Irish Thoracic Society

Spirometry: Performance and Interpretation

A Guide for General Practitioners

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1. Spirometry

Peak flow meters, whilst useful for monitoring obstruction in asthma and COPD from day to day, are of little value in diagnosing these diseases as the readings may lead to a serious underestimate of the extent of airway impairment. Spirometry measures the volume of air that the patient is able to expel from the lungs after maximal inspiration.

Spirometry is invaluable as a screening test of general respiratory health, similar to BP measurement in cardiovascular disease. It is a reliable method of diagnosing and differentiating between obstructive airways disorders (e.g. COPD, asthma) and restrictive diseases (where the size of the lung is reduced, e.g. fibrotic lung disease).

Spirometry can also be used to determine the severity of asthma and COPD. This is important because the severity of these diseases cannot be predicted simply from the clinical signs and symptoms. The FEV_1 is the maximal volume of air exhaled in the first second of a forced expiration from a position of full inspiration (expressed in litres at BTPS). The forced vital capacity (FVC) is the maximal volume of air exhaled with maximally forced effort from a maximal inspiration (expressed in litres at body temperature and ambient pressure saturated with water vapour – BTPS).

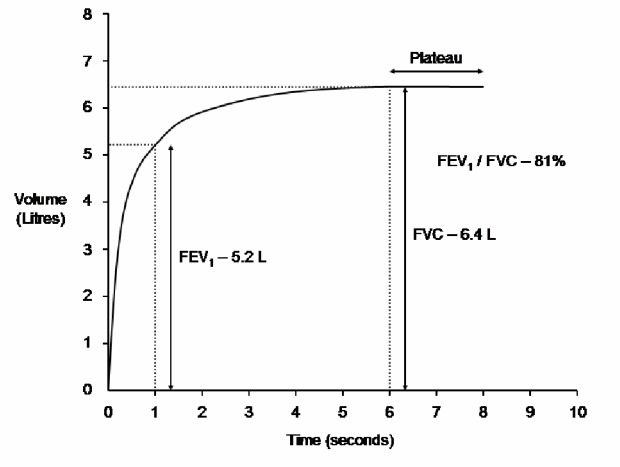
Some indicators that suggest spirometry may be warranted include:

- To screen individuals at risk for pulmonary disease e.g. smokers
- To evaluate patients with chronic, progressive symptoms of cough, wheeze and breathlessness
- Frequent exacerbations of bronchitis
- Patients whose occupations may expose them to respiratory irritants (fumes and dusts)
- To assess pre-operative risks
- Family history of pulmonary disease (eg. α_1-antitrypsin deficiency)
- As part of insurance evaluation

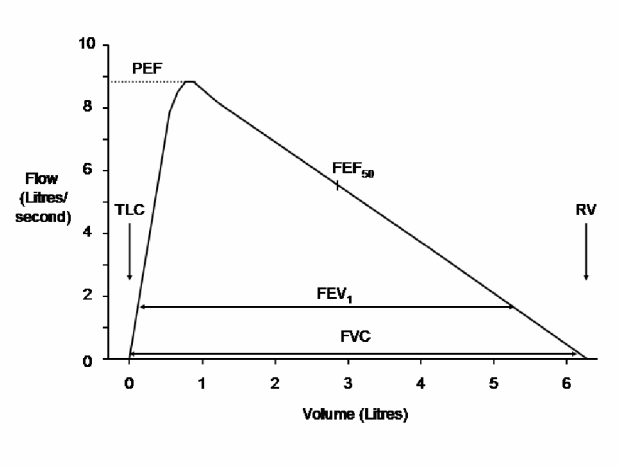
The Irish Thoracic Society recommends the use of spirometry to confirm diagnosis and assess response to treatment in asthma and COPD. Most patients with COPD do not present clinically until they have moderate or severe level of disease. One of the most important advantages of spirometry is that enables one to detect COPD before the symptoms become apparent. Early identification and persuading patients to stop smoking may mean minimal disease progression and long-term improved quality of life.

2. Spirometry curves

The Time-Volume curve



The Flow volume curve



3. Which Spirometer?

There are many different devices available: volume-displacement devices (piston, bellows or water sealed bell) or flow sensing (measuring pressure drop across resistance, turbine rotation or the cooling of a heated wire). Ideally, a spirometer should have a graphical display to allow technical errors to be detected. It should be able to produce a hard copy. Regular calibration is essential. Three types of spirometer are commonly used in primary care:

Small, hand held meters which provide digital readings.
These are the cheapest option and small enough to fit into a medical bag and produce FEV_1 and FVC readings. The lack of graphs can make it difficult to judge when a blow is complete. Predicted charts and a calculator will be needed to interpret the results.

