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*Commentary*

# Testing Patients' Lungs: Spirometry as Part of the Physical Examination

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ABSTRACT

Spirometric measurements of lung function are vital signs that unfortunately are not as widely used as blood pressure or cholesterol testing. Spirometry is an uncomplicated procedure that can easily be incorporated by primary care physicians into routine physical examinations. especially now that simple handheid spirometers suitable for all offices are available. Abnormal spiromerric patterns can alert physicians to patients' additional risk of developing chronic lung disease and to the need for interventions that prevent or forestail morbidity and mortality. Spirometry also is an important tool for monitoring patients' response to therapy in a number of disorders (eg. asthma). Spirometric testing in adults should begin at age 40 for *smokers* and patients with unexplained dyspnea. cough. wheezing. or excessive mucus. Children with asthma and cystic fibrosis should be identified and followed with spirometry. ***Key words:*** family practice, lung disease. predictive value of tests. risk factors. smokingiadverse effects. spirometry.

INTRODUCTION

"Test Your Lungs. Know Your Numbers" is the battle cry of a new national health care initiative. the National Lung Health Education Program (NLHEP).' The NLHEP is directed toward primary care physicians and aims to encourage identification of chronic obstmctive pulmonary disease (COPD) in its early stages. COPD. the fourth most common cause of death and the most rapidly growing health problem in the United States today,* is closely related to smoking, but for reasons that are not understood, only -20% of smokers develop the disorder.' Most smokers probably are protected by genetically determined tissue defense mechanisms that may be directed against oxidants and elastases. Smokers also are at increased risk of developing smoking-

