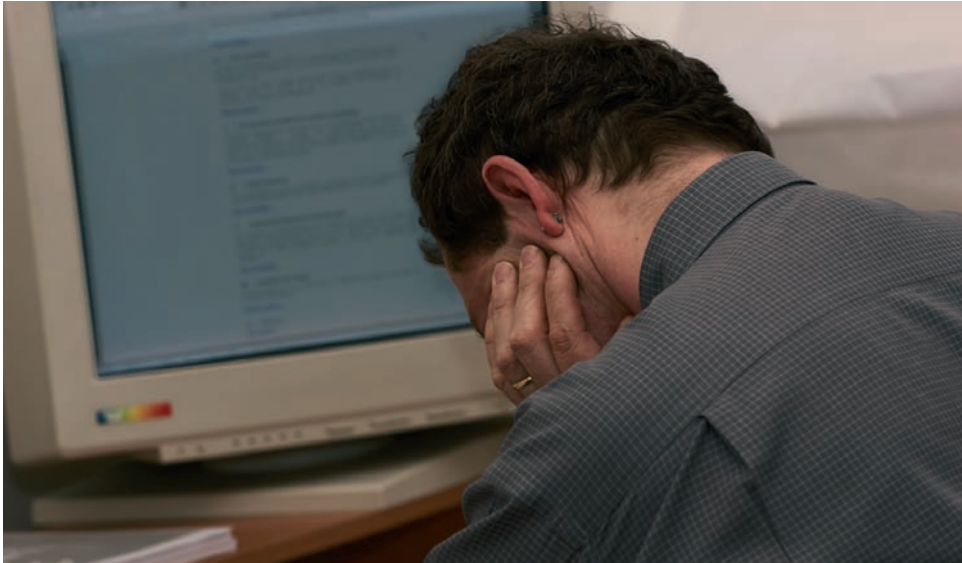


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# How to interpret spirometry



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## Educational aims

- › To explain how spirometry data can be interpreted in a clinical setting.
- › To outline and explain some of the patterns of abnormality that may be seen.

## Summary

Once spirometry has been carried out, it is vital to interpret the data properly. Before starting, one should find out whether the testing was performed properly – although some conclusions may be drawn from substandard data, it is best to proceed with caution.

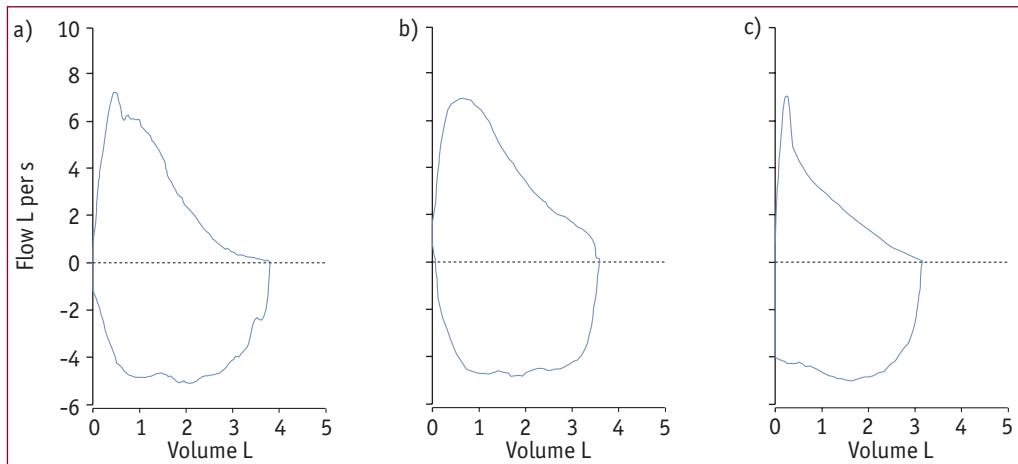
The next step is to look for abnormalities in the data, using the standard reference equations, and taking into account any peculiarities of the equipment. Certain patterns of results are known to be indicative of particular problems, and clinicians should become familiar with these, as spirometry is the key tool in lung function testing.

Without interpretation, data collection is a meaningless exercise. Even the most painstakingly precise measurements of lung function are no use if the clinician does not understand what they mean or, worse still, the clinician mistakenly thinks he understands what they mean. This article aims to spell out the main principles of interpreting spirometry.

## Is this test OK?

It is important to know that the tests which were performed were of a satisfactory standard (figure 1). It is possible to use results from patients where the accepted standards have not been met, but more caution is required in the use of these data.

**Figure 1**  
 a) A normal flow-volume curve. b) This patient gave up early. c) This patient did not start from total lung capacity.



Several errors are commonly made when recording spirometry.

- 1) Failure to start from the true total lung capacity (TLC). This means that forced expiratory volume in one second (FEV<sub>1</sub>), peak expiratory flow (PEF) and forced vital capacity (FVC) will be low.
- 2) Failure to continue to the true end of expiration. FVC will be low, FEV<sub>1</sub>/FVC ratio will be falsely high.
- 3) Mouth leak. PEF will be low and FEV<sub>1</sub> and FVC may be low.

## Normal or abnormal?

Having acquired data from an individual, the first step is to determine whether any of the test results are abnormal. Reference equations are available to predict expected lung function results for individuals. These take into account ethnicity, age, height and sex. Predictions may also need to take into account the type of equipment used to make the measurements since, for example, volume accumulating spirometers may have an error in their FEV<sub>1</sub> measurements owing to inappropriate full body temperature and pressure, saturated (BTPS) correction [1].

