Lung function testing tutorial: pitfalls for the unwary when performing spirometry

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Abstract

Spirometry is a simple, reliable, and informative tool in the assessment of respiratory function. It has many indications in both the diagnosis and monitoring of respiratory disease, but in Africa it could be most immediately useful in quantifying the unknown burden of chronic obstructive pulmonary disease (COPD) related to indoor air pollution as well as the burden of asthma. In order to ensure that spirometry is reliable, quality control is essential. In particular, normal values must be regionally appropriate, technique must be well taught, and equipment must be properly calibrated. In 2005, the ATS/ERS Task Force (American Thoracic Society and European Respiratory Society) issued guidelines aimed at integrating existing international guidelines. Good standards for spirometry will result in a useful, narrow range of normal values for a population and abnormalities in lung function will be easily detected. The aim of this article is to address the key issues regarding basic spirometry standards, and to highlight the common pitfalls.

Introduction

Normal values

Normal values are not available for much of Africa and this challenge must be met by an increased effort to collect accurate data on a region-by-region basis.

Equipment

To ensure the values recorded by a spirometer are an accurate measurement of respiratory manoeuvres, it is important that daily calibration checks are performed. The aim is to instill a known volume of air into the spirometer (usually 3 litres) via a syringe and measure the spirometry tracing. The limit of accuracy is defined as up to 3% of the instilled volume. A result outside this limit would require equipment maintenance. Regular testing (at least once a month) to exclude air leaks is also necessary. If in doubt about calibrating your machine, we suggest that you contact the manufacturer.

Infection control

Although low, there is a risk of transmission of infectious diseases, including tuberculosis, when inhalation manoeuvres are used. It is necessary that all mouthpieces used are disposable and appropriate valved mouthpieces are used for high-risk patients. In epidemiological work, it is better to avoid carrying out spirometry in patients with undiagnosed cough and sputum.

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Manoeuvres

The most important manoeuvres in basic spirometry are:

- *Forced vital capacity (FVC)* – the maximum amount of air expelled from an individual's lungs, at maximum effort, from maximal inspiration. This is measured in litres.
- *Slow vital capacity (SVC)* – the maximum amount of air expelled from an individual's lungs from maximum inspiration. In individuals with airway obstruction or in the elderly this may represent a more accurate measurement of vital capacity as it reduces the effect of air trapping. It is also measured in litres.
- *Forced expiratory volume in 1 second (FEV1)* – the amount of air expelled from an individual's lungs in 1 second, at maximum effort, from maximum inspiration. Measured in litres per second.

Success in obtaining good results depends on patient factors, correct position, and good instructions.

Patient factors

Prior to performing spirometry it is important to make attempts to minimise any factor that may affect the reliability of results. Patients should be discouraged from smoking within an hour of the test, eating a large meal within 2 hours, consuming alcohol within 4 hours, performing vigorous exercise within 30 minutes, and from wearing tight-fitting clothing. Individuals with significant cognitive impairment, chest wall pain, stress incontinence, and a history of exertional syncope are unlikely to be able to perform spirometry satisfactorily.

Position

Spirometry can be performed either sitting or standing. Sitting is recommended for safety reasons, given the risk of cough syncope. However, in obese patients, results when sitting may be significantly lower than when standing. Patient position must be clearly documented and the same position should be used for repeated spirometry.

Instructions

When supervising spirometry it is important that instruc-

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tions are clear and the participant is encouraged in order that satisfactory results are achieved. Table 1 shows an example of a suitable approach.

Table 1 Suggested method for spirometry

- Measure height and weight.
- Ensure any tight clothing has been loosened.
- Take a full inspiration.
- Make a tight seal around the mouthpiece with the lips.
- Blow out the air as fast as possible, for as long as pos sible, until the lungs are empty.

Interpreting your results

It is important to make a visual inspection of the spirometry trace if your equipment allows. Directly viewing the recording is the easiest way to ensure satisfactory technique. Flow–volume loops provide more detail when assessing the initial phase of the manoeuvre, particularly when ensuring maximal expiratory effort has been achieved (see Figure 1). Volume–time graphs provide more detail for the latter part of the manoeuvre (see Figure 3). Figure 1 provides an illustration of a flow volume loop in a healthy individual and demonstrates the common mistakes leading to unacceptable spirometry. In particular the flow–volume loop (Figure 1, right-hand side) illustrates the appearance of:

- a slow start to the blow (1);
- poor effort resulting in low flow (2) and a broad late peak (3);
- coughing or stopping (4) and a sudden early stop in blowing (5).

Figure 2 shows a flow–volume loop and further examples of problems encountered in spirometry. The problem of poor volume can be easily detected by doing a SVC manoeuvre first to determine the target FVC (maximum volume in volume–flow or volume–time chart).

