Review Article

Role of Spirometry in Diagnosis of Respiratory Diseases

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ABSTRACT

Spirometry is the most commonly used pulmonary function tests (PFTs), measuring lung function, specifically volume and/or flow of air that can be inhaled and exhaled. The spirometry test is performed using a device called a spirometer. Spirometry is easily and quickly performed in many settings so it is widely performed study and is important in initial screening and assessment of severity and type of respiratory disease. Besides, it also contributes prognostic information. It is usually done to distinguish between Obstructive and Restrictive diseases of the lungs and measure airflow obstruction to help make a definitive diagnosis.The important information provided by the spirometer are the FVC (Forced Vital Capacity), FEV1 (Forced Expiratory Volume in One Second), FEV1 /FVC (the ratio of FEV1 to FVC), FEV6 (volume of air that can forcibly be expired in 6 seconds). In normal cases FEV_1 and FVC is above 80% predicted and FEV_1/FVC ratio above 0.7. In obstructive lung diseases FEV_1 is below 80% predicted, FVC can be normal or reduced and FEV_1/FVC ratio below 0.7. In restrictive lung diseases FEV_1 is normal or mildly reduced, FVC below 80% predicted and FEV_1/FVC ratio normal - above 0.7.

Keywords: spirometry, obstructive lung disease, restrictive lung diseases.

INTRODUCTION

Spirometry means "the measuring of breath," and it is a routinely used pulmonary function test (PFT) that helps to measures the amount and speed of air that a person can inhale and exhale.[1] Thus spirometry is a method of assessing lung function by measuring the volume of air a patient can expel from the lungs after maximal inspiration. The results that are obtained from the test can be used to determine lung function and aid in the diagnosis of certain respiratory disorders.[2] Spirometry is an important screening test of general respiratory health in the same way as blood pressure provides important information about general cardiovascular health.[3] It is performed using an instrument called spirometer. Spirometer was discovered by Hutchinson in 1846 since then the measurements of the dynamic lung volumes and of maximal flow rates have been used in the detection and quantification of diseases of respiratory system.[4] Absolute lung volumes, residual volume (RV), functional residual capacity (FRC) and total lung capacity (TLC) cannot be determined by spirometry. They are technically more challenging, which limits their use in clinical practice[5]. The exact role of lung volume measurements in the assessment severity of disease, functional disability, course of disease and response to treatment remains to be determined in infants, as well as in children and adults. Nevertheless, in particular circumstances, measurements of lung volume are strictly necessary for a correct physiological diagnosis.

Some Indications for Spirometry are:[6-9]

- Diagnostic

To evaluate symptoms, signs or abnormal laboratory tests

To measure the effect of disease on pulmonary function

To screen individuals at risk of having pulmonary disease

To assess pre-operative risk

To assess prognosis

To assess health status before beginning strenuous physical activity programmes

- Monitoring

To assess therapeutic intervention

To describe the course of diseases that affect lung function

To monitor people exposed to injurious agents

To monitor for adverse reactions to drugs with known pulmonary toxicity

-Disability/impairment evaluations

To assess patients as part of a rehabilitation programme

To assess risks as part of an insurance evaluation

To assess individuals for legal reasons

-Public health

Epidemiological surveys

Derivation of reference equations

Clinical research

Contradictions to use of Spirometry

Some contraindications of spirometry are, acute disorders affecting test performance (e.g., vomiting, nausea,

vertigo), hemoptysis of unknown origin (FVC maneuver may aggravate underlying condition.), pneumothorax, recent abdominal or thoracic surgery, recent eye surgery (increases intraocular pressure during spirometry), recent myocardial infarction or unstable angina, thoracic aneurysms (risk of rupture because of increased thoracic pressure)

Spirometric Measures include the following:[10]

- Forced expiratory volume in 1 s **(FEV1)**

- Forced vital capacity **(FVC),** the maximum amount of air that can be exhaled when blowing out as fast as possible

- Vital capacity **(VC),** the maximum amount of air that can be exhaled when blowing out as fast as possible

- **FEV1/FVC ratio**

- Peak expiratory flow **(PEF),** the maximal flow that can be exhaled when blowing out at a steady rate

