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EDUCATIONAL SERIES

Spirometry

About the contributor

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Introduction

The following publication is intended as an educational resource for health professionals. It presents a short background on spirometry and guidance on its use in New Zealand. It is intended to help readers stay informed of developments and advancing clinical practice in the area.

Spirometry

Spirometry is a physiological test that measures how an individual inhales or exhales volumes of air as a function of time. Spirometry is a screening test of general respiratory health. In primary care spirometry is used to measure how much and how fast an individual can blow air out.[1]

Indications for Spirometry

Spirometry is useful in the diagnosis and management of obstructive and restrictive lung disease, particularly to measure and monitor responses to therapy for asthma and chronic obstructive pulmonary disease (COPD). Spirometry is the most useful test for detecting and managing asthma and COPD,[2] and is indicated for use in several other clinical situations commonly encountered by medical practitioners. Historically, measurement of spirometry was indicated in patients ≥45 years old who report smoking cigarettes (current and those who quit during the previous 12-months) in order to detect COPD.[3]

Primary Care Spirometry

The requirements for office spirometry use to detect and manage chronic obstructive pulmonary disease and asthma in the primary care setting are well documented.[4] The choice of office spirometer is important as there are differences between the precision of office spirometers, and differences between values measured on office spirometers and diagnostic spirometers that may lead to increased misclassification rates in COPD.[5]

Spirometry in COPD and Asthma

Spirometry is essential for the diagnosis and monitoring of both asthma and COPD.[6] Its use in primary care has been shown to positively influence physicians' diagnosis of airflow obstruction and management plans especially in patients with moderate-to-severe obstruction,[7] and to lead to improvements in the treatment of COPD.[8]

Along with equipment selection successful spirometry hinges on test performance and correct interpretation of results. A study to determine the repeatability of spirometry in 18,000 adult patients concluded that the ability of the patient to meet spirometry reproducibility goals did not depend on the patient characteristics when testing is performed by experienced personnel.[9] The need for formal training in the performance and interpretation of spirometry for primary care is required. Issues with the quality of spirometry performed by primary care practitioners has been demonstrated [10, 11, 12], however, Schermer concluded that spirometry testing in primary care is justifiable provided there is sufficient training of practice staff. [13]

Identifying Patients for Spirometry

Along with the taking of a careful history, spirometry is used to help differentiate between reversible (variable) airflow obstruction and fixed/non-reversible airflow obstruction.

In basic terms, patients who have shortness of breath, chronic cough or sputum production may have COPD, especially if they are >35 years of age with a history of smoking or occupational exposure to dust or gas/fumes.[14] In COPD the presence of post bronchodilator $FEV_1/FVC < 0.7$ [GOLD 2016], or preferably below the lower limit of normal [GLI-2012] confirms the presence of persistent airflow limitation and thus COPD.

In asthma spirometry is used to demonstrate rapid improvement (reversibility) in FEV_1 measured within 10 to 15 minutes after inhalation of rapid-acting bronchodilator or more sustained improvement over days or weeks after introduction of effective controller treatment.[15]

GUIDELINES

1. Australian Asthma Handbook. National Asthma Council Australia. http://www.asthmahandbook.org.au/
2. Australian Asthma Handbook: Quick reference guide. http://www.asthmahandbook.org.au/uploads/555143d72c3e3.pdf
3. Global Initiative for Chronic Obstructive Lung Disease. Pocket guide to COPD diagnosis, management and prevention: A guide for health care professionals. Updated 2016. http://goldcopd.org/pocket-guide-copd-diagnosis-management-prevention-2016/
4. Global Initiative for Asthma. Global strategy for asthma management and prevention. Updated 2016. http://ginasthma.org/2016-gina-report-global-strategy-for-asthma-management-and-prevention/
5. Lung Foundation Australia. COPD-X Concise guide for primary care. http://lungfoundation.com.au/wp-content/uploads/2014/11/LFA-COPD-X-doc_V3.02_0316_web.pdf
6. The National Institute for Health and Clinical Excellence. Chronic obstructive pulmonary disease in over 16s: diagnosis and management. Clinical guideline [CG101]. https://www.nice.org.uk/guidance/cg101

Spirometry

Spirometry measures the forced vital capacity (FVC) and the forced expiratory volume measured over one second (FEV_1).