Figure 2 Flow–volume spirometry in a healthy individual with examples of unsatisfactory spirometry

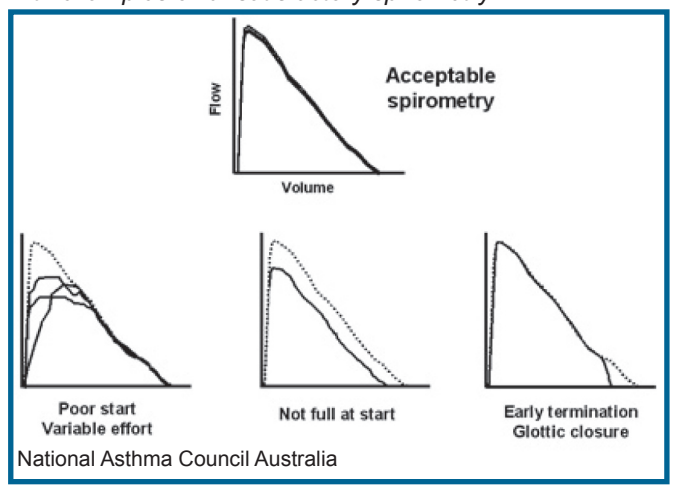


Figure 3 Volume–time spirometry in a healthy individual and examples of unsatisfactory spirometry

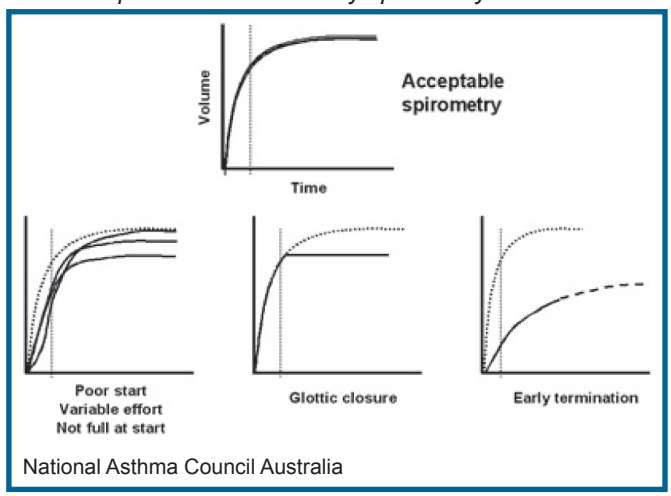
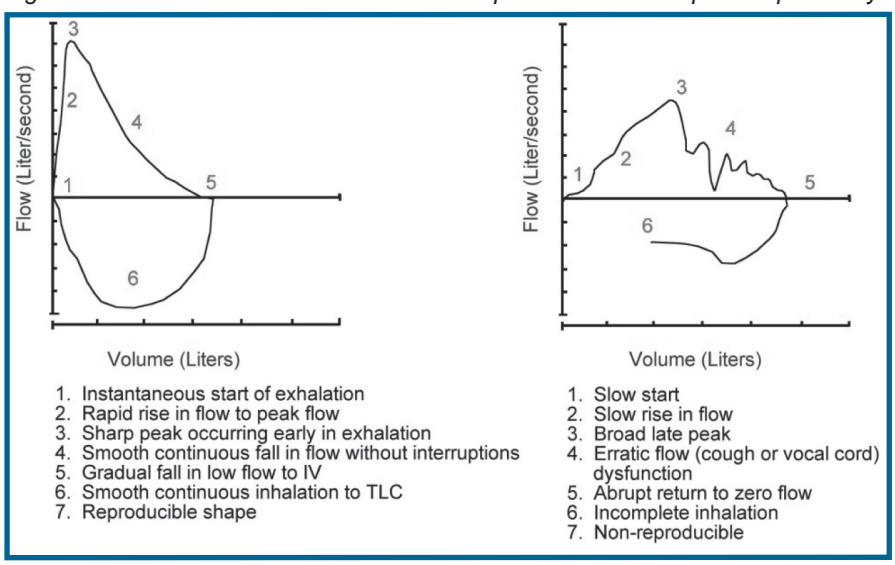


Figure 1 Flow-volume characteristics of acceptable and unacceptable spirometry[1]



Criteria for acceptable spirometry

It is vital that spirometry results are representative. To ensure this, specific acceptability and reproducibility criteria have been devised.

Acceptability criteria (American Thoracic Society guidelines)

- Free from artefact.
- Free from leaks.
- Good start, i.e. maximum flow reached within 120 milliseconds or extrapolated volume of less that 5% or 0.15 litres (whichever is greater).
- Acceptable exhalation – at least 6 seconds and/or plateau in volume curve for 1 second.

Reproducibility criteria

- Three acceptable manoeuvres (achieving the above criteria).
- The two largest FVC measurements within 0.2 litres of each other.
- The two largest FEV_1 measurements within 0.2 litres of each other.

Pitfalls

Failing to achieve maximal expiratory effort and failing to ensure a sufficient duration of expiration are two of the most common pitfalls. The common reasons for poor-quality spirometry are listed in Table 2. To ensure results are representative a minimum of three manoeuvres should be performed. This can be repeated to a maximum of eight manoeuvres. Spirometry can induce bronchospasm therefore further repeats are not recommended.

Table 2 Causes of poor quality spirometry

• Sub-maximal effort
• Failure to take maximum inspiration prior to manoeuvre
• Glottis closure
• Cough
• Tight clothing
• Splinted diaphragm, e.g. full stomach
• Leak around lips
• Failure to calibrate
• Poor posture

Conclusion

In order that spirometry results are valid it is vital that it is performed according to the standard set down in international guidelines. This review is a brief summary of the key issues, but healthcare professionals involved in the ordering, performance, or interpretation of lung function should ideally familiarise themselves with current guidelines and this can be achieved on-line at http://www.thoracis.org/sections/publications/statements.

Reference

1. McCarthy K. Pulmonary function testing. *eMedicine* November 2006, www.emedcine.com/MED/topic2972.htm#Multimediamedia1.