Week 3 Alterations in Pulmonary Function

- Obstructive Lung Disease vs. Restrictive Disease
- COPD
- Asthma
- Interstitial Lung Disease

Weekly objectives

1. WO3.3- Differentiate between normal and abnormal respiratory structure and function. (CO1)
2. WO3.1-Analyze pathophysiological mechanisms associated with alterations in respiratory processes. (CO1)
3. WO3.2- Describe outcomes of disruptive or alteration in respiratory processes. (CO2)
4. WO3.4- Apply a clinical practice guideline in the management of a patient with altered respiratory function. (CO5).

Mechanics of Respiration: Pulmonary Function Tests

Pulmonary function tests (PFTs) are non-invasive tests that provide information about lung function. PFTs alone cannot differentiate among the causes of respiratory abnormalities. Therefore, the patient's history, physical exam and other diagnostics must be considered when making a diagnosis. The PFT can help the NP determine the patient's respiratory pattern, specifically if the abnormality is due to an obstructive or restrictive problem. Once the pattern is identified, PFTs allow the NP to determine the severity of the disease. This data combined with other patient findings, leads to a diagnosis.

There are some indications to help the NP to determine when to order PFTs:

- When signs and symptoms of a respiratory problem requires evaluation (cough, dyspnea, cyanosis, wheezing, hypoxemia, hypercapnia and lung hyperinflation).
- When disease progression needs to be determined.
- When monitoring the effectiveness of drug therapy.
- When monitoring for potential toxic effects of certain drugs.

Components of a Pulmonary Function Tests

Spirometry: This measures air movement in and out of the lungs during various respiratory maneuvers. The NP can also determine how much air the patient is breathing in and out and how fast the patient is doing it. Think about the respiratory cycle in terms of lung volume and lung capacities. The capacity is just simply the sum of one of more volumes.

There are three important measures on which the NP focuses when reviewing spirometry results. These are summarized in the table below:

Measure	Definition	Maneuver
Forced Vital Capacity (FVC); Normal 80-120%	The FVC measures the volume of air in the lungs that can be exhaled.	Patient inhales as deep as possible and then exhales as long and as forcefully as possible.
Forced Expiratory Volume in 1 second (FEV1); Normal 80-120%	Amount of air forcefully exhaled from the lungs in the first second.	The patient inhales and forcefully exhales as fast as possible.
FEV1/FVC ratio	Determines if the pattern is obstructive, restrictive or normal	This is a calculated ratio that represents the proportion of a person's vital capacity that they are able to expire in the first second of forced expiration to the full, forced vital capacity.

Diffusing capacity: The diffusing capacity is simply how well the lungs are able to exchange gas. Gas exchange is most efficient in a lung that has high surface area because it's easier for the blood to pick up the gas that's being exchange. An example of a condition that decreases the patient's diffusing capacity because of a loss of surface area is emphysema. Conditions that increase the lungs thickness can also decrease diffusing capacity as in the case of pulmonary fibrosis.

Residual volume (RV) and Total Lung Capacity (TLC): RV is the amount of air that remains in the lungs after a forceful exhalation. RV + FVC = TLC. Note that the RV cannot be measured by spirometry. Other methods are used that require the patient to inhale an inert gas (helium) or sit in an airtight booth where the pressure is measured during breathing. These measurements are also called static lung volumes. The values add to the information obtained from spirometry. If the patient has an obstructive disease, RV and TLC results will be elevated which reveals air trapping and hyperinflation. In restrictive disease, the TLC is needed to confirm true restriction. It can also help in quantifying the degree of restriction.

Steps to Analyze Pulmonary Function Tests (PFTs)

First, the NP must understand how the results of the PFT is delivered. The results will yield measured values and percentages of predicted values. Predicted values and lower limits of normal have been standardized by population studies using individuals without lung disease. Each patient's predicted values depend on the age, height, and gender. This information is entered into a computer prior to the PFT.

Once the results have been received, the NP looks at two factors: 1) the pattern of the condition; 2) severity of the condition.

Step 1: Determine the Pattern

In order to classify the respiratory issue as either obstructive, restrictive or normal., the NP starts by looking at the FEV1/FVC ratio.
Obstructive pattern: If the FEV1/FVC ratio is less than 70% or less than the lower limit of normal for the patient. FEV1 also falls to a greater degree than the FVC.
Restrictive pattern: If the FEV1/FVC ratio is greater than 70% or greater than the lower limit of normal, then the spirometry test is either normal, or a restrictive respiratory abnormality is present. To make this

distinction, the NP must look at the TLC. In restrictive disorders, the percent predicted of TLC is <80%, where 80-120% represents a normal range.