Portable meters with integral printers.
More advanced spirometers produce traces (i.e. visual display or print-out) of the volume of air exhaled over time so you can see how well the patient has carried out the maneuver. These are more expensive but they will undertake all the calculations, including reversibility. Small displays of the volume time graph help monitor the blow and the printout includes a flow volume loop. If your spirometry has a memory facility, you may also store the trace.

Systems designed to work with a computer
Many electronic spirometers also display a flow-volume curve. You do not need this information to calculate FEV_1 and FVC values for your patient, so it is not necessary to use this facility when you are beginning. These systems display a graph, calculate predicted and reversibility and provide a printout.

Your local pulmonary function laboratory may be able to recommend a specific device.

4. Performing the test

1. Explain the purpose and method of the test to the patient (correct posture with head slightly elevated). The test involves maximal rapid inspiration, followed by forced exhalation of air through the mouthpiece sealed by mouth. It is useful to demonstrate the correct technique to the patient and ask the patient to undertake practice attempts beforehand.

2. Prepare the patient (ask about smoking, recent illness, medication use and measure weight, height and age).

3. Input the patient data where appropriate.

4. Attach a clean, disposable mouthpiece to the spirometer (a fresh one for each patient).

5. Ensure that the patient is comfortable, in particular that they are seated (in case they experience any faintness during the procedure). Attach a clean nose clip, place mouthpiece in the mouth and close lips around this. Inhale completely and rapidly with a pause of no longer than < 1 sec at full inspiration. Then exhale maximally until no more air can be expelled while maintaining an upright posture.

    a. Encourage the patient to keeping blowing out. Ensure that patient has exhaled for at least 6 seconds; the blow should continue until a volume plateau is reached. For patients with severe COPD this can take up to 15 seconds.
    b. Some spirometers give a bleep to confirm the maneuver is complete.
    c. Actively encourage patient as they perform the test
        i. "Take a deep breath in and fill up your lungs"
        ii. "Now BLAST IT OUT as hard as you can and KEEP BLOWING, KEEP BLOWING, KEEP BLOWING ……"
    d. Watch the patient during the procedure to ensure maximal effort
    e. Assess the flow volume curve for evidence of poor effort, hesitation etc.

6. Now repeat the procedure, and then repeat it again (but no more than 8 times as patients will fatigue). You should have three readings of which at least two of the FVC and FEV_1 components are reproducible, i.e. within 100ml, or 5%, of each other. The expiratory volume-time graph should be smooth and free from irregularities.

7. Depending on your model of spirometer the results may appear on a display (which you may be able to store against the date and time) or may be printed.

8. If spirometry shows airflow obstruction or you suspect a diagnosis of asthma, consider proceeding with reversibility testing..

    a. Reversibility tests involves performing spirometry before and after bronchodilator therapy and can help distinguish between asthma and COPD (note that spirometry may be normal in stable asthma).
    b. The patient's condition should be stable (i.e. at least 6 weeks since an exacerbation). Before a bronchodilator reversibility test, the patient should stop their short acting β_2 agonist for 6 hours, long acting bronchodilator for 12 hours and theophyllines for 24 hours. Avoid smoking for 1 hour prior to and during the test.

9. Perform baseline spirometry. Administer bronchodilator (at least 400mcg salbutamol or bricanyl, e.g. 4 puffs using a spacer device e.g. volumatic spacer or 5mg by nebuliser). Then perform spirometry again after 15 minutes. An increase in FEV_1 of >12% and >200mls suggests significant reversible airflow obstruction).

10. A steroid trial (30 - 40mg prednisolone daily for 2 weeks or 1,000 µg of inhaled corticosteroid for three months) may also be appropriate to assess bronchodilator reversibility if asthma is still suspected.

5. Maintaining accuracy of the test

The most common reason for inconsistent readings is patient technique. Errors may be detected by observing the patient throughout the manoeuvre and by examining the trace.

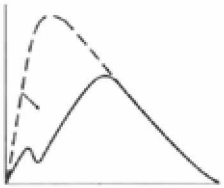
Common problems include:

- Lips not tight around the mouthpiece
- Inadequate or incomplete inhalation
- A slow start to the forced exhalation
- Exhalation stops before complete expiration
- Some exhalation through the nose
- Additional breath taken during maneuver
- Coughing

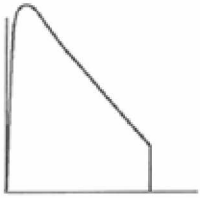
N.B. **Spirometers should be kept clean, and accuracy checked regularly in accordance with the manufacturer's recommendations**.