- Forced expiratory flow, also known as **mid expiratory flow**; the rates at 25%, 50% and 75% FVC are given

- Inspiratory vital capacity **(IVC),** the maximum amount of air that can be inhaled after a full expiration

The predicted values depends on the individual's age, gender, height and race .The numbers are presented as percentages of the average expected in someone of the same age, height, sex, and race. This is called percent predicted. Airway abnormalities are indicated by increase or decrease FEV_1 and FEV_1 /FVC values relative to reference or predicted values.[11-13]

Procedure to perform Spirometer:[14]

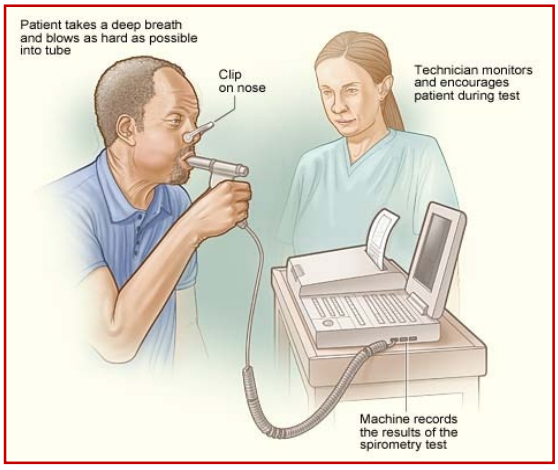

Figure1: Procedure of performing spirometry

Source: National Heart Lung and Blood Insitute (NIH)

1. Explain the purpose of the test and demonstrate the procedure to the subject/patient.
2. Record the patient's age, height and gender and enter on the spirometer
3. Note when bronchodilator was last used
4. Make the patient sitting comfortably
5. Ask the subject to breath in until the lungs are full
6. Pinch his nose or attach a nose clip to prevent air leakage
7. Hold the breath and seal the lips tightly around a clean mouthpiece
8. Blow the air out as forcibly and fast as possible. Provide lots of encouragement!
9. Continue blowing until the lungs feel empty

- Watch the patient during the blow to assure the lips are sealed around the mouthpiece
- Check to determine if an adequate trace has been achieved
- Repeat the procedure at least twice more until ideally 3 readings within 100-150 ml or 5% of each other are obtained.[1]

Spirograms

Spirograms are tracings or recordings of the information obtained from the test. Measurements of expired air volume (in liters), time (in seconds), and airflow rates (in liters per sec) are determined and displayed on the spirograms.

There are two types of Spirograms:

Volume-Time: The basic volume vs. time curve contains points corresponding to the FEV1 and FVC and

Flow-Volume: The expiratory flow vs. volume curve displays instantaneous airflow rates as a function of volume exhaled. This curve also contains points corresponding to the PEF and FVC.

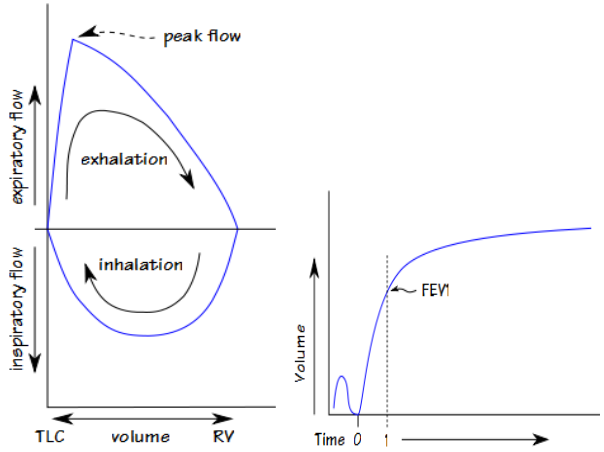

Figure 2a: Flow-Volume curve, b: Volume-Time curve

Spirogram Patterns

The spirometry pattern is different in Normal, Obstructive, Restrictive and Mixed Obstructive and Restrictive respiratory disorders.[16]

Normal:

- FEV1 and FVC above 80% predicted

- FEV1/FVC ratio above 0.7

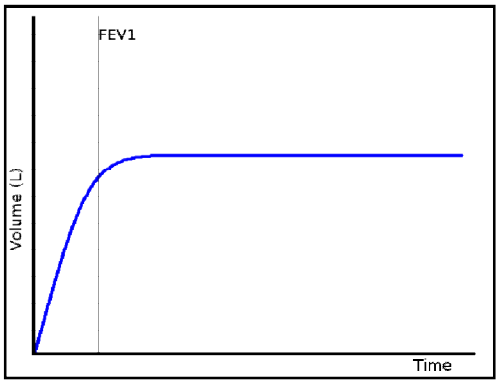

Figure 3: Normal Tracing showing FEV_1 and FVC

Spirometry in Obstructive Disease

Diseases associated with airflow obstruction are COPD, Asthma, Bronchiectasis, Cystic Fibrosis, Post-tuberculosis, Lung cancer (greater risk in COPD), Obliterative Bronchiolitis

In Obstructive Lung Diseases:

- FEV1 below 80% predicted
- FVC can be normal or reduced – usually to a lesser degree than FEV1
- FEV1/FVC ratio below 0.7

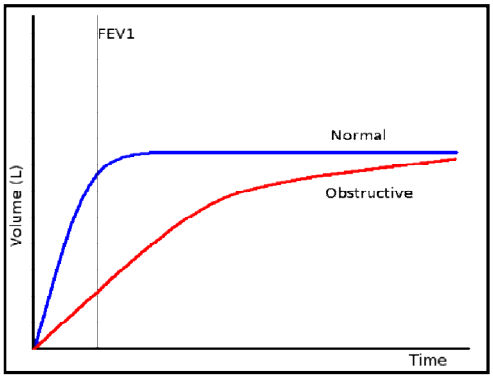

Figure 4: Spirometry in obstructive disease

The severity of obstruction is graded on the basis of the reduction in FEV_1 and has been determined by agreed on standards from the American Thoracic Society.

- FEV_1 < 65-80 % mild obstruction
- FEV_1 < 50-65% moderate obstruction
- FEV_1 < 50% severe obstruction

Bronchodilator Reversibility Testing

- Provides the best achievable FEV_1 (and FVC)
- Helps to differentiate COPD from asthma

Reversibility test must be interpreted with clinical history as neither asthma nor COPD are diagnosed on spirometry alone.

Bronchodilator Reversibility Testing in COPD[17]

Preparation

- Tests should be performed when patients are clinically stable and free from respiratory infection
- Patients should not have taken: inhaled short-acting bronchodilators in the previous six hours, long-acting bronchodilator in the previous 12 hours, and sustained-release theophylline in the previous 24 hours.
- Then FEV_1 should be measured (minimum twice, within 5% or 150mls) before a bronchodilator is given
- The bronchodilator should be given by metered dose inhaler through a spacer device or by nebulizer to be certain it has been inhaled. Possible dosage protocols: 400 µg β_2-agonist, *or* 80-160 µg anticholinergic, *or* the two combined.
- FEV_1 should be measured again: 15 minutes after a short-acting bronchodilator and 45 minutes after the combination

Calculation of Bronchodilator Reversibility

% FEV1 Reversibility = Post-bronchodilator FEV1 – Pre bronchodilator FEV1 x 100 / Pre-bronchodilator FEV1

An increase in FEV_1 that is both greater than 200 ml and 12% above the pre-bronchodilator FEV_1 (baseline value) is considered significant

Spirometry Restrictive Disease

Some Restrictive Diseases are kyphoscoliosis, Muscular Dystrophy Problems, Arthritis Pleural Problems, Interstitial Lung Disease, Obesity.