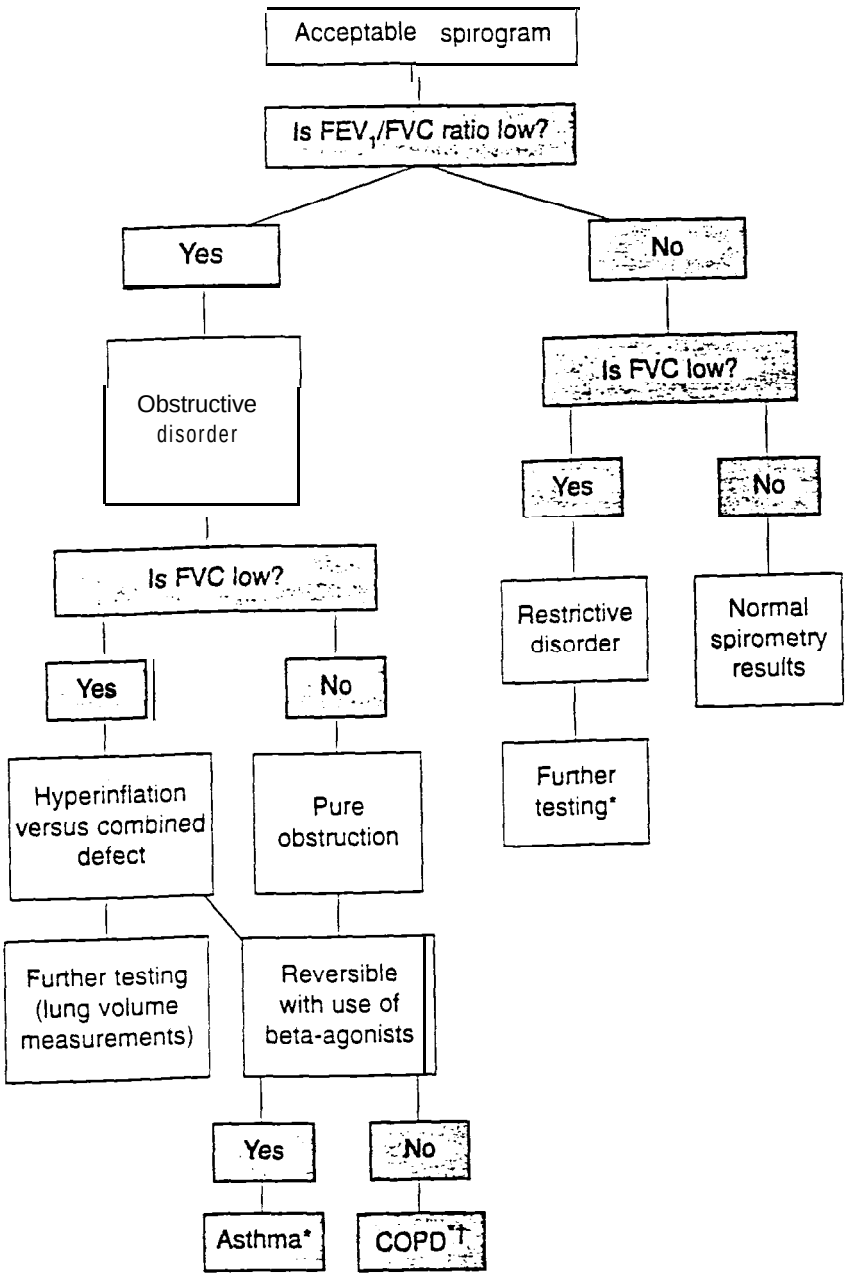


Figure 1. A spirometer interpretation algorithm with 2 variables. *If clinical correlation is present. †Some chronic obstructive pulmonary disease (COPD) may have a reversible component. $FEV_1$ = forced expiratory volume in 1 second; FVC = forced vital capacity.

by the author that permits quick classification of obstructive and restrictive ventilatory disorders. Obstructive disorders, which are much more common than restrictive abnormalities. include asthma and COPD. Asthmatic bronchitis, chronic bronchitis. and emphysema are included in COPD. Bronchiectasis and cystic fibrosis and combinations of these conditions are also obstructive lung diseases but are normally separated from COPD. Less common are sarcoidosis. healed tuberculosis. bronchiolitis obliterans. and histiocytosis. These diseases can be identified by a low $FEV_1/FVC$ ratio or an FEV, that is lower than predicted. The specific diagnosis must be made in the context of the patient's history, physical examination. and chest roentgenograms. as well as specific serum levels (eg, cystic fibrosis) and histologic studies. Responses to inhaled bronchodilators help separate asthma from COPD. but some degree of airflow improvement from inhaled bronchodilators is common in COPD.

Restrictive disorders occur when the lung's elasticity is increased in fibrotic states such as idiopathic pulmonary fibrosis. the pneumoconioses. collagen diseases of the lungs. thoracic deformities. and congestive heart failure. Pleural effusions or pulmonary congestion are commonly associated with a reduced FVC. In fact. one of the original applications of spirometry was to monitor heart failure.[10]

## PATTERN RECOGNITION

Historically, spirometric data have been presented as exhaled volume over time. These volume-time curves are easy to visualize and allow physicians to identify FEV,, FVC, and expiratory time at a glance. Since the development of the flow transducer, another method. flow over volume. has also become popular. The so-called flow-volume convention actually measures the same thing as does volume over time. although the values are expressed in a different. somewhat more confusing manner. All primary care physicians should be able to use either method of analyzing airflow and volume. The flow transducer permits physicians to visualize peak flow and timed peak flow. which is a check of patients' efforts. FEV,, FVC, and $FEV_1/FVC$ ratio are expressed in terms of lower limit of normal (LLN).

Figure 2 presents normal expiratory flow-volume and time-volume curves. Figure 3 shows these curves in a patient with a mild degree of airflow obstruction. Note that the FEV, as a percentage of FVC is 59%. which is well below the LLN of 71%. In this example, the absolute FEV, (2.74 L) is 88% of predicted, which is within the normal range. but the ratio indicates an abnormality. Figure 4 shows flow-volume and time-volume curves in a patient with moderate airflow obstruction. Here the $FEV_1/FVC$ ratio is about the same as that in Figure 3 (ie, 57% vs 59%), but the absolute FEV, is only 66% of predicted and is thus well below LLN. Figure 5 shows flow-volume and time-volume curves in a patient with severe aifflow obstruction. Figures 6 and 7 show these curves in a patient with a moderate and a severe restrictive ventilatory defect, respectively. Note the high $FEV_1/FVC$ ratios in Figures 6 and 7; the FVC of 3.20 in Figure 6 is 82% of predicted, which is well within the normal range of +20%, but the high ratio (89%) indicates that a restrictive ventilatory defect is present. In Figure 7 the FVC is only 48% of predicted and the ratio is 99%.

