Spirometry

Miranda A Paraskeva
Brigitte M Borg
Matthew T Naughton

This article forms part of our ‘Tests and results’ series for 2011 which aims to provide information about common tests that general practitioners order regularly. It considers areas such as indications, what to tell the patient, what the test can and cannot tell you, and interpretation of results.

Spirometry measures the flow and volume of air entering and leaving the lungs. It is used to assess ventilatory function and differentiates between normality and diseases causing obstructive and possibly restrictive defects.

Keywords: asthma; respiratory tract diseases; pulmonary disease, chronic obstructive; respiratory tract diseases

Spirometry should be performed early in the assessment of a patient presenting with symptoms of ventilatory dysfunction. Common indications are listed in Table 1.

Precautions

While spirometry is generally considered to be safe, high airway and intrathoracic pressures are generated during the test, hence it is not recommended in the following settings: 1

- if the patient is unable to cooperate or sit upright
- recent pneumothorax (within 6 weeks)
- unstable angina or recent myocardial infarction (within 4 weeks)
- haemoptysis (within 48 hours)
- recent abdominal, thoracic or eye surgery (within 6 weeks)
- thoracic, aortic or cerebral aneurysm
- suspected or confirmed communicable infectious disease (eg. tuberculosis or influenza).

Patient preparation

Most patients are able to complete the test when coached by a trained respiratory technician. An interpreter is recommended in patients with a limited understanding of English.

The patient should: 2

- attempt to withhold inhaled medications, especially short acting (for 4–6 hours) and long acting (for 12–24 hours) bronchodilators
- not smoke or perform strenuous exercise on the day of the test
- not consume alcohol or eat a large meal within 4 hours of the procedure
- wear unrestricted, loose clothing during the procedure.

How to do the test

With the patient sitting upright on a chair or in standing position, and with their lips sealed tightly around a spirometer mouthpiece, the patient is asked to exhale as hard and as fast as they can from a position of maximal inhalation until they cannot blow out any more.

How does the test work?

Spirometry provides three measurements:

- Forced vital capacity (FVC) is the maximal volume of air that can be forcibly expelled from the lungs from a position of maximal inhalation. It indicates lung volume
- Forced expiratory volume in 1 second (FEV1) is the maximal volume of air exhaled in the first second of an FVC manoeuvre. In individuals with normal lung function this is 75–80% of FVC. FEV1 reflects the mechanical properties of the large and medium sized airways
- Forced expiratory ratio (FEV1/FVC or FER%) is the ratio of FEV1 to FVC, expressed as a percentage. It assists with distinguishing obstruction from possible restriction when FEV1 is reduced. If restriction is suspected, further testing with static lung volumes may be required.

Flow volume loop

The flow volume loop (Figure 1) illustrates the relationship between flow and volume as a maximal effort from maximal inspiration to maximal expiration (positive flows) and from maximal expiration to maximal inspiration (negative flows). The shape of the loop depends on the mechanical properties of the lungs and may assist in the diagnosis of ventilatory dysfunction.
Interpretation of results

Simplistically, ventilatory impairment diagnosed on spirometry can be divided into:
- obstructive
- restrictive, and
- mixed defects (Table 2).

Obstructive ventilatory defect

Obstructive airways disease is characterised by expiratory airflow limitation. There is a disproportionate reduction in FEV₁ as compared to FVC (decreased FEV₁/FVC ratio).

The typical obstructive flow volume loop shows concavity of the expiratory limb (Figure 2). Lung volume determination is rarely used to confirm obstructive disease. Assessment of bronchodilator reversibility is usually relevant.

Bronchodilator reversibility

Significant bronchodilator reversibility is defined by a 12% and greater than 200 mL increase in either FEV₁ or FVC (or both).³ It is assessed by the administration of a short acting beta 2 agonist and repeating spirometry after around 10 minutes.⁴ Failure to respond does not preclude clinical benefit from bronchodilators.

### Table 1. Indications for spirometry

<table>
<thead>
<tr>
<th>Evaluation of symptoms, signs or abnormal investigations*</th>
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<tbody>
<tr>
<td>Symptoms: chronic cough, dyspnoea, wheeze, orthopnoea, sputum production</td>
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<tr>
<td>Signs: chest deformity (barrel chest), cyanosis, prolonged expiration, wheeze/stridor, unexplained crackles</td>
</tr>
<tr>
<td>Investigations: hypoxaemia, hypercapnia, polycythaemia, abnormal chest X-ray</td>
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<thead>
<tr>
<th>To follow the course of disease and assess prognosis</th>
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<tr>
<td>To screen at risk individuals**</td>
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<tr>
<td>History of tobacco smoking</td>
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<tr>
<td>Occupational exposure</td>
</tr>
<tr>
<td>Use of drugs with potential pulmonary toxicity</td>
</tr>
<tr>
<td>Neuromuscular diseases (eg. motor neurone disease, Guillain-Barre syndrome)</td>
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<th>To monitor therapy</th>
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<tr>
<td>* Medicare rebate available for pre- and post-bronchodilator spirometry</td>
</tr>
<tr>
<td>** Screening for employment or recreational activities is not covered by Medicare</td>
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</tbody>
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### Table 2. Causes of obstructive and restrictive impairment on spirometry

