Abstract

Function pulmonary tests are important tools to assess the respiratory health and clinical diseases. Spirometry, carbon monoxide of diffusion lung capacity, hyper-responsiveness and measurement of volume and resistance have a variety of application in the diagnosis, pre-operative and monitoring of respiratory disease, as chronic obstructive pulmonary disease (COPD) and asthma. Asthma is characterized by hyper-responsivity, inflammation and variable obstruction in airways. However, spite of alteration in lung function, the diagnosis of asthma is based on clinical symptoms. These findings as cough, wheeze, and dyspnea are unspecific and can represent other diseases, in these cases the measurement of lung function can help in the diagnosis. Pulmonary function testing are very helpful in assessing the physiologic consequences of the chronic obstructive pulmonary disease (COPD) and asthma, where the hallmark is a decrease in expiratory flow rates. Spirometry is the most widely used test for evaluating and treating patients. Tests more complex including lung volumes and cardiopulmonary exercise testing provides useful information about the overall lung function and functional capacity that can be fundamental in categorizing and staging of these diseases.

Keywords: Asthma; Pulmonary disease, chronic obstructive; Respiratory function tests.

Functional concepts of asthma and chronic obstructive pulmonary disease

Asthma is a chronic inflammatory disease of the airways and is characterized by obstruction that is reversible after bronchodilator use. This obstruction occurs until bronchial remodeling is established, causing repair of the airway. During spirometry, asthma behaves as an obstructive disorder. The forced expiratory volume in one second (FEV 1) is an important parameter for establishing disease severity and assessing reversibility with bronchodilator use.
A positive bronchodilator test suggests, but does not define, a diagnosis of asthma.¹,²

Chronic obstructive pulmonary disease (COPD) is also an obstructive disturbance, but the limited airflow is persistent and either does not vary or varies only slightly after bronchodilator use. Spirometry is used to define disease diagnosis and stage. Lack of response to bronchodilators in patients with a clinical history strongly suggests the diagnosis of COPD.¹,²

Certain cases can raise diagnostic questions, i.e., asthmatic smokers, COPD patients with a marked response to bronchodilators, and patients who have asthma combined with COPD. In these cases, clinical histories, measurement of sputum cellularity, and more accurate tests (such as the diffusion test using carbon monoxide (CO) are required to distinguish whether patients have asthma, COPD, or the overlap syndrome.³

**Pulmonary function in asthma and COPD: what can be measured?**

Measuring peak expiratory flow

In physiological terms, the peak expiratory flow (PEF) corresponds to the maximum rate at which air is expelled from the lungs and is measured in liters per minute. In patients with suspected obstructive airway diseases, PEF measurements indicate the degree of obstruction in the major airways.¹ PEF analysis is based on predicted values that consider the following 3 variables: age, height, and gender. PEF measurements are often used in patients with asthma; however, this method is not used in patients with COPD.¹ Measurement of PEF is a standard method that correlates physiological function with asthma severity and has been used as an asthma control indicator.² However, caution should be exercised in interpreting PEF values in asthmatic patients because this method should not be used to establish a diagnosis of asthma.⁴

The PEF method is easy and can be performed by a skilled health professional. Patients who are capable may also measure their own PEF at home or at work, which facilitates the control of asthma and identifies possible exposure sites causing exacerbations of the disease; therefore, this method also facilitates the diagnosis of occupational asthma.¹ PEF should be measured with the patient in a sitting or standing position. The highest value from 3 forced expiration attempts should be considered as the value of PEF. If 2 of the 3 maneuvers do not reach 40 L/min, then more than 3 measurements should be taken.⁴

Comparative analysis of PEF variation yields a good predictive value for future exacerbations. This analysis of variability is more important than the absolute value of variability.¹,⁴ Variability should be assessed from multiple measurements taken during a minimum of a 2-week period. At least 2 measurements should be taken per day; however, the more measurements that are collected, the better is the estimate. Variability is calculated to obtain the percentage variation between the highest and lowest PEF measurements; up to 20% variability is accepted as normal.⁴,⁵

