

Literally, spirometry means ‘measuring breathing’. At its most basic it is a simple bedside or officebased test which takes less time to perform than measuring blood pressure. However, whereas sphygmomanometry is one of the most familiar clinical measurements, spirometry remains, for many, an obscure manoeuvre related to the black art of respiratory physiology.

It is true that patients referred for full pulmonary function tests (PFTs) in a specialist hospital laboratory will return with a complex set of figures that may be challenging to interpret. For evaluation of those conditions that account for more than 90% of respiratory disease – asthma and COPD – simple spirometry is more than adequate. The devices now available are as robust and less expensive than a standard sphygmomanometer.

EARLY IDENTIFICATION OF COPD

On October 14, 2010, World Spirometry Day was held to promote the use of spirometry as a standard screening test to identify undiagnosed COPD and prompt early intervention with smoking cessation, flu vaccination and bronchodilator therapy. This initiative aims to demystify spirometry and incorporate it as a routine preventive health measure.

Modern spirometers are compact devices (Figure 1) that measure airflow at the mouth and then calculate various measurements of lung function. In practice only two parameters are needed to evaluate airflow obstruction – the forced expiratory volume in one second (FEV1) and the forced vital capacity (FVC). However, it is worth going into a bit more detail on spirometry to place these in context.

Figure 2 shows the static lung volumes, so called because



Fig. 1: Simple desktop spirometer

they do not depend on how quickly or how forcefully the patient performs the manoeuvre. The tidal volume (TV) is the amount of air that is moved by each breath during normal resting breathing – typically around 400ml.

If a patient is asked to take in a full breath then the difference between a normal tidal inspiration and a maximal inspiration is the inspiratory reserve volume (IRV). If a patient is asked to breathe out to the maximum possible then the difference between a normal tidal expiration and a maximal expiration is the expiratory reserve volume (ERV). The difference between a maximal inspiration and a maximal expiration is the vital capacity (VC).

Figure 2 also shows three other measurements which are important to know about but which cannot be measured with a spirometer. The residual volume (RV) is the amount of air remaining in the lungs at the end of a maximal expiration.

No matter how much air is forced out of the lungs there is always some left behind. The functional residual capacity (FRC) is the amount of air in the lungs at the end of a normal tidal breath and is the sum of RV and ERV. The total lung capacity (TLC) is the total amount of air in the lungs at the end of maximal inspiration and is the sum of RV and VC.

Most medical students are taught that reduction in VC

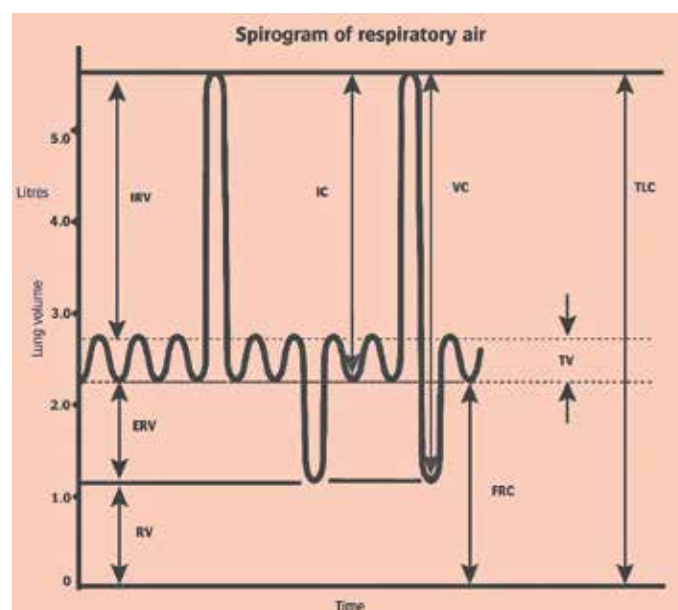


Fig. 2: Static lung volumes

Table 1: Examples of restrictive lung disease**Diseases of the lung parenchyma**

- Fibrosing alveolitis
- Pneumoconiosis
- Allergic alveolitis
- Drug induced pneumonitis

Diseases of the chest wall

- Kyphoscoliosis
- Thoracoplasty

Diseases of the respiratory muscles

- Muscular dystrophy
- Myasthenia

Lung resection

is caused by restrictive lung disease and that obstructive diseases affect only the dynamic measurements and rates of airflow (see below). Looking at Figure 2, we can see that there are two ways in which VC can be reduced – from the ‘top down’ by a reduction in TLC or from the ‘bottom up’ by an increase in RV.