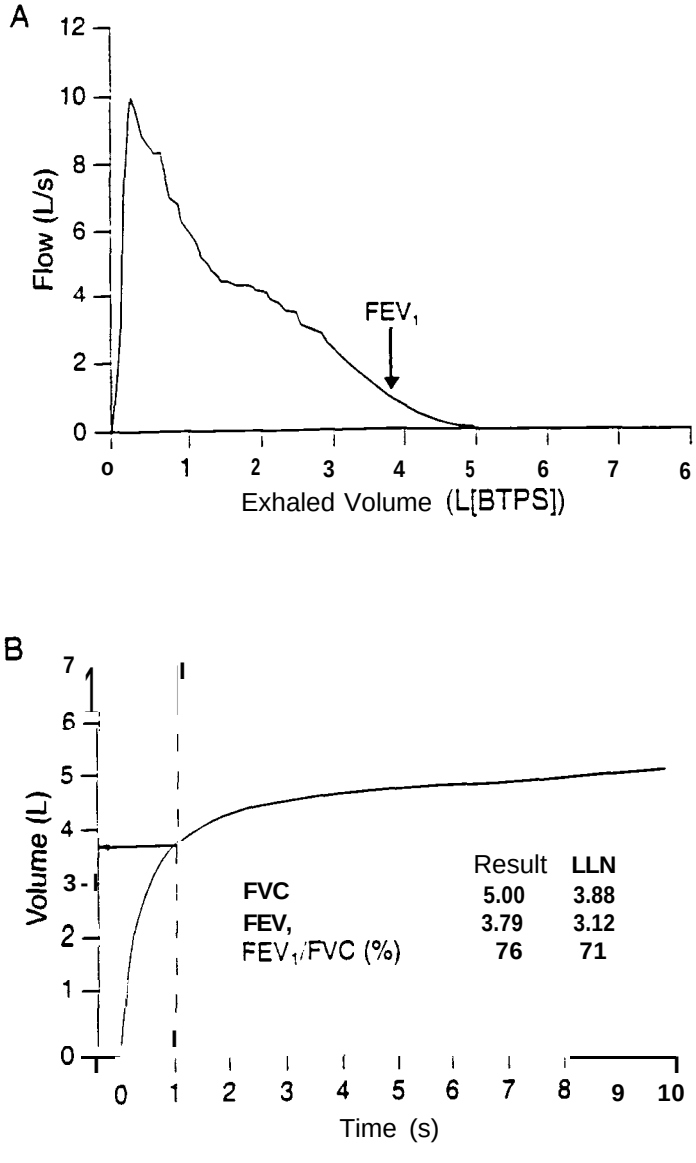


Figure 2. Flow-volume (A) and volume-time (B) curves in a healthy individual. Note that expiratory time can be visualized from the volume-time curve and that peak flow can be visualized from the flow-volume curve. Thus both curves are useful. $FEV_1$ = forced expiratory volume in 1 second: BTPS = body temperature. ambient pressure. snd saturated with water vapor; FVC = forced vital capacity; LLN = lower limit of normal.