In Restrictive Disease

- FEV_1: normal or mildly reduced
- FVC: < 80% predicted
- FEV_1/FVC: normal or > 0.7

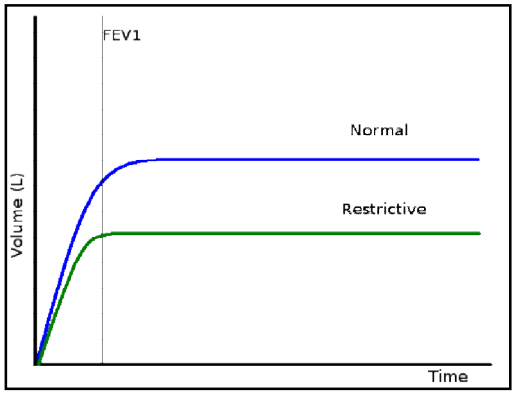

Figure 5: Spirometry in restrictive disease

Spirometry Mixed Obstructive/Restrictive

- FEV_1: < 80% predicted
- FVC: < 80% predicted

- FEV_1 /FVC: < 0.7

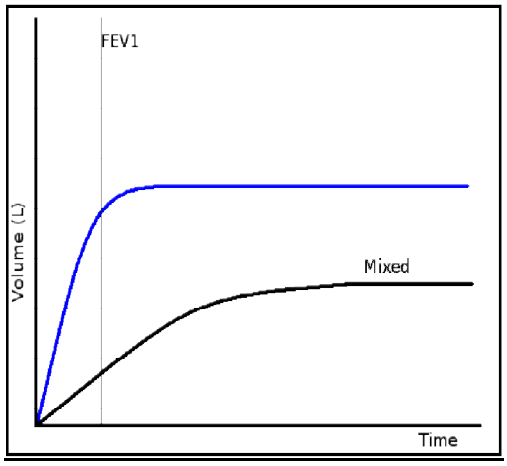

Figure 6: Spirometry in mixed obstructive and restrictive diseases

Flow-Volume Loop

The flow-volume loop is a plot of inspiratory and expiratory flow (y-axis) against volume (x-axis) during the performance of maximally forced inspiratory and expiratory maneuvers.[18-19] The normal expiratory portion of the flow volume loop is characterized by a rapid rise to the peak flow rate, followed by a near linear fall in flow as the patient exhales toward residual volume. The inspiratory curve, in contrast, is a relative symmetrical, saddle shaped curve.

- The shape of the flow-volume loop can indicate the location of airflow limitation. In Obstructive lung disease, there is a rapid peak expiratory flow, but the curve descends more quickly than normal and takes on a concave shape is qualitatively demonstrated by a concave "scooped-out" shape of the expiratory flow-volume curve.
- In restrictive lung diseases the shape of the flow volume loop is relatively unaffected but the overall size of the curve will appear smaller when compared to normal on the same scale.

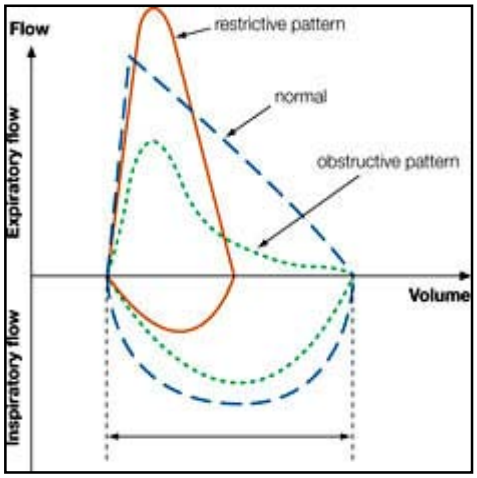

Figure 7: Flow volume loop in obstructive vs restrictive lung diseass

Common Problems faced during Spirometry

Some common problem faced during spirometry are inadequate or incomplete blow, lack of blast effort during exhalation, slow start to maximal effort, lips not sealed around mouthpiece, coughing during the blow, extra breath during the blow, glottic closure or obstruction of mouthpiece by tongue or teeth, poor posture – leaning forwards.

CONCLUSION

Spirometry is a powerful tool that can be used to detect, follow, and manage patients with lung disorders. Technology advancements have made spirometry much more reliable and relatively simple to incorporate into a routine office visit. However, interpreting spirometry results can be challenging because the quality of the test is largely dependent on patient effort and cooperation, and the interpreter's knowledge of appropriate reference values. A simplified and stepwise method is key to interpreting spirometry.

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