Spirometry is carried out in a range of settings, including primary care, hospital wards and outpatient departments. If performed incorrectly, however, it can lead to a misdiagnosis and delayed and/or unnecessary treatment. From 1 April 2017, a national register will be in place to ensure all health professionals who use spirometry are adequately trained and/or qualified. This article offers a quick guide to what spirometry is, how to perform it and how to interpret test results. It also explains the training requirements set out in recent national guidance and how professionals can obtain a certificate of competence.

Spirometry: technical overview and new training and certification requirements

Key points

1 Spirometry is used to measure lung volume and air flow
2 Spirometry can be used as a baseline investigation to refine a diagnosis or monitor disease or treatment, and for reversibility testing
3 New guidance lays out three levels of training: for those who only perform spirometry, those who only interpret spirometry results, and those who do both
4 From 1 April 2017, a national register will list all practitioners who are appropriately trained and/or certified in using spirometry

Spirometry: technical overview and new training and certification requirements

Author Alison Hughes is respiratory nurse specialist at St James’ Hospital, Portsmouth and The Vine Medical Group GP Surgery, Waterlooville.

Abstract Spirometry testing is easy to perform and can be used anywhere but, if performed incorrectly, it can lead to a misdiagnosis and delayed and/or unnecessary treatment. From 1 April 2017, a national register will be in place to ensure all health professionals who use spirometry are adequately trained and/or qualified. This article offers a quick guide to what spirometry is, how to perform it and how to interpret test results. It also explains the training requirements set out in recent national guidance and how professionals can obtain a certificate of competence.

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What is spirometry?

Spirometry is used to measure patients’ lung volume and air flow. It is the recommended tool for diagnosing, assessing and monitoring chronic obstructive pulmonary disease (National Institute for Health and Care Excellence, 2010). In NICE’s (2015) draft asthma guidance, spirometry is mentioned as one of the tests health professionals should aim to use, along with fractional exhaled nitric oxide, to diagnose asthma in anyone aged over five years.

As it is an effort-dependent test, spirometry is best performed when the patient is well. It shows a pattern of airflow and lung volumes rather than disease. The patterns can be:

- Normal;
- Obstructive – suggestive of COPD or asthma;
- Restrictive – suggestive of conditions such as interstitial lung disease;
- Combined – both obstructive and restrictive together.

Spirometry test results are only one piece in the jigsaw; to inform diagnosis, they need to be used in conjunction with:

- A detailed clinical history;
- An assessment of signs, symptoms and risk factors;
- Other tests such as a full blood count and chest X-ray.
Performing spirometry
Who can perform spirometry?
Guidance has recently been published on the level of training practitioners should receive before undertaking diagnostic spirometry (NHS England et al, 2016). There are three levels:

- Foundation certificate – certifies competence to perform spirometry, but not to interpret spirometry results. This is appropriate for healthcare assistants and nurses who do not need to interpret results;
- Full certificate – certifies competence to perform and interpret spirometry. This is appropriate for qualified clinicians, such as practice nurses and respiratory nurse specialists;
- Interpretation only – certifies competence to interpret spirometry results, but not to perform the test. This is appropriate for practitioners such as GPs.

A competency assessment document commissioned by NHS England resulted in the development of a national register. From 1 April 2017, all appropriately trained and/or certified practitioners will be placed on this register, which will be maintained by the ARTP. Anyone will be able to view it, including employers and the public.

Practitioners who perform and/or interpret spirometry will have until 31 March 2021 to undergo the necessary training (Fig 1). For information about available training courses, visit the ARTP’s website (Bit.ly/EducationForHealthCourses).

Lung function indices
Spirometry uses the following main lung function indices:

- Vital capacity (VC) – the maximum amount of air the patient can blow out during a full inspiration to full expiration;
- Forced vital capacity (FVC) – the maximum amount of air the patient can blow out during a full inspiration to full expiration during a forced blow;
- Forced expiratory volume in 1 second (FEV₁) – the maximum volume of air the patient can blow out in the first second of a forced blow;
- FEV₁/FVC – the volume of air expired during the first second of a forced blow, expressed as a percentage of FVC;
- FEV₁/VC – the volume of air expired during the first second of a forced blow, expressed as a percentage of VC;
- Peak expiratory flow (PEF) – maximum speed of expiration.