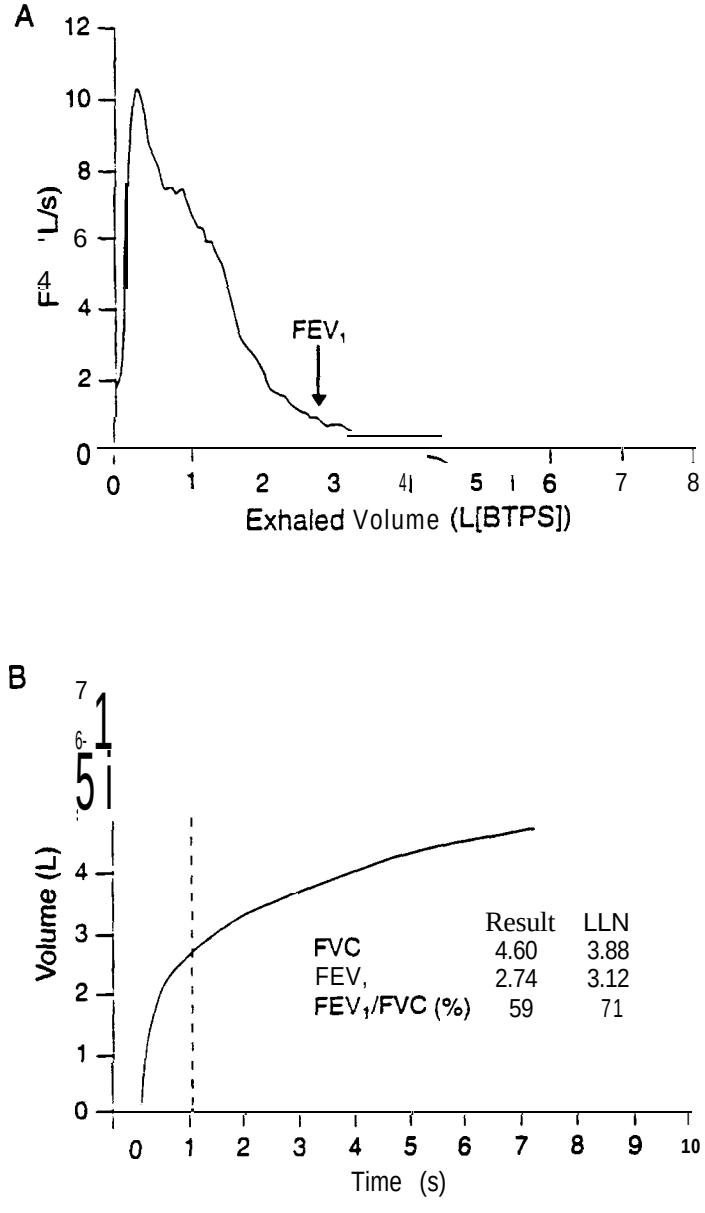


Figure 3. Flow-volume (A) and volume-time (B) curves in a patient with mild airflow obstruction. FEV, = forced expiratory volume in 1 second; BTPS = body temperature. ambient pressure. and saturated with water vapor; FVC = forced vital capacity: LLN = lower limit of normal.