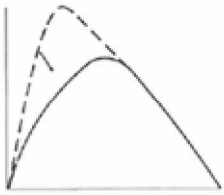
6. Identifying errors in spirometry traces

Hesitation

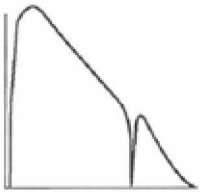


Premature finish

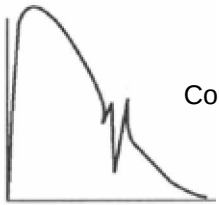




Poor effort



Premature finish and restart



Cough

7. Interpreting the results

1. Start with the FEV_1/FVC ratio

2. **In airflow obstruction**, patients cannot exhale the air in their lungs quickly. Therefore, the FEV_1 tends to fall, while the FVC remains relatively preserved (falling only in more severe airflow obstruction). **The FEV_1/FVC ratio is reduced below 70%.** If this is the case, **the patient may have asthma, COPD or another cause of airflow obstruction** – proceed to point 5

3. If the **FEV_1/FVC ratio is greater than 70%,** this usually represents **normal pulmonary function** but can occasionally represent **restrictive disease**. If the absolute values of FEV_1 and FVC are normal, then the test is normal. If the FEV_1 and FVC values are proportionately reduced, then the patient may have restrictive pulmonary disease.

4. The commonest cause of apparent restrictive disease is poor technique, where the apparent reduction in FEV_1 and FVC are due to poor patient effort rather than a true reduction in their value – this underscores the importance of observation of patient effort during the procedure.

5. The degree of airflow obstruction allows a classification of disease severity using the GINA (asthma) or GOLD (COPD) guidelines, and appropriate choice of therapy or action.

6. Assess the flow-volume curve to confirm your impression of the diagnosis (see below).

7. In a patient with respiratory symptoms, airway obstruction where the FEV_1 increases by 12% and 200 mls following bronchodilator therapy is suggestive of asthma.

8. In a patient with intermittent respiratory symptoms, the lack of airway obstruction, or the lack of a bronchodilator response do not rule out asthma. Similarly, a bronchodilator response with normal spirometry does not always indicate asthma.

9. Airway obstruction in an adult smoker is usually (but not always) due to COPD.

10. After spirometry, if you remain uncertain of the diagnosis, consider referral to a hospital pulmonary function laboratory for lung volumes and a diffusing capacity estimation (to assess for evidence of emphysema or

interstitial lung disease) or a histamine or methacholine inhalation challenge test or exercise test (to evaluate for asthma).

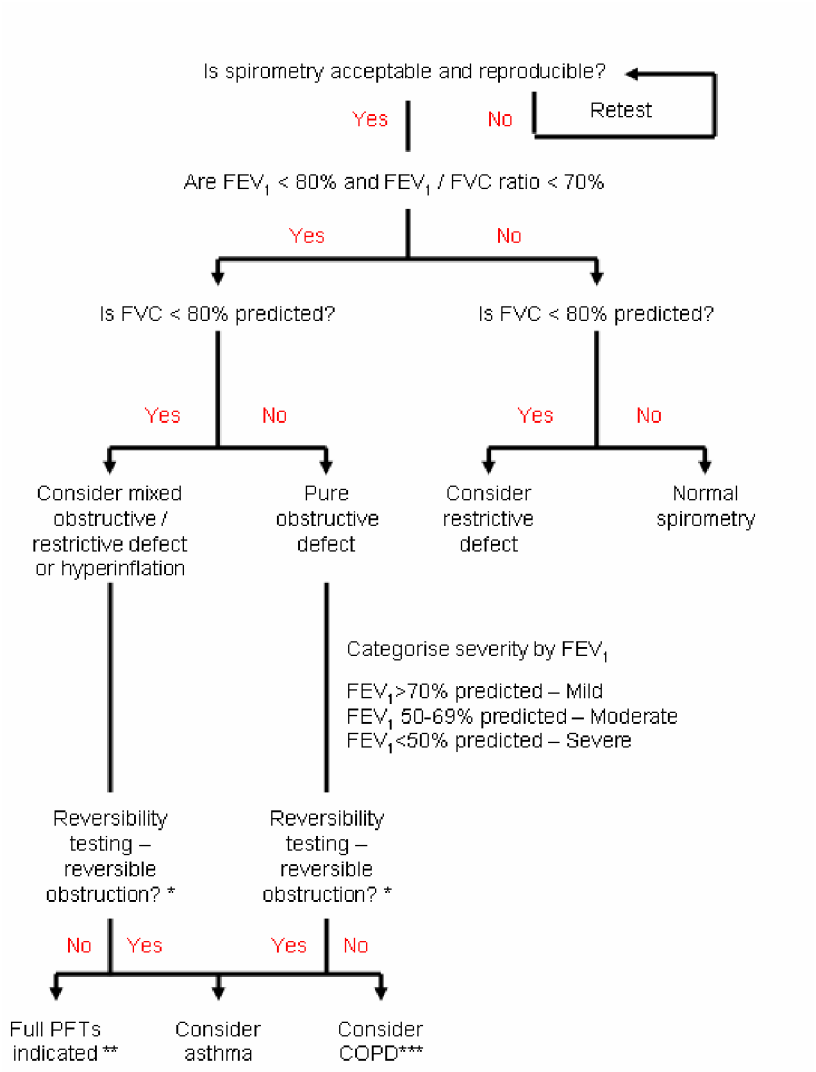
	Obstructive	**Restrictive**	**Combined**
FEV_1/FVC%	↓↓	N or ↑	↓
FVC	N or ↓	↓↓	↓
FEV_1	↓↓	N or ↓	↓