The clinical application of PEF measurements is limited by patient resistance to monitoring their own levels at home, in addition to the difficulty in storing daily PEF data.⁵ Other limiting factors include the fact that predicted values are currently considered to be obsolete, and that ethnic diversity in populations is not considered.³,⁴

**Spirometry**

Spirometry is the first test requested for patients with suspected airway disease, especially asthma and COPD.⁶-⁹ By measuring pulmonary flow and volume, spirometry can detect the presence and assess the severity of respiratory disorders.¹⁰,¹¹

**Technical aspects**

The patient is requested to place the mouthpiece of the spirometer in his/her mouth,
the nostrils are closed with a nose clip, and the patient is asked to perform maximal inspiration followed by forced maximal expiration. At least 3 acceptable and 2 reproducible maneuvers should be performed before and 15–20 min after inhaling a fast-acting bronchodilator, usually 300 mcg of salbutamol.9,10 Spirometry is a force-dependent test; submaximal force limits its validity and frequently yields erroneous results. Spirometric analysis should always include flow-volume and volume-time curves (figures 1 and 2) because their morphology facilitates assessment of the test’s technical quality and suggests the type of respiratory disorder present.9,10 Contraindications for performing spirometry include the following: hemoptysis, recent angina, retina discoloration, hypertensive crisis, pulmonary edema, and thoracic aortic aneurysm.10 The main parameters that are obtained are as follows: the forced vital capacity (FVC), the FEV1, and the FEV1/FVC ratio (known as the Tiffeneau index).10

Interpretation

The obtained results are compared to predicted values obtained from studies on large populations of healthy subjects. Predicted values generally vary according to sex, race, age, and height. However, to facilitate the use of spirometry, the main guidelines available6-8 use fixed values for interpreting the results. figure 3 shows the basic algorithm for interpreting spirometry. The criteria for assessing bronchodilator response differ between the Brazilian Thoracic Society (SBPT)10 (table 1) and the ATS/ERS (American Thoracic Society / European Respiratory Society)9 (table 2), which is the second most commonly used test. In the SBPT,10 when there is a 7% increase in the FEV1 compared to the predicted value along with 200 mL as the absolute value after inhaling a short-acting beta-2 agonist, the patient is considered to have a positive bronchodilator test. If the patient has no basal obstruction, a 10% increase compared to the predicted value is required for a positive result. In the ATS/ERS,9 the bronchodilator response is considered positive when there is a ≥ 12% increase and ≥ 200 mL of FEV1 or FVC, 15–20 min after inhaling a short-acting bronchodilator (400 mcg of salbutamol). Although FEV1 measurements are recommended before and after use of a bronchodilator for diagnosing and staging of asthma and COPD, assessment of the bronchodilator response should not be used to differentially diagnose asthma or to predict the response to treatment with bronchodilators and/or inhalation corticosteroids.8

Asthma

Spirometry in patients with suspected or diagnosed asthma has 3 objectives:6-8 (1) to confirm diagnosis; (2) to assess the severity of

Figure 1: Flow-volume and volume-time curves obtained by spirometry.
Source: 2002 IV Brazilian Guidelines for Asthma Management.
Functional definitions of asthma and chronic obstructive pulmonary disease (COPD) include (1) airflow obstruction; (2) an increased expiratory phase; and (3) to monitor disease progression and the changes resulting from treatment. The presence of limited airflow that is completely or partially reversed by inhalation of a bronchodilator strongly suggests asthma, but is not pathognomonic. The IV Brazilian Guidelines for Asthma Management list the following criteria as being indicative of asthma: (1) a FEV₁ < 80% of the predicted value and a FEV₁/FVC < 75% in adults and 86% in children; (2) a positive bronchodilator test, based on the criteria from the 2002 Guidelines for Pulmonary Function Tests of the SBPT, which emphasize that limited airflow without a bronchodilator response tested alone should not be interpreted as irreversible airway obstruction; and (3)

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**Table 1: Criteria for assessment of bronchodilator response according to the SBPT.**

<table>
<thead>
<tr>
<th>Without basal obstruction</th>
<th>With basal obstruction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FEV₁</td>
</tr>
<tr>
<td>Absolute change (L, post - pre)</td>
<td>≥ 0.20</td>
</tr>
<tr>
<td>or Percentage change in relation to predicted (%)</td>
<td>≥ 10</td>
</tr>
</tbody>
</table>

FEV₁ = forced expiratory volume in one second; FVC = forced vital capacity; VC = vital capacity; IC = inspiratory capacity.

