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Introduction

Hello and welcome to this special module on physical education. Today we will be discussing about the various efficiency tests that are being conducted to analyze the strength of a person's metabolic and physical endurance. Let's have a look.

Abnormalities can be classified by the physiologic patterns outlined below.

Obstructive defects

Disproportionate reduction in the FEV1 as compared to the FVC is reflected in the FEV1/FVC ratio and is the hallmark of obstructive lung diseases. This physiologic category of lung diseases includes but is not limited to asthma, acute and chronic bronchitis, emphysema, bronchiectasis, cystic fibrosis, and bronchiolitis. The forced expiratory flow at any given lung volume is reduced. The mechanism responsible for the reduction in airflow can be bronchial spasm, airway inflammation, increased intraluminal secretions, and/or reduction in parenchymal support of the airways due to loss of lung elastic recoil.

The use of a fixed lower limit of normal for the FEV1/FVC ratio as proposed by the Global Initiative for Obstructive Lung Disease (GOLD) lacks a scientific basis and results in significant misclassification of patients at either end of the age spectrum. Young patients are classified as "normal" when airflow obstruction is present, and older patients are classified as showing obstruction when no airflow obstruction is present. The use of the GOLD threshold for identifying airway obstruction should be discouraged in clinical practice where or when computerized predicted values are available.

The recommended practice for identifying a spirometric abnormality is to use the predicted lower limit of normal for that individual based on the sex, age, height, and ethnicity. Both the NHANES and GLI reference equations provide lower limits of normal for spirometric parameters.

Assessment of Reversibility of Airway Obstruction

When airway obstruction is identified on spirometry, assessing response to inhaled bronchodilators is useful. The ATS has recommended that the threshold for significant response be demonstration of an increase of at least 12% and 0.2 L in either FVC (provided the expiratory time for both sessions agree within 10%) or FEV1 on a spirogram performed 10-15 minutes after inhalation of a therapeutic dose of a bronchodilating agent. When concern about tremor or heart rate exists, lower doses may be used. Response to an anticholinergic drug may be assessed 30 minutes after four inhalations (40 mcg each, 160 mcg total dose) of ipratropium bromide. Failure to respond to bronchodilator challenge does not preclude clinical benefit from bronchodilators. A positive response to the bronchodilators may correlate with response to steroid therapy.

Restrictive defects

Reduction in the FVC with a normal or elevated FEV1-to-FVC ratio should trigger further evaluation of total lung capacity (TLC) to rule out restrictive lung disease. Measuring the TLC and residual volume (RV) can confirm restriction suggested by spirometry.

Quantification of Impairment by Spirometry

In normal spirometry, FVC, FEV1, and FEV1 -to-FVC ratio are above the lower limit of normal. The lower limit of normal is defined as the result of the mean predicted value (based on the patient's sex, age, and height) minus 1.64 times the standard error of the estimate from the population study on which the reference equation is based. If the lower limit of normal is not available, the FVC and FEV1 should be greater than or equal to 80% of predicted, and the FEV1 -to-FVC ratio should be no more than 8-9 absolute percentage points below the predicted ratio.

The ATS has recommended the use of lower limits of normal instead of the 80% of predicted for setting the threshold that defines abnormal test results.

A reduced FVC on spirometry in the absence of a reduced FEV1 -to-FVC ratio suggests a restrictive ventilatory problem. An inappropriately shortened exhalation during spirometry can (and often does) result in an artifactually reduced FVC. Causes of restriction on spirometry include obesity, cardiomegaly, ascites, pregnancy, pleural effusion, pleural tumors, kyphoscoliosis, pulmonary fibrosis, neuromuscular disease, diaphragm weakness or paralysis, space-occupying lesions, lung resection, congestive heart failure, inadequate inspiration or expiration secondary to pain, and severe obstructive lung disease. The severity of reductions in the FVC and/or the FEV1 can be characterized by the following scheme:

Mild - Greater than 70% of predicted

Moderate - 60-69% of predicted

Moderately severe - 50-59%

Severe - 35-49% of predicted

Very severe - Less than 35% of predicted

The lower limit of normal for the FEF25-75% can be less than 50% of the mean predicted value, making it important to use the lower limit of normal defined by the 95% confidence limit of the mean predicted value rather than a threshold defined by a fixed percentage of the predicted value. The FEF25-75% is also very dependent on expiratory time. If expiratory times of spirometry efforts vary by more than 10%, comparisons of the FEF25-75% before and after bronchodilator challenge are difficult to interpret. Early termination of expiration shifts the middle 50% of the exhaled volume toward the start of the exhalation, artifactually raising the FEF25-75%. For these reasons, the use of the FEF25-75% to assess airway function in adults is discouraged.