The ratio used (FEV₁/FVC or FEV₁/VC) depends on which volume measure is the largest. In some patients with obstruction, there may be air trapping, which might result in the VC being larger than the FVC. If the largest volume is not used, the obstruction might be missed.

When to perform spirometry
Spirometry should be performed on:

- Undiagnosed patients who show respiratory symptoms, such as wheeze, cough or shortness of breath (dyspnoea);
- Any patients suspected of having COPD, especially those with a smoking history and daily symptoms (Levy et al, 2009) including chronic cough, breathlessness on exertion, wheeze, frequent winter chest infections and sputum production.

The Quality and Outcomes Framework recommends using spirometry for the annual monitoring of patients with an established diagnosis of COPD. It is also useful to monitor patients who have been given new inhalers to ascertain whether these are effective. There are three situations when spirometry is used:

- Baseline testing – as part of initial investigations of symptoms;
- Post-bronchodilator spirometry – used to diagnose obstructive conditions following a baseline test that has shown obstruction, to determine whether there has been a response to treatment and to monitor disease progression;
- Reversibility testing – used to help differentiate asthma from COPD as

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**Fig 1. The process of obtaining certification of competence in diagnostic spirometry**

1. **I perform spirometry tests without interpreting the results**
2. **I perform spirometry tests and interpret the results**
3. **I interpret the results of tests performed by others**
4. **I have performed spirometry with or without interpretation for many years and consider myself competent**

**Undertake appropriate training**

**Assessment by ARTP-approved assessor**

**Successful training completion leads to certificate of competence**

**Enter certificate of competence in relevant category on the national register**

asthma responds to treatment with bronchodilators; however asthma is variable and might not always fully reverse with a single treatment.

**Contraindications**

Spirometry is an effort-dependent test so patients must be well enough to do it. They should also be asked whether they have any contraindications – classified as absolute or relative (PCC, 2013; Cooper, 2011).

Absolute contraindications are:

- Active infection – for example, tuberculosis showing positive on acid-fast bacillus testing until treated for two weeks;
- Conditions that may have serious negative consequences if aggravated by forced expiration, such as dissecting or unstable aneurysm and current pneumothorax;
- Recent surgery including ophthalmic, thoracic and abdominal surgery and neurosurgery. Relative contraindications are:
  - Suspected respiratory infection in the last 4-6 weeks;
  - Unexplained chest symptoms; for example, haemoptysis;
  - Any condition that may be aggravated by forced expiration, such as previous pneumothorax or an unstable vascular status in the last month (myocardial infarction, uncontrolled hypertension, stroke or pulmonary embolism);
- Communication issues, for example, due to dementia, confusion or learning disabilities.

Calibration and cleaning requirements

The spirometer needs to be quality assured using a calibration check, which should be performed before every session and again every four hours or after every 10 patients (whichever happens first). Checks need to be recorded in a calibration log. If the calibration fails, the equipment should receive its usual full cleaning, then be checked again. If calibration still fails, all tests must be postponed until the equipment has been serviced or repaired.

Cleaning should follow manufacturers’ instructions and local infection control policies (Miller et al, 2005); a cleaning protocol and log are required. One-way mouth pieces or bacterial filters are required for tests.

**Patient information**

Before spirometry testing, all patients should be asked to:

- Avoid smoking for at least 24 hours – or for as long as possible if 24 hours is too much;
- Avoid eating a large meal for four hours;
- Avoid vigorous exercise for 30 minutes before the test – depending on the patient’s condition, the walk from the waiting room to where the test is to be performed could constitute vigorous exercise;
- Avoid wearing tight clothing;
- Avoid having a full bladder.

Patients undergoing a baseline or reversibility test should be asked to stop using short-acting bronchodilators for four hours, long-acting beta-2 agonist bronchodilators for eight hours, and long-acting anticholinergic bronchodilators for 36 hours before the test. They should, however, continue using oral and inhaled steroids (PCC, 2013).