In restrictive diseases (Table 1) VC is reduced by a reduction in TLC – ie. from the ‘top down’. In obstructive diseases – asthma and COPD – TLC is normal or may even be increased, particularly when emphysema is present.

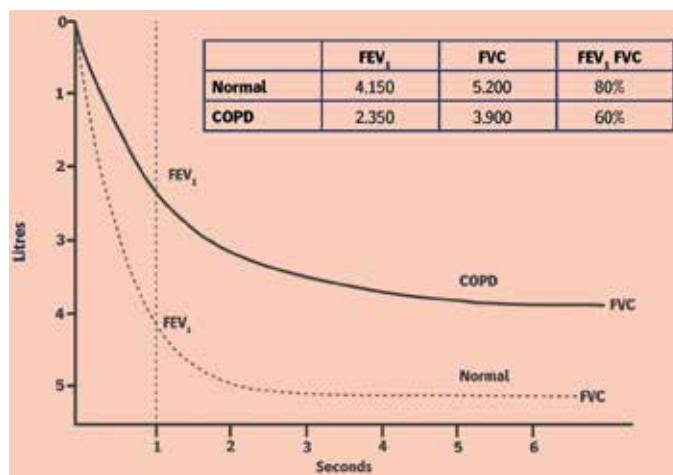
However, VC is reduced because airway obstruction prevents maximal expiration due to ‘air trapping’ and RV is increased – ‘bottom up’.

Figure 3 shows the dynamic lung volumes that are measured from a single forced expiration that is the basis for the most commonly performed spirometric manoeuvre. The graphs in Figures 2 and 3 have the same axes – volume in litres on the vertical axis with inspiration upwards and time on the horizontal axis.

In Figure 3 the graph starts with a maximal inspiration. The patient is asked to “take a deep breath in and hold it, and then blow out as long and as hard as you can”. The entire test is repeated two or three times and the best set of measurements recorded. Two measurements are made from the forced expiratory manoeuvre.

The FVC is exactly the same as the VC except it is measured with a ‘dynamic’ or ‘forced’ technique. The FEV₁ is the amount of air that is blown out in the first second of the manoeuvre. Change in volume with time is, by definition, flow and the FEV₁ is a measurement of airflow during the first second of a forced expiration.

Understandably, diseases that affect airflow such as asthma and COPD will have their predominant impact on FEV₁. As explained above, however, and as illustrated

**Fig. 3: Dynamic lung volumes**

in Figure 3, obstructive diseases like COPD will also reduce FVC as a result of air trapping and increased RV. So, is it possible to differentiate restrictive and obstructive diseases without being able to measure RV? In practice the ratio of FEV₁ to FVC (FEV₁/FVC) is helpful.

AIRFLOW AND FEV₁/FVC

Although obstructive lung diseases will reduce FVC, their predominant effect is on airflow and the reduction in FEV₁ will be proportionately greater than the reduction in FVC. As a result, FEV₁/FVC is always reduced (< 80%) in obstructive disease. Indeed in a pure restrictive disease such as fibrosing alveolitis (idiopathic pulmonary fibrosis) the patient may have such a reduction in TLC that they can blow virtually the whole breath out in the first second and the ratio is abnormally high (> 90%).

USE OF SPIROMETRY TO DIAGNOSE AND EVALUATE AIRWAYS OBSTRUCTION

As a simple rule of thumb, the FEV₁/FVC ratio tells us about the presence of airways obstruction and FEV₁ alone about the severity. Thus a patient with an exacerbation of asthma may have FEV₁ of 1.0L, FVC of 2.0L, ratio 50%.

Next day the FEV₁ may rise to 1.3L, FVC to 3.0L, ratio 43%. On both days the FEV₁/FVC ratio is reduced, more so on day two. However, the FEV₁ rises on day two by 30% indicating improvement in severity.

SUMMARY

Finally, does spirometry tell us everything we need to know? Not quite. Certainly patients with severe COPD have very little variation in spirometry – hence the term ‘irreversible airways obstruction’, but they have obvious clinical variations in disease severity and exacerbations. In these cases subjective symptom scores (eg. Borg score) and other measures such as the six-minute walking distance may be useful.