The FVC is a reliable means of assessing the clinical status in idiopathic pulmonary fibrosis (IPF). A minimum clinically important difference of the FVC, expressed as a percentage of the mean predicted normal value, of 2-6% of has been established. This obviates the need to obtain a total lung capacity (TLC) measurement to assess disease progression or the effects of medical therapy.

Special Assessments

Sitting versus supine vital capacity

Evaluation of diaphragm strength can be accomplished by measuring the vital capacity in an upright or sitting position followed by a measurement made in the supine position. A reduction in the vital capacity to less than 90% of the upright vital capacity suggests diaphragm weakness or paralysis. Interpreting an increased reduction in vital capacity in the supine position as diaphragm dysfunction should be made cautiously if the patient's body mass index is greater than 45 kg/m2. [4] Studies reporting the normal reduction of the vital capacity of less than 10% from upright to supine were conducted with individuals who were not obese. Slightly greater reductions in obese individuals in a supine position may not indicate diaphragm dysfunction, but rather an increase in the resistive forces against which the diaphragm descends. Reductions in the supine vital capacity more than 20% of baseline indicate hemidiaphragm or diaphragm dysfunction or paralysis.

Identifying central airway obstructions

The configuration of the flow-volume curve of a properly performed spirometry test can be used to demonstrate various abnormalities of the larger central airways (larynx, trachea, right and left mainstem bronchi). Three patterns of flow-volume abnormalities can be detected: (1) variable intrathoracic obstructions, (2) variable extrathoracic obstructions, and (3) fixed upper airway obstructions. Reproducing these findings on every effort is important because spurious non-reproducible reductions in inspiratory flow are not uncommon after completion of forced expirations in subjects without upper airway obstruction. Examples of variable intrathoracic obstruction include localized tumors of the lower trachea or mainstem bronchus, tracheomalacia, and airway changes associated with polychondritis.

Variable upper airway obstructions demonstrate flow reductions that vary with the phase of forced respirations. Variable intrathoracic obstructions demonstrate reduction of airflow during forced expirations with preservation of a normal inspiratory flow configuration. This is observed as a plateau across a broad volume range on the expired flow limb of the flow-volume curve. The reduction in airflow results from a narrowing of the airway inside the thorax, in part because of a narrowing or collapse of the airway secondary to extraluminal pressures exceeding intraluminal pressures during expiration.

Variable extrathoracic obstructions demonstrate reduction of inspired flows during forced inspirations with preservation of expiratory flows. Again, the major cause of the reduced flow during inspiration is airway narrowing secondary to extraluminal pressures exceeding intraluminal pressures during inspiration. Causes of this type of upper airway obstruction include unilateral and bilateral vocal cord paralysis, vocal cord adhesions, vocal cord constriction, laryngeal edema, and upper airway narrowing associated with obstructive sleep apnea.

Fixed upper airway obstructions demonstrate plateaus of flow during both forced inspiration and forced expiration. Causes of fixed upper airway obstruction include goiters, endotracheal neoplasms, stenosis of both main bronchi, postintubation stenosis, and performance of the test through a tracheostomy tube or other fixed orifice device.

Test

Lung volumes provide useful information that confirms the presence of restrictive lung disease suggested by a low vital capacity on a spirometry test. Hyperinflation, elevation of the RV and TLC can be demonstrated by this test. The test is dependent first on an accurate measurement of the volume of gas in the lungs at a resting end-expiration, known as the FRC, which represents the balance of the elastic recoil properties of the lung and the chest wall.

