In this article...

- How to interpret spirometry results
- Interpreting abnormal spirometry results
- The differences between obstructive and restrictive lung disease

Good technique is essential when undertaking spirometry tests, and correct interpretation of the results is important to avoid making an incorrect diagnosis.

Lung function results are reported as absolute values in litres, and as a percentage of predicted values based on age, height, sex and ethnicity. Studies have been carried out on a large population of white people to determine the reference range of results. A correction factor can be applied to the spirometry machine for different ethnic groups. This is because their predicted results may differ from the standard predicted values (Pellegrino et al, 2005; Hankinson et al, 1999).

Interpreting spirometry results

A mean (mid) value is used as the reference value when interpreting results but there are upper and lower levels of normal values; lung volumes of 80-120% of the predicted values are considered to be within normal limits (American Thoracic Society, 1991). Population studies of predicted values for adolescents and the older age group are limited, and the predicted values used are often an extrapolation (Stanojevic et al, 2008). It is therefore important that all results are interpreted alongside the patient’s clinical status.

In healthy people, around three-quarters of the forced vital capacity (FVC) can be exhaled in the first second. Therefore, the forced expiratory volume in one second (FEV1) should be around three-quarters of the FVC. This gives an FEV1:FVC ratio (FEV1/FVC or FEV1%) of around 0.75 or 75% (Miller, 2008). Figure 1 shows how the slope for the normal values rises rapidly to reach its high point before declining and producing a record of the FVC.

Abnormal spirometry results

Abnormal results can be divided into obstructive and restrictive types (Table 1).

Obstructive lung disease

Air flow obstruction, whether acute or chronic, will reduce the FEV1 by increasing the airway resistance to expiratory flow. In chronic air flow obstruction, the chronic resistance can lead to chronic hyperinflation of the lungs. Due to premature closing intrapulmonary conditions affecting lung elasticity

4 Reversibility testing can help practitioners differentiate between asthma and COPD

5 Interpreting spirometry results requires an understanding of lung volumes and conditions that can affect lung function. Training is essential if accurate results are to be obtained.

COPD in a 79-year-old female smoker.

<table>
<thead>
<tr>
<th>FEV1</th>
<th>FVC</th>
<th>FEV1/FVC ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&gt;80% predicted</td>
<td>&gt;80% predicted</td>
</tr>
<tr>
<td>Obstruction</td>
<td>&lt;80% predicted</td>
<td>Normal or low</td>
</tr>
<tr>
<td>Restriction</td>
<td>&lt;80% predicted</td>
<td>&lt;70%</td>
</tr>
</tbody>
</table>
of the airways on expiration, the FVC will also decrease but not as much as the FEV1. The FEV1/FVC will fall. The flow/volume graph has a concave appearance (Fig 1). The volume/time graph will show a line that rises slowly to reach its highest point, completing the full expiratory manoeuvre (Fig 2).

When a forced expiration is performed with severely obstructed airways, there may be more collapse of the airways, giving a greater concave appearance (Fig 3). More air can usually be exhaled from the lungs using a relaxed manoeuvre with a prolonged expiratory time, measuring the vital capacity (VC) of the lungs. In these cases, the VC will be higher than the FVC, and the FEV1/VC ratio will give the “best” results for that patient (Levy et al, 2009).

An FEV1/FVC of <0.7 (70%) is diagnostic of airflow obstruction and confirms obstructive disease (NICE, 2010). However, a lower than normal FEV1/FVC may not be abnormal for an asymptomatic older person. The FEV1 does not have to be <80% predicted for a diagnosis of airflow obstruction. If the FEV1 is >80% predicted value with an FEV1/FVC of <0.7 (70%), a diagnosis of COPD should only be made in the presence of respiratory symptoms such as breathlessness or cough. This would be classified as stage 1 (mild) COPD.