**Table 2: Criteria for assessment of bronchodilator response according to the ATS/ERS**

<table>
<thead>
<tr>
<th>FEV₁</th>
<th>FVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute change (L, post - pre)</td>
<td>≥ 0.20</td>
</tr>
<tr>
<td>and</td>
<td>or</td>
</tr>
<tr>
<td>Percentage change in relation to predicted (%)</td>
<td>&gt;12</td>
</tr>
</tbody>
</table>

FEV₁ = forced expiratory volume in one second; FVC = forced vital capacity.
Figure 3: Basic algorithm for the interpretation of spirometry.

*FEV₁/FVC normal with FEV₁ normal and FVC > 120% of predicted can be classified as “physiological variant”. OLD = obstructive lung disease. IVD = indetermined ventilatory disease
***The presence of normal spirometric indices before bronchodilator use with a positive bronchodilator response suggests “increased bronchomotor tone.”

A greater than 20% increase in FEV₁ and a 250 mL spontaneous increase over time or after intervention with a controlling drug (i.e., 30–40 mg of oral prednisone/day for 2 weeks).

The Global Initiative for Asthma (GINA) document uses the FEV₁/FVC ratio as a parameter for assessing the presence of limited airflow. A Tiffeneau index below 0.75–0.80 for adults or below 0.90 for children indicates the presence of lower airway obstruction. Asthma is classified based on the level of control, considering the patient's clinical and functional parameters. The presence of a FEV₁ or PEF below 80% of either the predicted value or the patient's best value (as measured previously) is one of the criteria for classifying asthma as uncontrolled or partially controlled.

COPD

The definition of COPD (chronic airflow obstruction that is not fully reversible) requires that spirometry be used for diagnosis. Obstructive patterns observed by spirometry that are not fully reversible after bronchodilation in patients who are older than 40 years and have a history of exposure to inhaled gases or particles (mainly smoking) are strongly suggestive of COPD, even in asymptomatic individuals.

Although the only impact of COPD is on the degree of limited airflow, post-bronchodilator FEV₁ measurement is used to classify COPD severity, as shown in table 3. The correlation between the degree of obstruction and the severity of symptoms is weak; however, spirometry, which is a practical and low-cost test, is commonly used as a tool for staging of the disease. In addition to the diagnosis and classification of severity, FEV₁ measurements have also been combined with other parameters for determining COPD prognosis (table 4).

Bronchial provocation test

The bronchial provocation test should always be considered when asthma is a likely diagnosis because traditional methods, especially simple spirometry, cannot establish the diagnosis of this condition. The bronchial provocation test also has great value in diagnosing occupational asthma in individuals exposed to sensitizers in the workplace. In asthma, it appe-
ars that inhaling cold air during hyperventilation is the triggering factor for the entire process. Heat that is lost from the bronchial tree to warm the cold, inspired air is the primary cause of subsequent pathophysiological phenomena.12

The most widely applied method for evaluating bronchial hyper-responsiveness involves administering aerosols of pharmacological agents—generally, histamine, methacholine, and carbachol—that affect the contractile airway muscle. Changes in lung function (decreasing FEV₁) are measured by serial spirometry after inhalation of increasing doses of these substances. The results are expressed as the cumulative dose or the agonist concentration that produces a 20% decrease in FEV₁ (figure 4). Individuals with bronchial hyper-responsiveness exhibit a better response to these agents.13

Static lung volumes and airway resistance

When evaluating static lung volumes in obstructive diseases, the most striking phenomenon is increased residual volume (RV), which is due to airway closure at higher than normal lung volumes. Due to the loss of elastic recoil, the functional residual capacity (FRC) also increases. Another mechanism that is responsible for increasing FRC is the shortening of expiratory time, when inspiration begins before completion of expiration and elimination of air from the lungs—that is, before the resting point of the respiratory system has been reached.