**Procedure**

Patients should be shown what they are required to do, and given lots of encouragement.

When measuring VC:

- Make sure the patient is sitting comfortably and upright, preferably in a chair with arms;
- A nose clip is required, as some air can escape from the nose and will not be recorded;
- Ask the patient to inhale as far as possible then exhale slowly, as if letting out a long sigh for as long as possible;
- Wait at least 30 seconds and repeat;
- At least three blows are required as long as the difference between all blows is no more than 100ml (or 150ml for highly variable patients) (Levy et al, 2009);
- There should be no more than five blows; if the patient is unable to achieve a valid result, the test should be rebooked.

When measuring FVC:

- No nose clip is needed;
- Ask the patient to breathe in to the full then breathe out fast for as long as possible, putting maximum effort into the first second of expiration; encourage the patient to exhale for as long as possible;
- Wait at least 30 seconds and repeat;
- At least three blows are required as long as the difference between blows is no more than 100ml (or 150ml for highly variable patients);
- A maximum of eight blows is recommended; if the acceptability criteria are not achieved after eight blows, the test should be rebooked.

It is important to watch your patient and the read-out from the machine to spot any issues that would interfere with the results, including cough, poor effort, leak around the mouthpiece, slow start, abrupt stop and an extra breath.

Patients requiring reversibility testing need to take their bronchodilator after the baseline test – normally 4 x 100µg salbutamol as single puffs via a spacer or 2.5mg salbutamol via a nebuliser. They then need to wait at least 15 minutes before the forced test is repeated (PCC, 2013).

**Interpreting spirometry**

**Expressing the results**

Lung volumes vary according to:

- Gender – men have a larger lung volume than women;
- Age

**Table 1. Choosing the best results**

<table>
<thead>
<tr>
<th>Blow 1</th>
<th>Blow 2</th>
<th>Blow 3</th>
<th>Best blow</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC (litre)</td>
<td>3.80</td>
<td>3.78</td>
<td>3.72</td>
</tr>
<tr>
<td>FEV₁ (litre)</td>
<td>2.45</td>
<td>2.51</td>
<td>2.48</td>
</tr>
<tr>
<td>FVC (litre)</td>
<td>3.72</td>
<td>3.75</td>
<td>3.82</td>
</tr>
</tbody>
</table>

FEV₁ = forced expiratory volume in 1 second. FVC = forced vital capacity. VC = vital capacity.

**Table 2. Interpreting the patterns**

<table>
<thead>
<tr>
<th>FEV₁/FVC or FEV₁/VC</th>
<th>Normal</th>
<th>Obstructed</th>
<th>Restricted</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;70%</td>
<td>&lt;70%</td>
<td>Normal or reduced</td>
<td>&lt;70%</td>
<td>&lt;70%</td>
</tr>
</tbody>
</table>

FEV₁ = forced expiratory volume in 1 second. FVC = forced vital capacity. VC = vital capacity.

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Nursing Practice

Review

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Age – lung volume naturally starts to reduce after the age of 25;
Height – shorter people have lower lung volumes than taller people.

These three pieces of information need to be recorded and programmed into the spirometer as the predicted values are based on these for each individual. When values are recorded, they are expressed as % predicted – that is, the patient’s test result as a percentage of the predicted values for patients of similar gender, age, and height.

To assist with interpretation of results, the patient’s weight and ethnic background should also be recorded.

Choosing the best results
For interpretation, the best results should be used. These can be from different blows, as long as the blows are technically acceptable and reproducible. In the example in Table 1, the best results have been selected from different blows:
- The best VC is 3.80L and the worst is 3.72L, so there is 80ml between the blows, which is acceptable;
- The best FEV^1 is 2.51L and the worst is 2.45L, so there is 60ml between the blows, which is acceptable;
- The best FVC is 3.82L and the worst is 3.72L, so there is 100ml between the blows, which is acceptable.

The FVC is larger than the VC, so the FVC should be used.