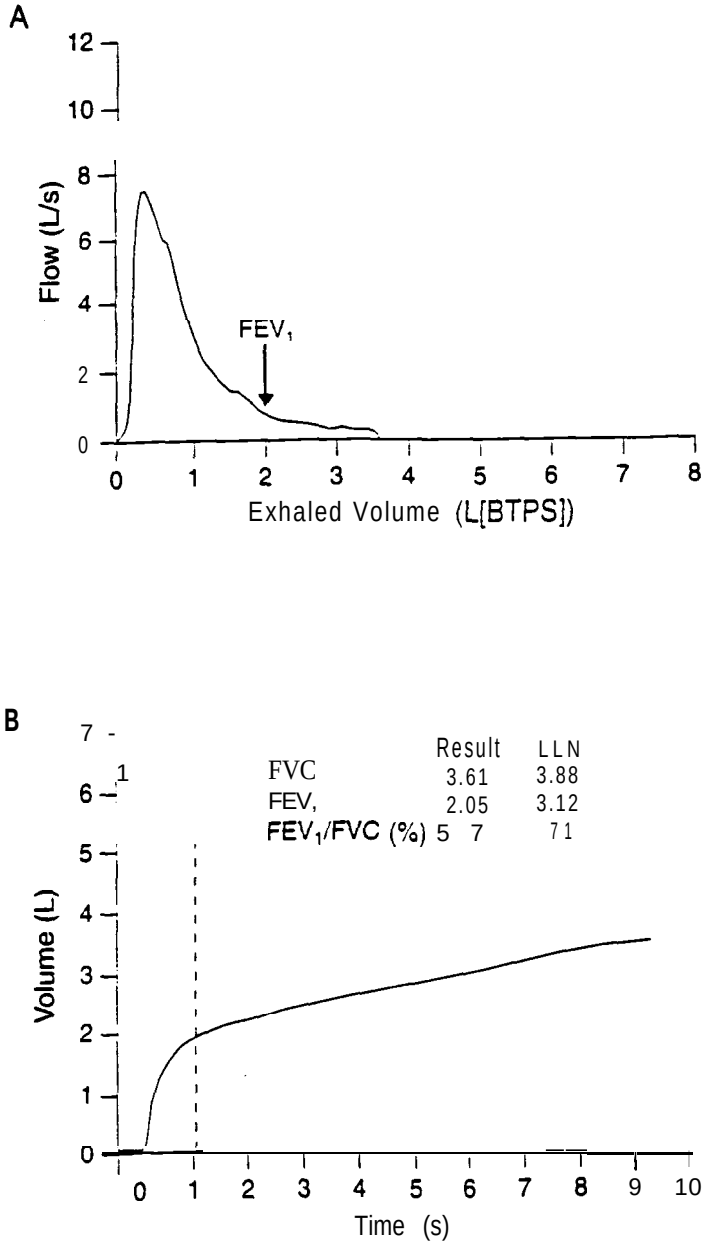


Figure 4. Flow-volume (A) and volume-time (B) curves in a patient with moderate airflow obstruction. $FEV_1$ = forced expiratory volume in 1 second: BTPS = body temperature. ambient pressure. and saturated with water vapor; FVC = forced vital capacity; LLS = lower limit of normal.

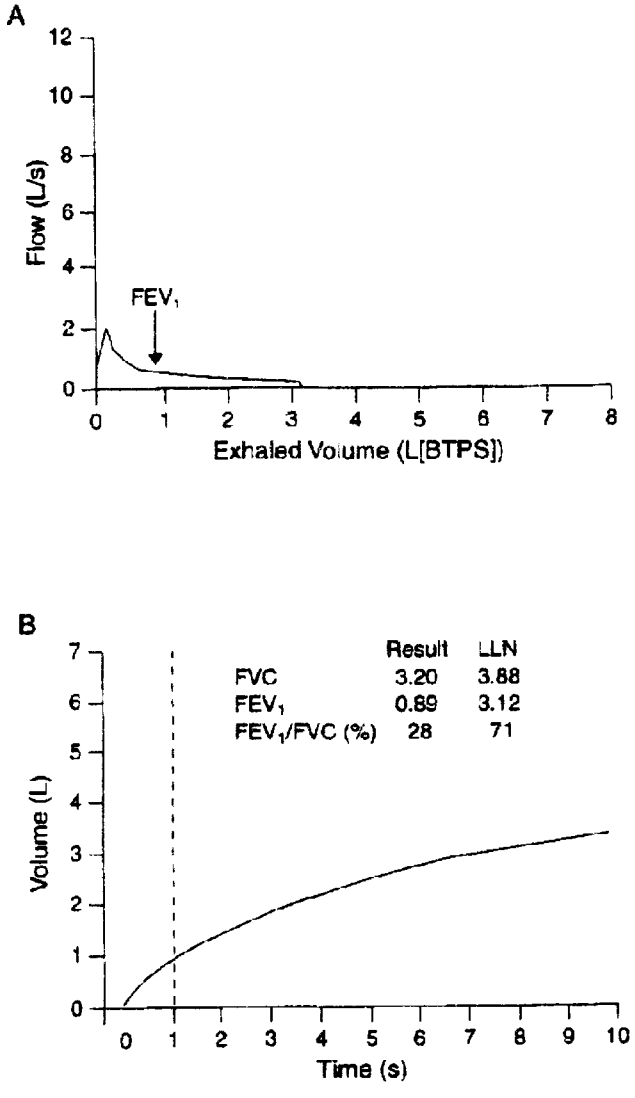


Figure 5. Flow-volume (A) and volume-time (B) curves in a patient with severe airflow obstruction from emphysema. $FEV_1$ = forced expiratory volume in 1 second; BTPS = body temperature, ambient pressure, and saturated with water vapor; FVC = forced vital capacity; LLN = lower limit of normal.