The total lung capacity (TLC) is determined

<table>
<thead>
<tr>
<th>Phase</th>
<th>Classification</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>MILD</td>
<td>• FEV₁/FVC &lt; 70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• FEV₁ post-BD ≥ 80%</td>
</tr>
<tr>
<td>II</td>
<td>MODERATE</td>
<td>• FEV₁/FVC &lt; 70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• FEV₁ post-BD ≥ 50% and &lt; 80%</td>
</tr>
<tr>
<td>III</td>
<td>SEVERE</td>
<td>• FEV₁/FVC &lt; 70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• FEV₁ post-BD ≥ 30% and &lt; 50%</td>
</tr>
<tr>
<td>IV</td>
<td>VERY SEVERE</td>
<td>• FEV₁/FVC &lt; 70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• FEV₁ post-BD &lt; 30% or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• FEV₁ post-BD ≥ 30% and &lt; 50% + chronic respiratory failure*</td>
</tr>
</tbody>
</table>

FEV₁ = forced expiratory volume in one second; FVC = forced vital capacity; BD = bronchodilator.

* Arterial oxygen pressure (PaO₂) < 60 mmHg (in room air, at sea level).

Table 3: Staging of COPD according to the GOLD

<table>
<thead>
<tr>
<th>Variables</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>1</td>
</tr>
<tr>
<td>FEV₁ (% predicted)</td>
<td>2</td>
</tr>
<tr>
<td>6MWT</td>
<td>3</td>
</tr>
<tr>
<td>MRC dyspnea scale</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 4: BODE index

<table>
<thead>
<tr>
<th>Variables</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>1</td>
</tr>
<tr>
<td>FEV₁ (% predicted)</td>
<td>2</td>
</tr>
<tr>
<td>6MWT</td>
<td>3</td>
</tr>
<tr>
<td>MRC dyspnea scale</td>
<td>4</td>
</tr>
</tbody>
</table>

BMI = body mass index; FEV₁ = forced expiratory volume in one second; 6MWT = 6-minute walk test; MRC = Medical Research Council.
by the pulmonary and thoracic elasticities as well as respiratory muscle strength; because these muscles cannot increase in strength to similar percentage levels as the increase in FRC caused by disease, a patient with an obstructive disorder cannot increase their inspiratory capacity (IC). Since the increases in TLC, if any, are less than the increases in FRC, the IC decreases. This phenomenon also explains why the vital capacity (VC) can be reduced in asthma and COPD. Under these conditions, reduced VC is more easily observed when the RV is greatly increased while the TLC is minimally elevated and not proportional to the increased RV; hence, the RV/TLC ratio can be used as an indication of lung hyperinflation (figure 5).13

Static volumes can be determined by whole-body plethysmography or by the gas dilution technique. Whereas plethysmography facilitates measurement of the overall volume in the intrathoracic gas compartments, the gas dilution technique does not measure the volume of gas sectors that have no contact with the airways. Therefore, the plethysmographic method is distinctly advantageous for use in patients with obstructive diseases, especially in cases of bullous emphysema, in which TLC measurements may be 2–3 liters higher when obtained by plethysmography. Furthermore, this technique also facilitates the measurement of airway resistance, which is useful for confirming the presence and severity of obstruction, demonstrating the bronchodilator response, and assessing expiratory collapse.13

Diffusion capacity

The diffusion test is a gas exchange measurement and, as such, tends to change early in the course of certain diseases and/or conditions that compromise the lungs. The test examines gas transfer from the alveoli into red blood cells. However, for diffusion to occur, it is necessary to overcome 2 barriers in series: (1) alveolar wall + basal membrane + interstitial tissue and (2) capillary wall + plasma + hematic wall + hemoglobin.

