THIRD EXERCISE
SPIROMETRY TESTS. BRONCHOPROVOCATION TESTS

DEFINITIONS

Spirometry is a physiological test that measures how an individual inhales or exhales volumes of air as a function of time.

A spirometry is a functional test of the lungs. Different spirometry tests exist. The main spirometry tests are:

FVC (Forced Vital Capacity): the single most important test in spirometry. FVC is the maximal volume of air exhaled with maximally forced effort from a maximal inspiration, i.e. vital capacity performed with a maximally forced expiratory effort, expressed in litres at body temperature and ambient pressure

FEV1 is the maximal volume of air exhaled in the first second of a forced expiration from a position of full inspiration, expressed in litres

VC (Vital Capacity or Slow Vital Capacity): this test used to be performed to get VC and to be able to calculate the FEV1/VC ratio (FEV1% or Tiffeneau index). Now this old parameter has been replaced with a new Tiffeneau index (FEV1/FVC ratio).

Forced Vital Capacity

The Forced Vital Capacity consists of a forced expiration in the spirometer followed by a forced inspiration. Although the test can be performed while standing up, most recommend to do it while sitting down. It is recommended to loosen or take of tight cloths for the test (eg. a tie). Although not strictly necessary it is recommended to put a nose clip on the patient's nose during the test.

MVV (Maximum Voluntary Ventilation): this test is now rarely performed.

Performing an FVC test

Many spirometers allow to perform a few respiratory cycles at rest before the FVC is performed. This tidal breathing can be helpful for the patient to understand better what needs to be done during the test. Other spirometers do not allow this tidal breathing and the patient will need to inspire completely before puttng the mouthpiece in his mouth. This way of performing a test is more error prone.

Tidal breathing

If the spirometer permits it, it is recommended to start with some tidal breathing and explaining the patient what he is doing while showing it on the screen of the spirometer or computer.

Maximum inspiration

The patient fills his lungs entirely. This first inspiration does no need to be forced but must be as deep as possible.

Forced expiration

Immediately after the complete inspiration the patient performs a maximal expiration during which all the air is blasted out of the lungs as fast, as hard and

as long as he can. It is important to empty the lungs as much as possible. Some say patients should hold their breath shortly (but not more than 2 seconds) after complete inspiration, others say there does not need to be pause.

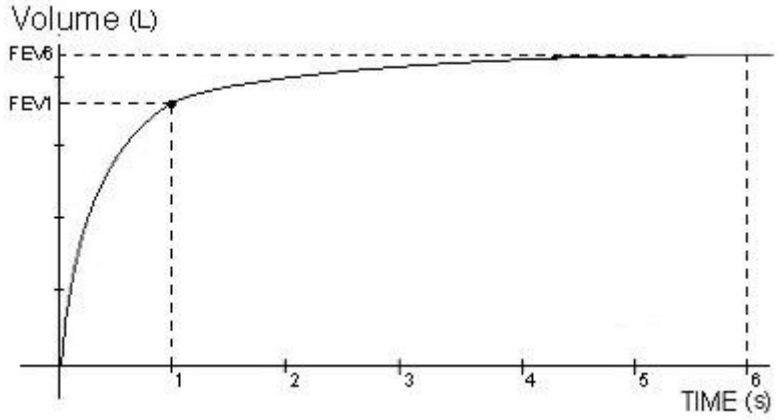
Forced inspiration

Immediately after the forced expiration a second inspiration is performed. The second inspiration will be forced and as quickly as possible.

The results of the test are compared to the predicted values that are calculated from his age, size, weight, sex and ethnic group.

Two graphs are shown after the test: the flow-volume loop and volume-time curve.

The Volume-Time curve explained:



The volume expired in the first second of the FVC test is called FEV1 (Forced Expiratory Volume in the first second) and is a very important parameter in spirometry.

The FEV1% is the FEV1 divided by the VC (Vital Capacity) times 100: FEV1%=FEV1/VC X100. This parameter is also known as the Tiffeneau index, named after the french physician that discovered the FEV1/VC ratio. Nowadays FEV1/FVC X100 is also accepted as FEV1% (FEV1/FVC ratio).

A healthy patients expires approximately 80% of all the air out of his lungs in the first second during the FVC maneuver.

A patient with an obstruction of the upper airways has a decreased FEV1/FVC ratio.

After the PEF the curve descends (=the flow decreases) as more air is expired. After 25% of the total expired volume, the parameter FEF25 is reached.

Halfway the curve (when the patient has expired half of the volume) the FEF50 is reached: Forced Expiratory Flow at 50% of the FVC.

After 75% the parameter FEF75 is reached.

The mean flow between the points FEF25 and FEF 75 is also a very important parameter and is called the FEF2575. This is actually the first parameter that will decline in many respiratory diseases.