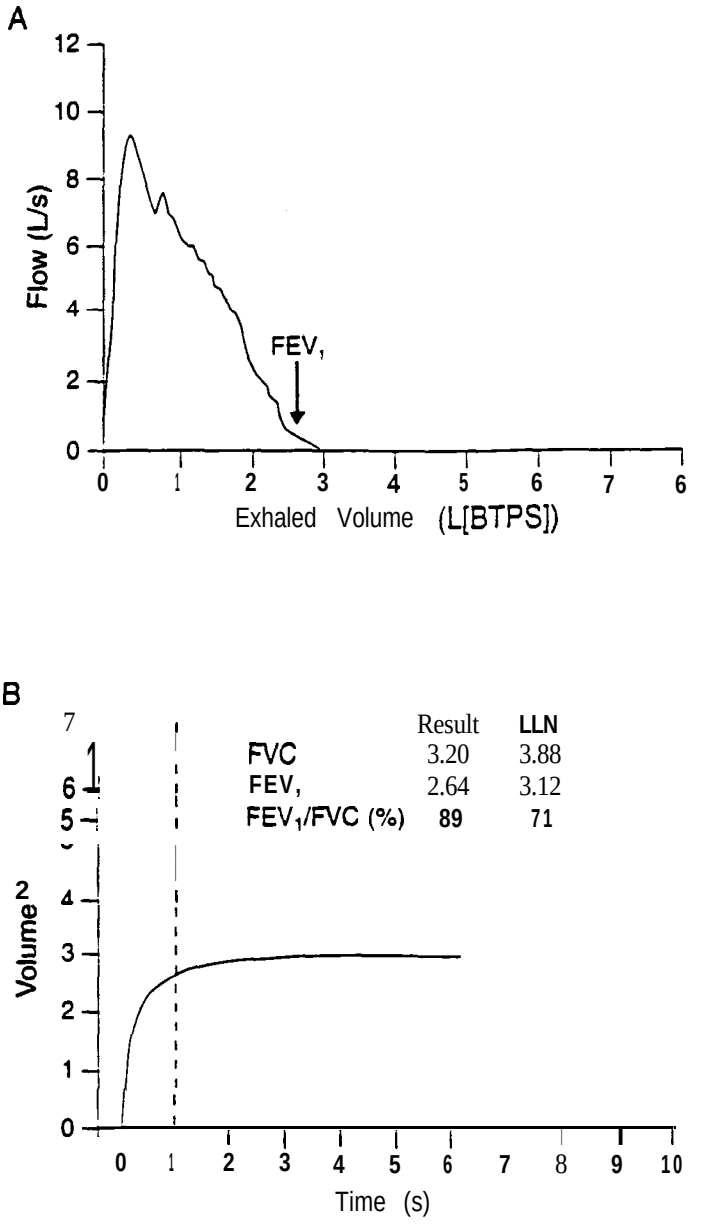


Figure 6. Flow-volume (A) and volume-time (B) curves in a patient with a moderate restrictive ventilatory disorder. The ratio of forced expiratory volume in 1 second (FEV,)/forced vital capacity (FVC) is nearly 90%. A ratio this high may suggest a restrictive disorder: however, healthy individuals can often empty most of the lung in 1 second. BTPS = body temperature, ambient pressure. and saturated with water vapor; LLN = lower limit of normal.