1. **Forced Vital Capacity (FVC) –** the volume of air that can be exhaled in a forced manoeuvre after a maximal inhalation.
2. **Forced Expired Volume in One Second (FEV_1) –** the volume of air exhaled in the first second of the FVC manoeuvre.
3. **FEV_1/FVC Ratio -** The ratio is a more sensitive parameter than FEV_1 for detecting airway obstruction in its early stages and is used as an indication of the presence of airway obstruction.

Reversible airflow obstruction (reversibility) is defined as an increase of 12% or more in FEV_1 or FVC. Improvements in FEV_1 or FVC of >12% and 200 mL compared with baseline during a single testing session suggest a significant" bronchodilation.[15]

Enright[12] has suggested that spirometry may add more value when the lack of airway obstruction, after bronchodilator therapy, is used to rule out COPD, than it does to confirm COPD in a smoker with respiratory symptoms.

Measurement of Spirometry: techniques for good results

There are three distinct phases to the spirometry manoeuvre[16]; 1) a maximal inspiration, 2) a 'BLAST' of exhalation, and 3) continued complete exhalation to end of test.

Explain the Test to the Patient: Explain the purpose of the test is to determine how hard and fast air can be exhaled, and that the test is like 'blowing out the candles on a birthday cake.' The patient must inhale as deeply as possible and, when the lungs are completely full, quickly seal the lips around the mouthpiece and '**BLAST**' the air out of the lungs.

Demonstrate the Test Manoeuvre: Demonstrate the FVC manoeuvre with a separate mouthpiece, emphasising the deep breath. Clearly demonstrate the positioning of the mouthpiece over the tongue, with teeth around the mouthpiece and lips sealing tightly. Finally, dramatically **BLAST** out as hard and fast as possible for at least six seconds. The test is performed with the patient seated in an upright position, feet flat on the floor and slightly apart.

Coach the Patient: Ensure that the spirometer is ready to record the FVC manoeuvre. Coach the patient to take as deep a breath as possible watching to ensure maximal inhalation. Encourage patient to keep chin up. Once the mouthpiece is in the mouth with lips tightly sealed around the mouthpiece, shout loudly, "**BLAST out the air**!" Then tell the patient more quietly to, "Keep going, keep going, keep going," and encourage them to blow all the air out of their lungs, whilst maintaining an upright posture.

Repeat Manoeuvre: Repeat spirometry for a minimum of three manoeuvres; no more than eight are usually required. Check test repeatability and perform more manoeuvres as necessary.

Recognise Poorly Performed Breathing Manoeuvres: As soon as poor inspiration or sub-maximal exhalation is detected tell the patient to stop. Instruct the patient how to perform the test better and demonstrate the manoeuvre again. Prepare the spirometer again and repeat the test. The goal is to obtain three acceptable manoeuvres with the best two matching closely.

Interpretation of Spirometry Results

The FEV_1 expressed as a percent predicted value is used to determine the severity of lung function impairment.[15] Reference equations should include explicit definitions for the upper and lower limits of the normal range, with values below the 5th percentile considered to be below the expected "normal range".[17] For primary care, where FEV_6 is recommended as a surrogate for FVC, the reference ranges from Stanojevic[18], now known as GLI-2012[19], are recommended.

Using the lower limit of normal (LLN) healthy individuals, who are able to inhale maximally and exhale quickly (without obstruction), will demonstrate measured FEV_1, FVC and FEV_1/FVC ratio with values >LLN.

Figure 1 illustrates expiratory flow-volume curves (left) and volume-time curves (right) for normal, obstructive and restrictive spirometry.

For the normal curve (N) flow quickly rises to a peak in the flow-volume curve and then descends at a 45-degree angle until the FVC is reached. The volume-time graph shows a fast increase in volume over the first second of forced exhalation followed by a plateau once the FVC has been reached.

The obstructive pattern (Obs) is recognised by the "scooping out" of the flow-volume curve. Flow quickly reaches its peak then falls off leading to depression of the subsequent flow rates, which become very low as FVC is approached. In severe airways obstruction the flow-volume curve shows sudden fall in flow rate after the peak is reached with low flow to FVC producing a "rat's tail" effect. The volume-time curve is defined by a slow

increase in forced expiratory volume to FVC due to the time it takes to exhale the air, so a flat plateau is often not obtained.