The diffusion test requires using a gas with a high affinity for hemoglobin or with high solubility in the plasma. Both oxygen (O₂) and CO satisfy this criterion; however, CO has an affinity for hemoglobin that is 210 times higher than that of O₂ and is therefore preferred. Furthermore, the capillary pressure of CO is practically zero, which further facilitates measurement of

Figure 4: Test bronchial by histamine, showing the cumulative dose and the concentration of agonist that produced a 20% decrease in FEV₁.
its diffusion.\textsuperscript{14}

In the context of obstructive bronchial syndrome, a reduction in the CO diffusion (DLCO) can indicate emphysema because it is caused by loss of the alveolar surface and damage to the pulmonary capillary bed. In COPD, this measurement has also been used to indicate an accelerated decrease in FEV\textsubscript{1} and decreased survival. Measurements that are less than 50\% of the theoretical values are associated with desaturation during exercise, indicating imminent O\textsubscript{2} use. As in asthma, diffusion is normal or even elevated. This increased DLCO is apparently related to the redirection of blood flow to the lung apices, especially during periods of disease crisis.\textsuperscript{15}

Exercise testing

In recent decades, there have been considerable advances in understanding cardiorespiratory integration dynamics. The growing interest in cardiopulmonary exercise testing (CPET) was essentially driven by its noninvasive nature, as well as increased recognition of the various pathophysiological patterns of exercise and technological and computational advances. Furthermore, there has been a sustained absence of a single rest variable—whether clinical, functional, or biochemical—that can accurately predict the fitness of an individual to perform a physical task. Currently, the integrated assessment of metabolic, respiratory, and cardiovascular responses during exercise plays an important role in diagnosing and prognosing cardiopulmonary diseases, and is primarily based on 3 criteria: (1) early detection of functional changes, because abnormalities that are undetected at rest can be easily identified during exercise, when the cardiovascular and pulmonary systems are functionally overloaded; (2) greater impact on clinical decisions regarding the underlying pathophysiological process, because it has a much more palpable anatomo-physiological substrate; and (3) a standard CPET protocol, which provides the only firm evidence that an individual is functioning normally, rendering it unnecessary to perform further tests.\textsuperscript{15}

In COPD, CPET can be particularly useful in differentiating between dyspnea with a pulmonary etiology and dyspnea with a cardiovascular origin, which is a common situation in clinical practice. Moreover, in these patients, CPET may be used to indicate and assess the therapeutic effect of O\textsubscript{2}.\textsuperscript{15}

Can asthma be functionally distinguished from COPD?

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\textbf{Figure 5: Behavior of different lung volumes in pulmonary and extrapulmonary conditions.}
Asthma and COPD are major respiratory diseases worldwide, and it is critical to differentiate between these 2 conditions in clinical practice because the therapeutic measures that should be adopted for each are distinct. Understanding the functional differences between asthma and COPD is invaluable for studying their pathology.

Although we have discussed the various COPD phenotypes and the clinical syndromes that are distinct forms of asthma, we are often faced with only the basic disease type. Ultimately, the question remains as to what the functional difference between asthma and COPD is. When this question is asked of fourth year medical students, their first response is that asthma is an obstructive lung disease with a positive bronchodilator test and that COPD is an obstructive lung disease in smokers or ex-smokers, with a negative bronchodilator test. While these students are not entirely wrong, this simplistic analysis does not consider all the functional nuances of these 2 obstructive diseases.

When faced with a young patient who is a non-smoker with a history of allergic rhinitis and who reports that his or her symptoms vary throughout the day, the onset of respiratory symptoms, along with spirometry results, demonstrate an obstructive disorder that establishes the diagnosis of asthma. By contrast, when presented with a middle-aged patient who has smoked more than 40 pack-years and who complains of dyspnea that has progressively worsened over the years, we expect to find a functional analysis typical of COPD upon spirometry. These are classic cases that are easily resolved.