<table>
<thead>
<tr>
<th>Restrictive lung disease</th>
<th>Obstructive lung disease</th>
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<tbody>
<tr>
<td>Pulmonary fibrosis</td>
<td>Chronic obstructive pulmonary disease (COPD)</td>
</tr>
<tr>
<td>Neuromuscular disorders</td>
<td>Asthma</td>
</tr>
<tr>
<td>Congestive cardiac failure</td>
<td>Bronchiectasis/cystic fibrosis</td>
</tr>
<tr>
<td>Sarcoidosis</td>
<td>Cystic fibrosis</td>
</tr>
<tr>
<td>Obesity</td>
<td>Bronchiolitis</td>
</tr>
<tr>
<td>α1 – antitrypsin deficiency</td>
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### Figures

1. Normal flow volume loop
2. Flow volume loop showing an obstructive ventilatory defect
3. Flow volume loop showing a restrictive ventilatory defect
In conjunction with history, examination and other investigation modalities, a diagnosis should be made and best practice clinical guidelines followed (eg. the COPD-X Plan or Asthma Management Handbook, see Resources).

If spirometry suggests a restrictive ventilatory defect or restrictive component (eg. mixed defect), then further evaluation with static lung volumes is needed to confirm restriction. Diffusion capacity helps distinguish parenchymal from extraparenchymal disease. Figure 4 provides an algorithm for further investigation.

**What if spirometry is negative or inconclusive?**

A normal spirometry result does not exclude pulmonary disease. If there is a high clinical suspicion of lung disease the patient should be referred for more complex lung function testing in conjunction with other investigations (eg. radiological imaging). Referral to a respiratory physician may be considered.

**Case study**

You review the spirometry results of a female exsmoker, 38 years of age, who presented to her doctor with shortness of breath and wheeze. As the differential diagnosis was asthma, pre- and post-bronchodilator spirometry was requested (Figure 5).

**Resources**

- For spirometry training courses: www.anzsrs.org.au/escourses.html

**Authors**

Miranda A Paraskeva MBBS, is a respiratory registrar, Department of Allergy, Immunology and Respiratory Medicine, Alfred Hospital, Melbourne, Victoria. m.paraskeva@alfred.org.au

Brigitte M Borg BAppSc, CRFS, is Senior Respiratory Scientist, Department of Allergy, Immunology and Respiratory Medicine, Alfred Hospital, Melbourne, Victoria

Matthew T Naughton MD, FRACP, is a respiratory and sleep physician, Department of Allergy, Immunology and Respiratory Medicine, Alfred Hospital and Monash University Melbourne, Victoria.

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**Restrictive ventilatory defect**

Restrictive lung disease cannot be categorically diagnosed by spirometry alone. It is characterised by reduction in the FVC with a normal or increased FEV₁/FVC ratio. Such a result should trigger a diagnostic work up to rule out restrictive lung disease, including more detailed lung volume measurement. The flow volume loop tends to be tall and narrow with steep end expiratory phase (Figure 3).

**Next steps**

An obstructive ventilatory defect requires no further confirmatory pulmonary function testing.
<table>
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<tr>
<th>Spirometry parameters and their units</th>
<th>Baseline % predicted</th>
<th>Postbronchodilator % change</th>
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<tbody>
<tr>
<td>FEV&lt;sub&gt;1&lt;/sub&gt; (L)</td>
<td>3.00</td>
<td>3.70&lt;sup&gt;⁹&lt;/sup&gt; +23%&lt;sup&gt;#&lt;/sup&gt;</td>
</tr>
<tr>
<td>FVC (L)</td>
<td>4.51*</td>
<td>4.85                        +8%</td>
</tr>
<tr>
<td>FEV&lt;sub&gt;1&lt;/sub&gt;/FVC (%)</td>
<td>67%&lt;sup&gt;⁸&lt;/sup&gt;</td>
<td>80%                         76</td>
</tr>
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Technical comments:

Test performance was good

Report:

There is an obstructive ventilatory defect.*
There was a significant response to inhaled bronchodilator.* Results are consistent with a diagnosis of asthma.<sup>⁶</sup>

* Baseline FEV<sub>1</sub>/FVC is below the lower limit of normal (normal range >71%). FVC is within normal limits (>3.13); indicates obstruction

# There was a >12% increase in FEV<sub>1</sub> (23%) that was also >200 mL (700 mL). Therefore the response to inhaled bronchodilator is significant

<sup>⁶</sup> Fully reversible obstructive pattern on spirometry is consistent with suboptimally controlled asthma

**Figure 5. Spirometry results of Case study patient**

**References**


**correspondence** afp@racgp.org.au