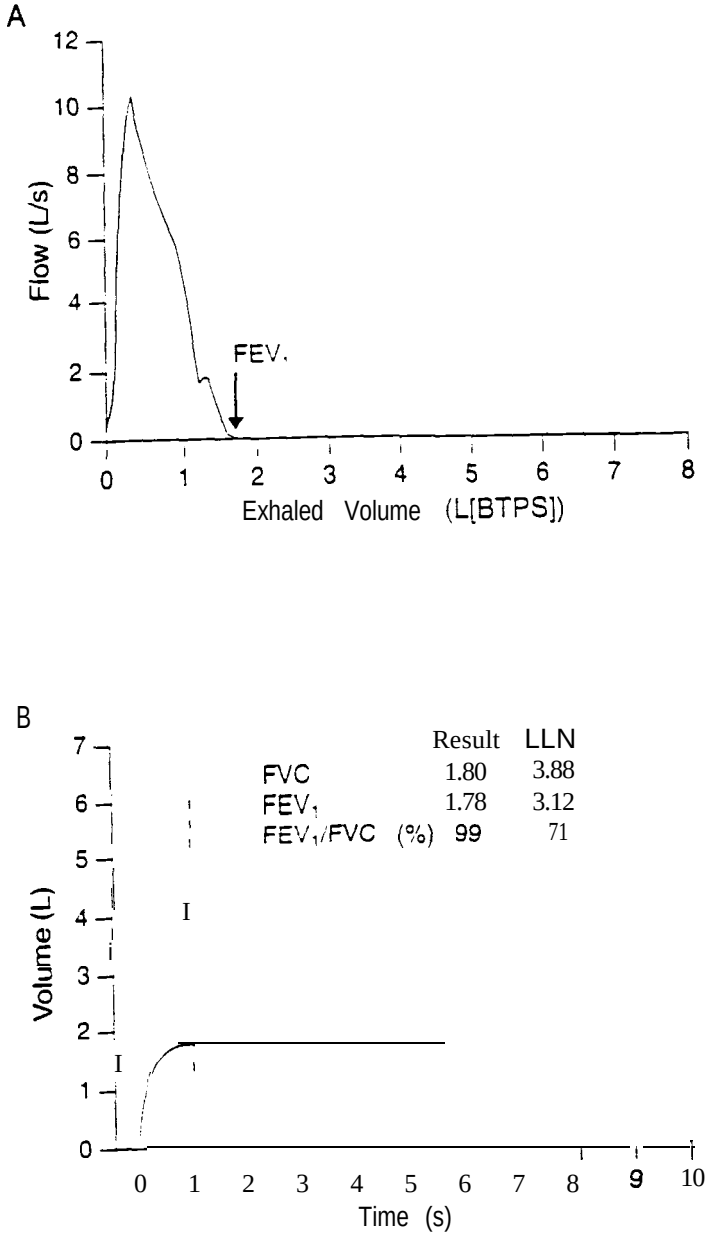


Figure 7. Flow-volume (A) and time-volume (B) curves in a patient with a severe restrictive ventilatory disease due to idiopathic pulmonary fibrosis. The ratio of forced expiratory volume in 1 second ($FEV_1$)/forced vital capacity (FVC) is 99%. BTPS = body temperature. ambient pressure. and saturated with water vapor: LLN = lower limit of normal.

Tables I and 11 list common obstructive and restrictive ventilatory disorders.

Clinicians may find it as easy to recognize the patterns of these normal and abnormal flow-volume and time-volume curves and to display and record the 2 key numbers of simple spirometry as it is to record systolic and diastolic blood pressure and easier to recognize than many electrocardiographic abnormalities. However, just as blood pressure measurements are often incorrectly obtained. physicians must be taught to perform spirometric tests correctly and to interpret their results accurately.

Table I. Common obstructive ventilatoty disorders.

| |
|---|
| Asthma |
| Asthmatic bronchitis |
| Chronic obstructive bronchitis |
| Emphysema |
| Chronic obstructive pulmonary disease (COPD*) |
| Asthmatic bronchitis |
| Chronic bronchitis |
| Bronchitis |
| Emphysema |
| Cystic fibrosis |

*COPD is a genetic term. These conditions commonly overlap.

Table II. Common restrictive ventilatory disorders.

| |
|---|
| Idiopathic fibrosing alveolitis |
| Interstitial pneumonitis and fibrosis associated with: |
| Drug reactions (eg. bleomycin) |
| Occupational exposures (eg, asbestosis: collagen disease. such as rheumatoid arthritis) |
| Fibrotic residue of disseminated granulomas |
| Tuberculosis |
| Histoplasmosis |
| Sarcoidosis |
| Thoracic deformities |
| Congestive heart failure |

## WHO SHOULD UNDERGO SPIROMETRIC TESTING?

### *Initial Testing*

It could easily be argued that because spirometry is an important part of a patient's health database. all adults should undergo spirometry at least once as part of a complete physical examination. Normal spirometric findings predict good survival[4,10]; abnormal spirometric findings indicate an adverse prognosis. including mortality from various diseases.

Simple spirometric measures are an imponant database for primary care physicians and are key to identifying various diseases and to objectively monitoring therapy for these diseases. Certainly, all patients >5 years of age with cough. shortness of breath. or wheeze should undergo spirometry and can cooperate during testing.

Smokers

Spirometry is particularly useful in teenagers who smoke. because they never achieve full lung growth: this is a disadvantage if they develop chest infections in adulthood or continue to smoke." All smokers aged >45 years should have spirometric testing, according to a statement from the NLHEP.[12] This study indicated that patients with spirometric abnormalities had a poorer prognosis in terms of rate of lung function loss if they continued to smoke than if they stopped smoking.[3] Patients had to have smoked 1 pack of cigarettes a day for 10 years or more to be enrolled in the study. Although a 20-pack year

has historically been considered a threshold for the smoking risk group, no level of smoking is safe. and all current and former smokers should therefore undergo spirometric testing at least once. especially individuals who have smoked for more than 5 years.