However, we often find it difficult to functionally differentiate between the 2 pathologies of asthma and COPD. The following are examples of these situations: asthmatic smokers; young, severely asthmatic individuals exhibiting fixed airway obstruction with bronchial remodeling; patients with COPD and excessive responses to bronchodilators; and patients with both diseases (the overlap syndrome). Additionally, spirometry combined with the bronchodilator test sometimes fails to distinguish whether patients have asthma, COPD, or the overlap syndrome. A clinical history and a cytological sputum analysis (when available) along with spirometry would facilitate this differentiation. However, a full functional test may be requested to help differentiate these pathologies, using techniques such as the following:

1) assessment of the static lung volumes when spirometry results do not elucidate the diagnosis; the TLC, RV, and FRC are usually lower in asthma than in COPD;

2) measurement of DLCO, which is also a resource for differentially diagnosing between the 2 diseases when this is not possible by spirometry alone; the DLCO is normal or increased in asthma and reduced in COPD;

3) analysis of exhaled nitric oxide (NO), which is performed in a specialized laboratory and is difficult to implement due to its high cost; however, this test appears to be highly predictive—values above 16 ppb suggest asthma, whereas values below 16 ppb suggest COPD (table 5).

How is the functional monitoring of asthma and COPD performed?

Asthma

The assessment of asthma control includes management of clinical manifestations and reduction of future risks such as exacerbations, accelerated decline in lung function, and side effects of treatment. Asthma control can be obtained in most asthmatics when they are properly monitored and treated. One of the control criteria is the pulmonary function test, which should be normal or near normal (table 6). Periodically monitoring the control of asthma is fundamental to adjust adjustments to treatment. Since patients with asthma, particularly those individuals with long-standing disease, tend to underestimate the severity of their symptoms, pulmonary function tests are
required for the objective evaluation of limited airflow, as well as its reversibility and variability. The term reversibility refers to a rapid increase in FEV₁ or PEF 10–20 min after inhaling a fast-acting bronchodilator or to a sustained increase in these measurements after introducing an effective control treatment with inhalation corticosteroids. The term variability applies to the symptoms and lung functions that improve or deteriorate over the course of one day (diurnal variability), from one day to another, from month to month, or from one season to another (seasonal variability). The greater the variability, the more ineffective is the asthma control. Both reversibility and variability indicate the presence of bronchial hyper-responsiveness and, in final analysis, airway inflammation. Ideally, one should perform spirometry at each patient visit and assess the bronchial responsiveness annually; moreover, the patients themselves should take serial PEF measurements at home.

PEF measurements, described above, are useful for assessing the control of asthma. Modern PEF gauges are portable, relatively inexpensive, and can be used by patients at home without medical supervision to obtain objective measurements of limited airflow. One of the disadvantages of measuring PEF is that its value does not correlate with FEV₁ or other spirometric indices. Another disadvantage is that PEF can underestimate the degree of limited airflow, particularly when there is trapped air. In addition, PEF values differ based on the meter model, and the range of normal values is wide. Consequently, for monitoring purposes, PEF values should be compared with the patient’s best previous value, using their own PEF meter. The patient’s best previous value is obtained during the asymptomatic or optimized-treatment state and serves as a reference to monitor the effects of any changes in treatment and assess crisis severity. One should be careful to instruct the patient on how to obtain a reliable PEF measurement because this value is dependent on effort. Generally, the patient is instructed to obtain their first measurement in the morning before taking any medication (when the lowest daily value is expected) and to obtain their second measurement at night (when the highest daily value is expected). Self-monitoring of PEF for treating asthmatic exacerbations may improve crisis outcomes.

COPD

The Global Initiative for Chronic Obstructive Lung Diseases (GOLD) document recommends that the monitoring of patients with COPD should include the following assessments: (1) exposure to risk factors, especially cigarette smoking; (2) disease progression and the presence of complications; (3) pharmacological and non-pharmacological therapies.