Such equations quote the various coefficients for age and height and also the residual standard deviation (RSD; standard error of the estimate) for the prediction. This latter number is sex-specific and is used to derive the deviation from predicted value as standardised residuals (SR) [2], where  $SR = (\text{recorded} - \text{predicted}) / RSD$ .

SR values are dimensionless and indicate how many standard deviations the subject's result is from predicted. So for a conventional 90% lower confidence limit, an SR value more

negative than -1.645 means the index is abnormal. Thus, the physician must request that all lung function data are presented with their SR values. A quick scan to see whether any are more negative than -1.645 will indicate whether there is an index in the "abnormal" range.

The % predicted value is not the correct way to determine whether a result is abnormal [3], since the cut-off value that determines abnormality varies between spirometric indices and with sex, age and height of subjects. Thus, a single % pred value is never correct for all subjects in determining whether a subject is abnormal.

## Patterns of abnormality

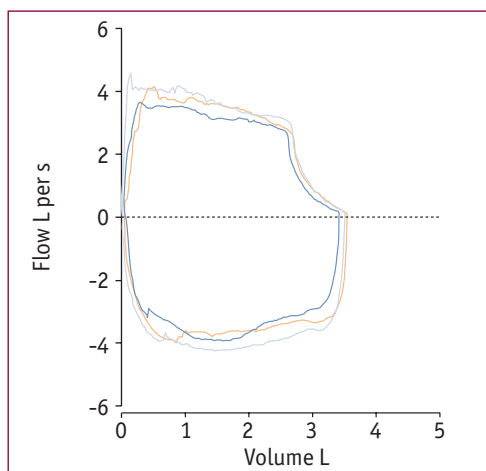
In using spirometric data to help in clinical situations, certain patterns of abnormal results help to categorise the clinical problem.

### Low PEF and normal FEV<sub>1</sub>

Upper airway obstruction characteristically gives airflow limitation that significantly reduces both PEF and peak inspiratory flow without much effect (if any) on FEV<sub>1</sub>. This discordance is not seen with other causes of airflow obstruction. Another way to identify this is to look at the ratio of FEV<sub>1</sub> in mL divided by the PEF in L per min. If this is above 8, then upper airway obstruction is likely (figure 2) [4, 5]. This ratio is another way of highlighting discordance between PEF and FEV<sub>1</sub>.

### Low PEF, low FEV<sub>1</sub> and low FEV<sub>1</sub>/FVC

This pattern characterises intrapulmonary airflow obstruction, which is found in asthma, chronic obstructive lung disease and bronchiectasis (figure 3).



**Figure 2**

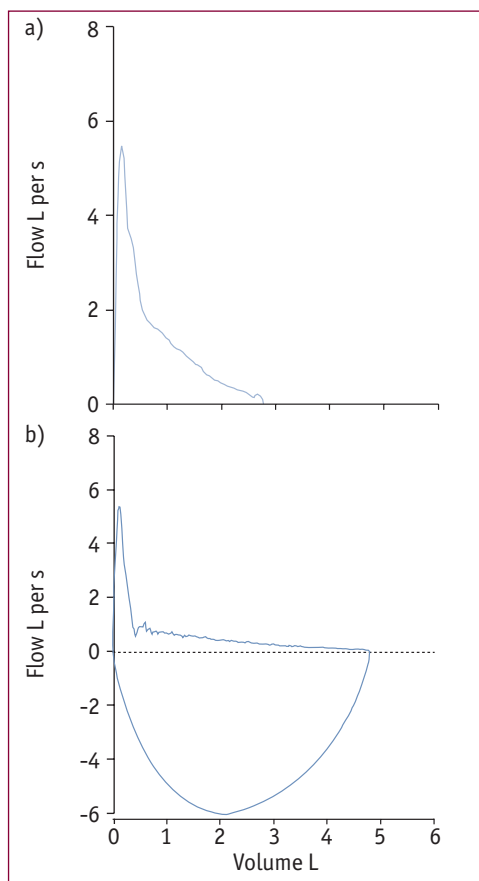
A flow-volume curve illustrating upper airway obstruction. Note the elevated FEV<sub>1</sub>/PEF ratio.

### Low FEV<sub>1</sub>/FVC with normal FEV<sub>1</sub>

Sometimes the ratio of FEV<sub>1</sub> to FVC is below the lower limit of normal (-1.645 SR), with the FEV<sub>1</sub> being in the normal range but the subject's FVC being much greater than predicted. There is some uncertainty about the clinical picture here, but a subject can be born with supra-normal lung function, then later develop airflow obstruction, for instance due to chronic obstructive pulmonary disease or asthma. The FEV<sub>1</sub> then falls from its previous abnormally high value to a lower one that is still within the normal range for the population. However, the FEV<sub>1</sub>/FVC ratio is low. This picture may also be a normal variant if the subject has an unusually low residual volume relative to total lung capacity, so raising the FVC relative to the FEV<sub>1</sub>. If symptoms are present, it is best to think of this as a form of airflow obstruction and consider usual treatment.

### Low FEV<sub>1</sub> and low FVC with normal or supranormal FEV<sub>1</sub>/FVC

This is the usual finding if a subject has a restrictive ventilatory defect, for instance as a result of cryptogenic fibrosing alveolitis. However, to be



**Figure 3**

Flow-volume curves from a) an asthmatic and b) a patient with chronic obstructive pulmonary disease.

certain of this finding, static lung volume measurements are needed as well. Many patients with significant restrictive defects have normal spirometry but abnormal static volumes, so spirometry alone is not the way to investigate or diagnose this condition.

## Conclusion

Spirometry is the mainstay of lung function testing and all clinicians need to ensure they are familiar with the signals these data can provide – and also the potential pitfalls – so that sound clinical decisions can be made for each individual patient.

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