The flow-volume curve of the restrictive pattern where there is reduced inflation with no airflow obstruction (RINO) demonstrates a sharp peak with a steeper decline than normal as the air is exhaled rapidly to FVC. The volume-time curve shows that a flat plateau is rapidly obtained.

The diagnostic flow diagram can be used for interpretation of spirometry (Appendix 1). The algorithm uses the lower limit of normal (LLN) as the cut off points in the decision-making process.

Ongoing Review of Patients with Asthma and COPD

Pre-planned, structured review of asthma is associated with reduced rates of exacerbations, improved symptom control and fewer days absent from work or school. Repeat spirometry is recommended every 1 to 2 years in stable asthmatics.[20] In patients at high risk of COPD when the results of the first spirometry are normal it is recommended that spirometry is repeated at 3- to 5- year intervals.[3]

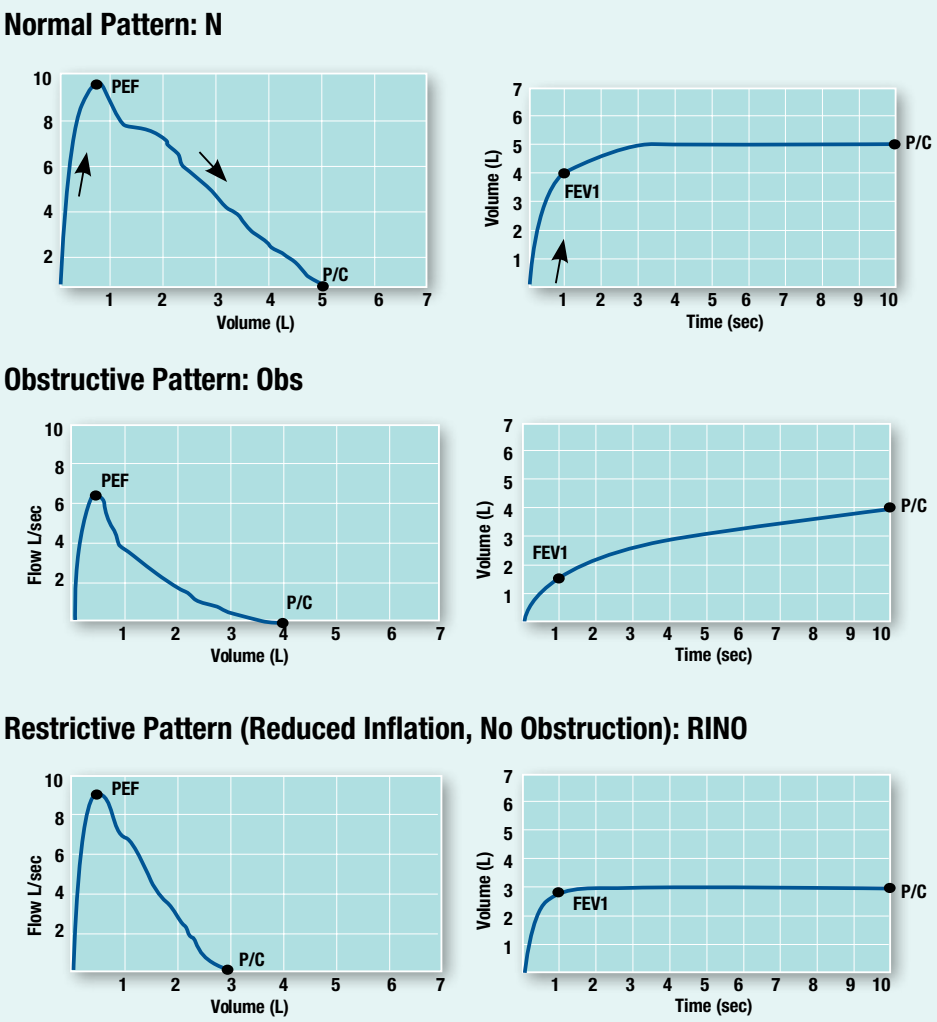

Figure 1: Reproduced from Petty TL and Enright PL. Simple Office Spirometry for Primary Care Practitioners. http://www.nlhep.org/Documents/simple_office_spirometry.pdf

Conclusion

Spirometry is the lung function test of choice for diagnosing asthma and for assessing asthma control in response to treatment. Spirometry is also the recommended method for confirming the diagnosis, assessing severity and monitoring of COPD. Successful spirometry is dependant on the patient taking a maximal inspiration, a forceful BLAST on exhalation and continued exhalation for a minimum of six seconds or until the patient can exhale no further.