The concept of "lung age" provides another way of looking at how smoking affects lung function.[13] It is computed by comparing an individual's FEV, value with the age for which that FEV, value is considered normal based on predicted values. For example. if a 6-foot. 47-year-old man has an FEV, of 2.2. his lung age is 72. because 2.2 is the $FEV_1$ measurement considered normal for a 6-foot man aged 72 years. Calculating a patient's lung age and revealing it to him or her can be a potent motivator in smoking cessation.[13]

*Patients with Lung Cancer*

Death rates from lung cancer. the most common fatal malignancy in both men and women. remain high because the disease is usually discovered late in its course. with symptoms of cough. chest pain. or hemoptysis driving the patient to the physician. The frequent use of chest roentgenograms and sputum cytologic findings in screening large populations for lung cancer has been studied in 3 major centers with disappointing results.[14–17] Although earlier diagnosis through screening was found to be possible in men who smoked. it did not substantially improve overall mortality.[15] This has led to the widespread belief that screening for lung cancer is not worthwhile.[18] However. studies using spirometry. noted below. suggest that this advice be reconsidered.[19,20]

Several epidemiologic studies have indicated a common denominator between COPD and lung cancer.[21–24] In one study. 9 lung cancers were found in patients with airflow obstruction compared with only 2 patients in whom airflow was normal over a IO-year follow-up period.[23] These 2 groups were matched for age. sex. smoking history, and occupation. Thus the presence of airflow obstruction was a powerful predictor of the subsequent development of lung cancer. Furthermore, hypersecretion of mucus appears to be an independent indicator of lung cancer.[25]

*Patients with Myocardial Infarction*

The often-quoted Framingham Heart Study found a close correlation between reduction in FVC and the risk of death from heart disease.[26] The reason for this association is probably multifactorial. Patients at risk for myocardial infarction are commonly obese and of poor physical fitness. In addition. they may also have cardiac hypertrophy or occult congestive heart failure. Any or all of these abnormalities can lead to reduced FVC and an increased risk of myocardial infarction."

*Patients with Chronic Obstructive Pulmonary Disease*

Smoking is by far the greatest risk factor in the development of emphysema and chronic bronchitis (ie. the full spectrum of COPD).[28] In early COPD. $FEV_1$ begins to fall before FVC. This results in a reduced ratio between FEV, and FVC (<70%). Population studies have clearly shown that this single value ($FEV_1$/FVC%) can identify patients at risk for accelerated lung function loss. Abnormalities in FEV, and $FEV_1$/FVC% herald the onset of clinically significant COPD.[9]

*Retesting*

Once abnormal airflow is found, clinicians should be aware of how to monitor the patient's response to therapy. For ex-

ample. measurements obtained from inhalation of a bronchodilator will help separate asthma from COPD. although many patients with mild COPD show improved airflow, similar to patients with asthma. In fact. when only partial improvement in airflow follows inhalation of a bronchodilator. asthma cannot be distinguished from COPD based on 1 or 2 simple spirometric tests. When bronchodilators or corticosteroids are used for asthma or COPD. serial spirometry (spirometry repeated at each visit) will document responses to therapy. The interval of repeat spirometric testing should be guided by each medication and its expected pharmacologic response (ie. days or weeks with a bronchodilator or conicosteroids). Longitudinal follow-up is required to identify patients' responses over time, which can range from objective functional improvement to no change. or even to progressive deterioration.

The interval between spirometric retesting also should be based on patients' symptoms. Because symptoms do not correlate well with spirometric measurement.[29] objective functional improvement is needed to determine if a particular therapy (eg, bronchodilator. inhaled corticosteroid. systemic steroid. or theophylline) is working.

## DISCUSSION AND CONCLUSIONS

Spirometric measurements can be as fundamental to medicine as are pulse, blood pressure. temperature. height. and weight measurements and therefore could be considered in the physical examination as important vital signs. This is important. since potent bronchoactive and anti-inflammatory drugs are routinely used without a quantitative measurement of their efficacy. Just as hypertension is not treated without measurements of blood pressure or diabetes without measurements of blood glucose, drugs designed to improve airflow, volume, or both should not be used without spirometric monitoring.

Any deviations from "normal" measurements can point primary care physicians toward the use of behavioral modification aimed at smoking cessation and effective pharmacologic agents to prevent or forestall their patients' premature morbidity and mortality from many disease states, including premature deaths from all causes. The 2 basic spirometric measurements are not difficult to perform and, with proper instruction and training, primary care physicians or their assistants can perform spirometry and interpret the results with confidence. With so many potential benefits for patients, many believe that it is time to make spirometry a routine part of the physical examination.

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