N – Normal

↑ - Increased compared to predicted value

↓ - Decreased compared to predicted value

8. Spirometry Diagnostic Flowchart



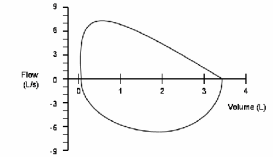
*** Reversibility testing** with β-agonist indicates an improvement of > 12% and >200ml in FEV_1 and/or FVC approximately 15 mins after inhalation.

**** Full PFT'S** refers to the measurement of diffusing capacity DL_{CO} and lung volumes using dilution or plethysmographic techniques in a computerized hospital based respiratory function laboratory to determine the severity of the defect.

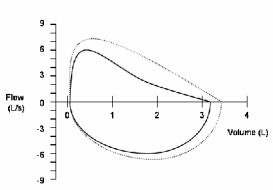
******* Some subjects with chronic asthma may not respond at all to a β-agonist. Some COPD patients may show an improvement post β-agonist.

9. Assessing the flow volume curve

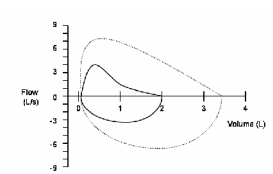
Airflow Obstruction



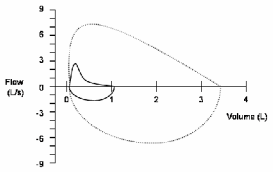
Normal



Mild Airflow Obstruction

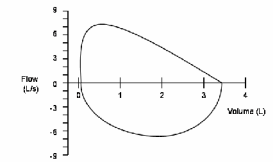


Moderate Airflow Obstruction

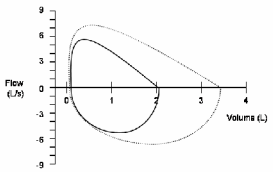


Severe Airflow Obstruction

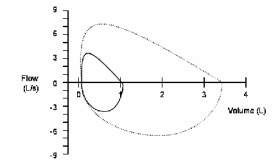
Restrictive Disease



Normal

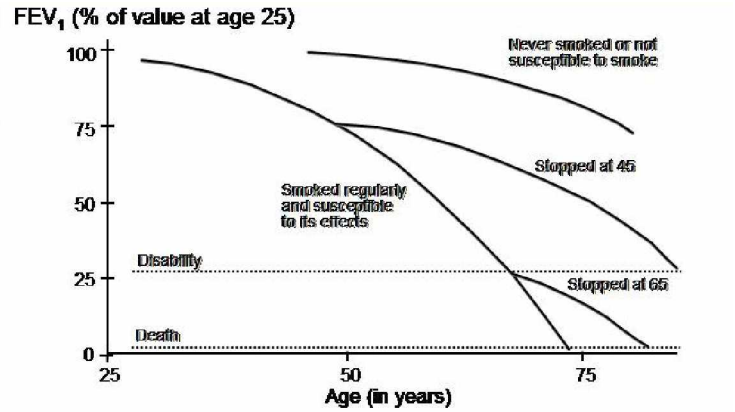


Moderate Restrictive Defect



Severe Restrictive Defect

10. Changes in FEV_1 due to aging and the detrimental effects of smoking



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