FRC can be measured by one of three techniques, inert gas dilution, nitrogen washout, or whole-body plethysmography. Both gas dilution techniques are subject to error by leaks at the mouthpiece or nose clip or, occasionally, even small leaks from the eardrum. When measured by whole-body plethysmography, resting end-expiratory volume is known as the FRCpleth and will include the volume of gas contained in noncommunicating spaces such as blebs or bullae that the FRC measured by gas dilution techniques will not measure. In addition to this advantage, body plethysmography allows multiple determinations of lung volumes to be made rapidly.

When measured by inert gas dilution or nitrogen washout, premature termination of the procedure before adequate demonstration of equilibrium or washout results in underestimation of FRC, RV, and TLC. Repeat measurements should allow a recovery period of 1.5 times the wash-in or wash-out time to prevent residual helium or oxygen from affecting the new measurement. Body plethysmography is performed rapidly, allowing multiple determinations in minutes. Ideally, each measurement of lung subdivisions should be linked to each FRC or ITGV measurement (patient should remain on the mouthpiece).

Two types of errors are known to occur with body plethysmography techniques. One involves the underestimation of mouth pressure swings during respiratory efforts when the airway is occluded. The assumption that when no airflow is present the mouth pressures accurately reflect alveolar pressure has been shown to be not true when respiratory efforts occur at a frequency of greater than 1 Hz (respiratory rate of 60 breaths per minute). Thus, FRCpleth is overestimated if the frequency of the respiratory effort is not kept between 0.5 and 1.0 Hz (30-60 breaths/min) during shutter closure.

The second type of measurement error using body plethysmography involves trying to pace the patient's tidal breathing before shutter closure. The ideal respiratory rate during shutter closure is far in excess of the patient's resting respiratory rate and causes dynamic hyperinflation, increasing the lung volume above the resting lung volume. Patients should breathe at a relaxed spontaneous respiratory rate without coaching before shutter closure.

Results

All lung volumes are expressed in liters to the nearest hundredth of a liter. FRC is the volume of gas in the lungs at the end of an average resting expiration. It is comprised of the expiratory reserve volume (ERV), the volume of gas that can be voluntarily exhaled beyond the FRC or ITGV, and the RV. The TLC then can be calculated by adding the RV to the vital capacity (VC). RV also is expressed as a fraction of the TLC, the RV-to-TLC ratio (see the image below). The expected repeatability of three repeated same-session measurements of FRC is ± 5%. The standards for expected repeatability of other parameters (RV, IC, TLC) have not been set, but the expected repeatability of the VC is the same as FVC, ≤ 0.15 L difference between the two largest.

Interpretation and Conclusion

Obstructive lung diseases, particularly emphysema, result in an increase in the RV and RV-to-TLC ratio. In severe emphysema, particularly bullous emphysema, the TLC can show a marked increase. Bronchial spasm, airway inflammation, excessive secretions in the airway, and loss of lung elastic recoil increase airways resistance and result in an insidious progressive increase in the end-expiratory lung volume that results in chronic hyperinflation (elevated RV, TLC, and RV-to-TLC ratio). Other pulmonary causes of increased RV include pulmonary vascular congestion and mitral stenosis. Extrapulmonic causes of increased RV include expiratory muscle weakness as observed in spinal cord injuries and myopathies.

Increased body weight due to increased fat causes an increase in chest wall elastic recoil, which favors a lower end-expiratory lung volume, resulting in less hyperinflation for any degree of airflow obstruction.

Lung volumes can confirm the presence of restriction when a reduced vital capacity is seen on spirometry. A reduced TLC is the hallmark of restrictive lung disease. An isolated reduction of the residual volume may be an early sign of restrictive lung disease. Pulmonary processes that can reduce the TLC include interstitial lung disease, atelectasis, pneumothorax, pneumonectomy, consolidation, edema, and fibrosis. Extrapulmonary causes of restriction include obesity, respiratory muscle weakness, thoracic deformities, and disease of the pleura.

So in this episode we have seen various physical tests can be administered to a person for his physical and metabolic endurance and with the help of instruments we can find whether that person has got that ability to a good athlete or not. I hope that the information that was provided was of some use to all of you. Thank you so much for watching.