Interpreting the patterns
As stated, the patterns spirometry shows are either normal, obstructed, restricted or combined (Table 2).

To visualise an obstructed pattern, imagine you are inflating a balloon but pinching it when letting the air out – the air goes in well but takes a while to come out. For a restricted pattern, imagine you are inflating a balloon inside a cup, then letting it go – the air goes in well but there is not much room for it so it is released quickly. For a combined pattern, there is a mixture of both phenomena.

The shape of the flow-volume curve on the spirometry graph (Fig 2) gives a great deal of information; results should not be interpreted without looking at their graphical display.

The spirometer displays the curve that is expected given the patient’s gender, age and height. If there is obstruction, the flow-volume curve is concave (the airways have started to collapse). When the obstruction is severe, the curve takes a more pronounced ‘church steeple’ form. In cases of restriction, the curve looks like the normal pattern but is smaller. If an obstructive pattern is recorded, the FEV^1 is used to grade the severity of the obstruction (Table 3).

In primary care, NICE (2010) guidance is used; this is the same as the Global Institute for Chronic Lung Disease’s (2017) guideline.

Reversibility
How reversibility is determined in adults depends on the guideline used:
- The British Thoracic Society and Scottish Intercollegiate Guidelines Network (2016) asthma guideline and the NICE (2015) draft asthma guideline say a 12% increase in FEV^1, together with a 200ml increase in volume is considered a positive reversibility test and indicates asthma;
- The NICE (2010) COPD guideline states a 400ml increase in FEV^1 is considered positive reversibility.

In children, a 12% increase in FEV^1 is considered positive (NICE, 2015).

The BTS and SIGN (2016) asthma guideline goes on to say that a 400ml increase in FEV^1 would strongly suggest asthma in adults; if there is a 400ml improvement in FEV^1, this does not mean the patient does not have asthma. It may be that a trial of treatment is required before spirometry is repeated or a serial peak flow diary is completed in both adults and children. Some patients with COPD will also have some reversibility (BTS and SIGN, 2016), which is one reason why a thorough clinical history is needed before making a diagnosis.

Conclusion
Spirometry is relatively straightforward to perform and interpret, but there are many points in the process when problems can occur or errors can be made. These can lead to a misdiagnosis, a delay in treatment and/or inappropriate treatment. Professionals who perform spirometry and/or interpret spirometry results need to make sure they do so safely and appropriately, and seek appropriate training if needed. They will also need to add their names to the national register of professionals certified in diagnostic spirometry, which is being established this year.

References
National Institute for Health and Care Excellence (2010) Chronic Obstructive Pulmonary Disease in over 16s: Diagnosis and Management. nice.org.uk/gg101

For more on this topic go online...

Table 2. Spirometry flow-volume curves

<table>
<thead>
<tr>
<th>Flow (L/s)</th>
<th>Normal spirometry</th>
<th>Mild obstruction</th>
<th>Severe obstruction</th>
<th>Possible restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal flow-volume curve</td>
<td>Obstructed flow-volume curve</td>
<td>Restrictive flow-volume curve</td>
<td>Combined flow-volume curve</td>
</tr>
</tbody>
</table>

Table 3. Severity of airway obstruction in patients with FEV^1/FVC <0.70% or 70% |

<table>
<thead>
<tr>
<th>Degree of severity</th>
<th>Stage (GOLD, 2017; NICE, 2010)</th>
<th>Predicted FEV^1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>GOLD 1</td>
<td>&gt;80%</td>
</tr>
<tr>
<td>Moderate</td>
<td>GOLD 2</td>
<td>50-79%</td>
</tr>
<tr>
<td>Severe</td>
<td>GOLD 3</td>
<td>30-49%</td>
</tr>
<tr>
<td>Very severe</td>
<td>GOLD 4</td>
<td>&lt;30%</td>
</tr>
</tbody>
</table>

FEV^1 = forced expiratory volume in 1 second. FVC = forced vital capacity. GOLD = Global Institute for Chronic Lung Disease. NICE = National Institute for Health and Care Excellence. VC = vital capacity.