### TABLE 2. DIAGNOSING COPD SEVERITY

<table>
<thead>
<tr>
<th>Post-bronchodilator FEV1/FVC</th>
<th>Post-bronchodilator FEV1 % predicted</th>
<th>Post-bronchodilator FEV1</th>
<th>Post-bronchodilator FEV1/FVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.7</td>
<td>80%</td>
<td>Stage 1 (mild)*</td>
<td>&lt;0.7</td>
</tr>
<tr>
<td>&lt;0.7</td>
<td>50–79%</td>
<td>Stage 2 (moderate)</td>
<td>&lt;0.7</td>
</tr>
<tr>
<td>&lt;0.7</td>
<td>30–49%</td>
<td>Stage 3 (severe)</td>
<td>&lt;0.7</td>
</tr>
<tr>
<td>&lt;0.7</td>
<td>&lt;30%</td>
<td>Stage 4 (very severe)**</td>
<td>&lt;0.7</td>
</tr>
</tbody>
</table>

* Symptoms should be present to diagnose COPD in people with mild airflow obstruction.

** Or FEV1 <50% with respiratory failure

Source: NICE (2010)

### TABLE 3. IDENTIFYING ASTHMA VERSUS COPD USING REVERSIBILITY TESTING

<table>
<thead>
<tr>
<th>COPD</th>
<th>Asthma</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV1 increase in response to bronchodilators</td>
<td>Possibly &gt;200ml or 15% in mild disease</td>
</tr>
<tr>
<td>FEV1 increase in response to 30mg oral prednisolone for 2 weeks</td>
<td>Possibly &gt;200ml or 15% in mild disease</td>
</tr>
<tr>
<td>Serial peak expiratory flow recordings for 2 weeks</td>
<td>Little diurnal or day-to-day variation</td>
</tr>
<tr>
<td>Appropriate inhaled steroid and bronchodilator therapy</td>
<td>20% or greater diurnal or day-to-day variation</td>
</tr>
</tbody>
</table>

Source: NICE (2010)
The severity of disease is determined by the FEV1 (Table 2).

The presence of irreversible or limited airflow obstruction should be confirmed by performing post-bronchodilator spirometry.

Where there is doubt over diagnosis, NICE (2010) recommends using reversibility testing to help differentiate between asthma and COPD (Table 3). Reversibility of FEV1 by more than 400ml or 20% suggests a diagnosis of asthma. If the condition has been untreated or undertreated for some time, there may be a degree of irreversibility where lung function will not return to predicted values.

If asthma is suspected from the patient’s history, but the patient is asymptomatic and the resting spirometry is normal, home serial peak flow measurements should be undertaken morning and evening for a minimum of two weeks. A diagnosis of asthma is confirmed if the results demonstrate a 20% or greater daily variability (NICE, 2010).

Other causes of obstruction include:
- Enlarged thyroid gland (goitre);
- Tumour;
- Inhaled foreign body;
- Epiglottal closure;
- Straining of throat area, such as vocal cord dysfunction.

Restrictive lung disease

Restrictive lung disease is caused by extrapulmonary conditions affecting movement of the chest wall (Box 1) and intrapulmonary conditions affecting lung elasticity (Box 2). Both affect inflation of the lungs and cause lung volumes to be reduced, but the calibre of the airways is unaffected. The volume/time graph has a shape similar to normal, but with a lower FEV1 and a lower FVC (Fig 4). The flow/volume graph has a squashed appearance (Fig 5).

Restrictive disorders have a near-normal or higher than normal FEV1/FVC, but both the FEV1 and FVC are reduced proportionally.

Mixed spirometry results

If a patient has asthma or COPD and develops a significant consolidation, such as pneumonia or a pleural effusion, the results may demonstrate airflow obstruction and some restriction. The patient is likely to be symptomatic and should have a clinical review.

**Box 1. Extrapulmonary Causes of Restrictive Lung Disease**
- Scoliosis
- Kyphosis
- Ankylosing spondylitis
- Diaphragm paralysis/elevated hemidiaphragm
- Neuromuscular diseases, such as polio, Guillain-Barre syndrome and Myasthenia gravis
- Obesity

**Box 2. Intrapulmonary Causes of Restrictive Lung Disease**
- Pulmonary fibrosis
- Drug induced fibrosis, for example with amiodarone or methotrexate
- Extrinsic allergic alveolitis
- Sarcoidosis
- Asbestosis

**Conclusion**

Spirometry should be performed at the time of diagnosis or suspected diagnosis, to monitor disease progression, and ascertain whether the diagnosis needs to be reconsidered. It is important that the practitioner is fully trained in spirometry testing to achieve consistently accurate and precise results, and to interpret the results correctly. To become competent in interpreting spirometry results, an understanding of lung volumes, the diseases and conditions that may affect lung function, and plenty of practice is required.

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**References**