Table 5: Differentiating asthma from COPD

<table>
<thead>
<tr>
<th>Functional testing</th>
<th>Asthma</th>
<th>COPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak expiratory flow</td>
<td>• Used fairly commonly—allows analysis of variability</td>
<td>• Not used</td>
</tr>
<tr>
<td>Spirometry</td>
<td>• FEV₁/FVC reduced</td>
<td>• FEV₁/FVC reduced</td>
</tr>
<tr>
<td></td>
<td>• FEV₁ reduced</td>
<td>• FEV₁ reduced</td>
</tr>
<tr>
<td></td>
<td>• FVC normal or reduced if RV increased</td>
<td>• FVC normal or reduced if RV increased</td>
</tr>
<tr>
<td></td>
<td>• BD test positive (flow–FEV₁ varying from 200 mL and 12%–and volume–FVC varying from 350 mL)</td>
<td>• BD test negative</td>
</tr>
<tr>
<td>Carbon monoxide diffusion</td>
<td>• Normal or increased</td>
<td>• Reduced</td>
</tr>
<tr>
<td>Nitrogen oxide exhalation</td>
<td>• Over 16 ppb</td>
<td>• Under 16 ppb</td>
</tr>
</tbody>
</table>

FEV₁ = forced expiratory volume in one second; FVC = forced vital capacity; RV = residual volume; BD = bronchodilator
treatments; (4) history of exacerbations; and (5) comorbidities. COPD is a progressive disease; thus, a decline in pulmonary function over time is expected, even with optimal treatment. In addition to monitoring of symptoms, objective measurements of limited airflow using pulmonary function tests should be performed periodically to detect possible complications and determine when treatment should be modified.⁸

For COPD, spirometry should be performed periodically; however, repeating this test within an interval of less than one year in stable patients has not proven useful.²⁸ In addition to this periodic assessment, spirometry should be performed if any of the usual symptoms significantly worsen or if any complications arise. Other pulmonary function tests such as measurement of DLCO and the static lung volumes are not routinely necessary.⁸ Arterial blood gas analysis is indicated for patients who have an oxygen saturation (SpO₂) of less than 92%⁸ in order to detect the presence of respiratory failure (arterial oxygen pressure [PaO₂] < 60 mmHg with or without arterial carbon dioxide pressure [PaCO₂] > 50 mmHg),⁸ which would put the patient at another stage of the disease and have a direct effect on therapy.⁸ Measuring the maximal inspiratory pressure (MIP) is useful for assessing patients in whom dyspnea or hypercapnia cannot be completely explained by respiratory function tests or in whom muscular weakness is suspected. This measurement can improve in COPD patients after rehabilitation, whereas other patients do not improve.²⁷-²⁹ Exercise tests (CPET, the 6-minute walk test, and the shuttle test) are indicated for those patients who are enrolled in cardiopulmonary rehabilitation programs.⁸

### References


### Table 6: Differentiating asthma from COPD.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>CONTROLLED (all features)</th>
<th>PARTIALLY CONTROLLED (≥ one feature in any week)</th>
<th>NOT CONTROLLED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daytime symptoms</td>
<td>≤ 2/week</td>
<td>&gt; 2/week</td>
<td>≥ 3 features of partially controlled asthma</td>
</tr>
<tr>
<td>Limitation of activities</td>
<td>None</td>
<td>Present at any time</td>
<td></td>
</tr>
<tr>
<td>Nocturnal symptoms</td>
<td>None</td>
<td>Present at any time</td>
<td></td>
</tr>
<tr>
<td>Need for relief medication</td>
<td>≤ 2/week</td>
<td>&gt; 2/week</td>
<td></td>
</tr>
<tr>
<td>Pulmonary function (FEV₁ or PEF)</td>
<td>Normal</td>
<td>&lt; 80% of predicted or patient’s best value</td>
<td></td>
</tr>
</tbody>
</table>

FEV₁ = forced expiratory volume in one second; PEF = peak expiratory flow.


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