilization of percent-predicted normal values does not improve predictive disposition criteria. The effects of age, sex, and height differences in large groups of patients on absolute measurements of airway flow tend to equalize, thus explaining this lack of predictive improvement (eg, there are presumably equal numbers of short and tall asthmatics, so that for every asthmatic whose absolute value underestimates the percent-predicted value, there is one whose value overestimates the predicted value). However, in the very short or tall asthmatic, a pretreatment PEFR or FEV_1 < 20% predicted normal and a post-treatment value < 60% similarly indicate the need for hospital admission or close outpatient follow-up.

While very reliable guidelines concerning disposition have been established, there are several reasons why such predictive parameters are not 100% distinctive. First, some Group III patients may have had a successful clinical course in spite of apparent lack of sufficient improvement in pulmonary function testing due to unmeasured decreases in lung volumes.[9,10] Second, some of the Group II patients who left the emergency department with significantly improved pulmonary function testing were thought to have relapsed on the basis of non-compliance in taking oral theophylline preparations. Three of four Group II patients with an initial PEFR > 100 L/min and a post-treatment PEFR > 300 L/min had subtherapeutic theophylline levels (< 10 mcg/ml) on re-evaluation in 48 hours. These factors were not taken into account in deriving the criteria.

If asthma is severe and resistant to beta agonist therapy, pulmonary function will not change rapidly.[2,11,12] The majority of such patients were identified on presentation to the emergency department, as the initial PEFR and FEV_1 were < 100 L/min and < 0.7 L, respectively. Moreover, they had negligible rises in these measurements (Δ PEFR < 60 L/min and Δ FEV_1 < 0.3 L) 15 minutes after initial treatment with terbutaline. Thus an initial PEFR < 100 L/min and an improvement < 60 L/min after initial terbutaline are early indicators of severe resistant disease requiring aggressive therapy, including corticosteroid administration and often inpatient management. Similar values for the FEV_1 are < 0.7 L with an improvement < 0.3 L. Also, if an asthmatic has an initial PEFR > 100 L/min or FEV_1 > 0.7 L, and a response to a beta agonist > 60 L/min or > 0.3 L, respectively, there is a high probability (Table 4) that such a patient will do well with routine asthma therapy.

SUMMARY

The PEFR, as measured by the mini-Wright peak flow meter, correlates well with the FEV_1. Both measurements are extremely valuable as objective guides in the early detection of severe and unresponsive airway obstruction and in the ultimate disposition of the asthmatic patient. However, the portability, inexpensiveness, and overall convenience of use makes the peak flow the more attractive form of pulmonary function testing in the emergency department.

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