Obstructive type: FEV1 and PEF are decreased. **FVC does not change**. Tiffeneau index is under 70%. Typical for asthma

Restrictive type: FEV1 and PEF are decreased. FVC is decreased. Tiffeneau index is normal. Typical for emphysema, COPD and pulmonary fibrosis

BRONCHODILATOR REVERSIBILITY TESTING

When airway obstruction is identified on spirometry, assessing response to inhaled bronchodilators is useful. Bronchodilators are medications that open the airways, making it easier to breathe. This test is often used in people who have asthma or chronic obstructive pulmonary disease (COPD).

Preparation: Withhold inhaled short-acting bronchodilators in the previous six hours, long-acting beta-agonists in the previous 12 hours, or sustained-release theophyllines in the previous 24 hours.

The reversibility testing steps include the following:
The patient is asked to take a deep breath and then blow into the mouthpiece of the spirometer as hard as he/she can. This is a baseline measurement. The spirometer records the results.
The patient is given a 400 mcg of salbutamol **(**bronchodilator medication) by means of an inhaler or nebulizer.
Patient is waiting for about 15 minutes.
The patient is taking a deep breath and then blow into the mouthpiece spirometer as hard as he/she can. Again, the spirometer records the results.
The patient will be asked to blow into the mouthpiece more than once to get the best reading possible.
An increase in FEV1 of >12% of the initial value and >200 mL is considered a positive result.

BRONCHIAL CHALLENGE TESTS

The purpose of a challenge test is to determine the amount of airway irritability of a patient.
I Methacholine Challenge Testing (MCT) – better established.
II Exercise Challenge
III Histamine challenge test
Methacholine challenge testing is one method of assessing airway responsiveness. Airway hyperresponsiveness is one of the features that may contribute to a diagnosis of asthma. MCT is sometimes used to determine the relative risk of developing asthma, assess the severity of asthma, and assess response to asthma therapy.
Inhaled methacholine causes bronchoconstriction. The safety of both patients and technicians should be considered in the design of the test room and the

testing procedures. Patients should not be left unattended during the procedure once the administration of methacholine has begun. Medications to treat severe bronchospasm (30) must be present in the testing area. They include epinephrine and atropine for subcutaneous injection. Oxygen and small-volume nebulizer must be available. Methacholine (acetyl-P-methylcholine chloride), available as a dry crystalline powder, is the agent for bronchoprovocation challenge testing. Methacholine solutions should be mixed and stored in a refrigerator at about 4.

We use two-minute tidal breathing dosing protocol.

After preparing the following 10 doubling concentrations of methacholine in sterile vials, we place them in a holder, and store them in a refrigerator: Diluent: 0.03 0.06 0.125 0.25 0.50 1 2 4 8 16 mg/ml The use of the diluent step is optional.

1. Remove the vials from the refrigerator 30 min before testing, so that the mixture warms to room temperature before use. Insert 3 ml of the first (diluent or lowest) concentration into the nebulizer, using a sterile syringe.
2. Perform baseline spirometry and calculate a target FEV, that indicates a 20% fall in FEV,
3. Use a nebulizer setup. Use dry compressed air to power the nebulizer, Adjust the flow meter to deliver the output established during the calibration procedure (0.13 ml/min,+- 10%). Attach a new exhalation filter
4. Instruct the patient to relax and breathe quietly (tidal breathing) for 2 min. Apply a noseclip. Set the timer for 2 min.
5. Ask the patient to hold the nebulizer upright, with the mouthpiece in his/her mouth. A face mask with a noseclip is a valid alternative and may be easier for some subjects (90). Start the timer and begin nebulization.
6. Watch the patient to ensure that he/she is breathing comfortably and quietly, and not tipping the nebulizer. After exactly 2 min, turn off the flow meter and take the nebulizer from the patient
7. Measure the FEV, about 30 and 90 s after the nebulization is completed. Obtain an acceptable-quality FEV, at each time point. This may require repeated attempts. Perform no more than three or four maneuvers after each dose.
8. At each dose, report the highest FEV, from the acceptable maneuvers.
9. If the FEV, falls less than 20%, empty the nebulizer, add 3 ml of the next highest concentration, and repeat steps e-h above.
10. If the FEV, falls more than 20% from baseline (or the highest concentration has been given), give no further methacholine, note signs and symptoms, administer inhaled albuterol, wait 10 min, and repeat the spirometry.

The postdiluent FEV, is the reference point for comparison. We recommend a 20% fall in FEV, following diluent as the threshold of significance for consistency with the thresholds used in the rest of the test.

ALLERGEN BRONCHOPROVOCATION TESTS

Allergen bronchoprovocation tests have been used for more than two decades in the investigation of respiratory allergic diseases such as asthma and rhinitis. These bronchial challenges are now well standardized and can offer key information on the therapeutic potential of new agents and on their anti-inflammatory effects on the airways.