More detailed information on spirometry can be found at:

1. American Thoracic Society/European Respiratory Society. Standardisation of spirometry. https://www.thoracic.org/statements/resources/pfet/PFT2.pdf
2. Simple Office Spirometry for Primary Care Practitioners. http://www.nlhep.org/Documents/simple_office_spirometry.pdf
3. National Asthma Council Australia. https://www.nationalasthma.org.au/health-professionals/spirometry-training-and-tools

Appendix 1: Diagnostic Flow Diagram for Spirometry

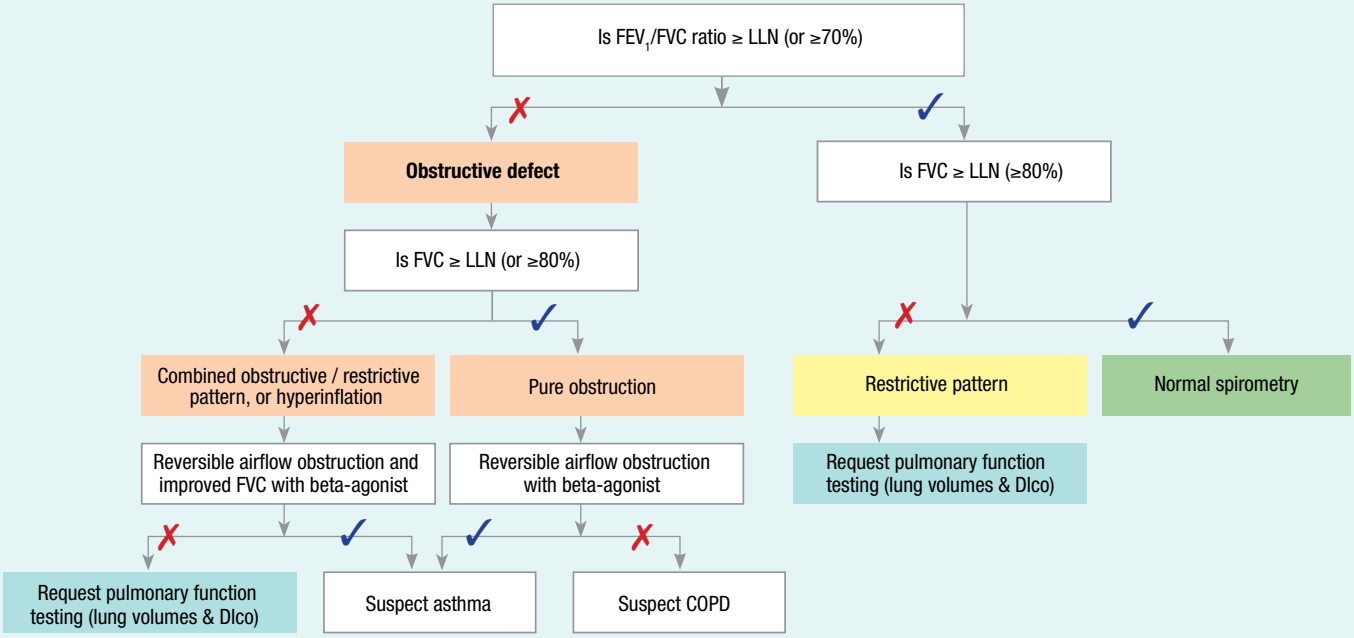

Figure 2: Diagnostic flow diagram for spirometry. Reproduced from Lowry JB. A guide to spirometry for primary care physicians. Boehringer Ingelheim (Canada) and updated using the simplified algorithm that may be used to assess lung function in clinical practice. Pellegrino R et al. Interpretative strategies for lung function. Eur Respir J 2005; 26:948-968.

FEV_1: Forced expiratory volume in one second; FVC: Forced vital capacity; DIco: diffusing capacity for carbon monoxide; LLN: lower limit of normal.

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This publication has been created with support funding from Boehringer Ingelheim. The content and opinions expressed in the publication do not reflect the views of Boehringer Ingelheim unless so specified.The content is entirely independent and based on published studies and the author's opinions.