The following table compares PFT values in terms of obstructive and restrictive:

Measurement	**Obstructive**	**Restrictive**
Forced vital capacity (FVC)	Decreased or normal	Decreased
Forced expiratory volume in 1 second (FEV1): Normal is > 80%	Decreased	Decreased
FEV1/FVC ratio: Normal is 70% or less than the lower limit of normal for the patient	Less than 70%	Normal or > 70%
Total lung capacity (TLC): Normal range is 80-120% of predicted	>120% (represents hyperinflation)	<80%

Step 2: Determine the Severity

The American Thoracic Society (ATS) system for grading the severity of pulmonary function test abnormality according to the FEV1 percent predicted, where normal is greater than 80%.

Severity	FEV1 % Predicted
Mild	>70%
Moderate	60-70%
Moderately Severe	50-60%
Severe	35-50%
Very Severe	<35%

Step 3: Bronchodilator Response

One other aspect of spirometry is that it may be repeated after the patient receives a bronchodilator. If either the FEV1 or the FEV increases by at least 12% and by at least 200 mL from the pre-bronchodilator values, then the patient has had a significant bronchodilator response. The NP must consider the degree of severity of the respiratory abnormality.

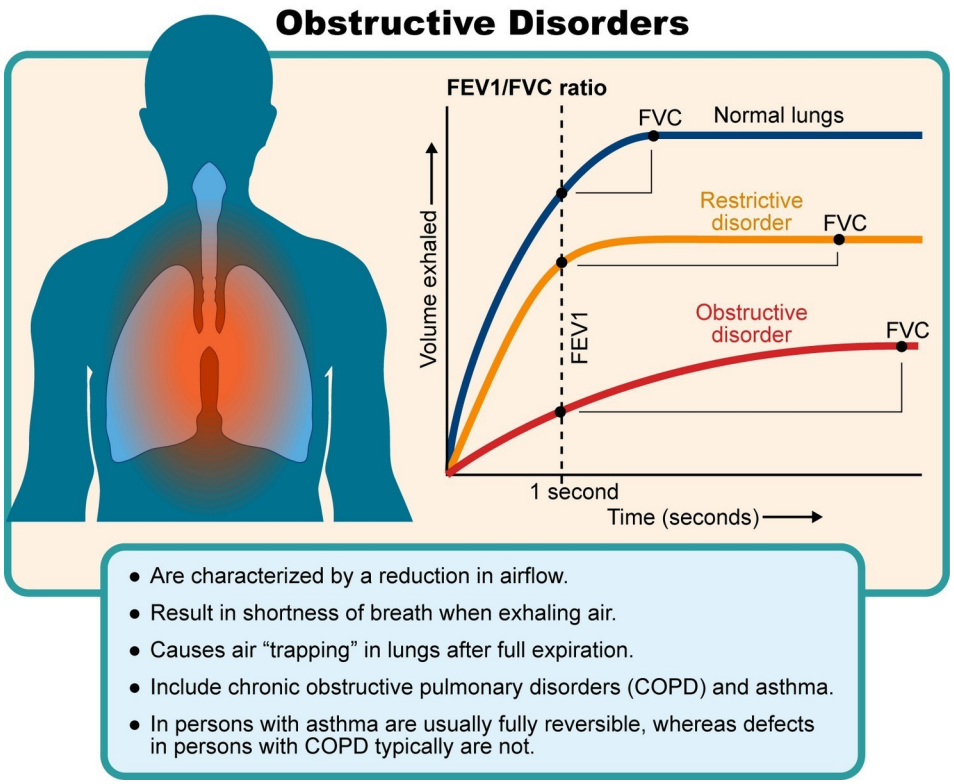
In the next page, we compare the characteristics of restrictive and obstructive lung disease and demonstrate how these are reflected in a PFT.

Characteristics of Obstructive and Restrictive Lung

Disease Before comparing obstructive and restrictive lung disease, remember that we are keying in on how much air the patient can forcefully expire. FEV1 is the amount of air that the patient can forcefully expire in 1 second. The normal range is between 80% - 120%. Also keep in mind the FVC, which is the amount of air that the patient can forcefully inspire and expire. The normal range is between 3-5 liters. These values can be altered in obstructive and restrictive pulmonary disease.

Obstructive Disorders

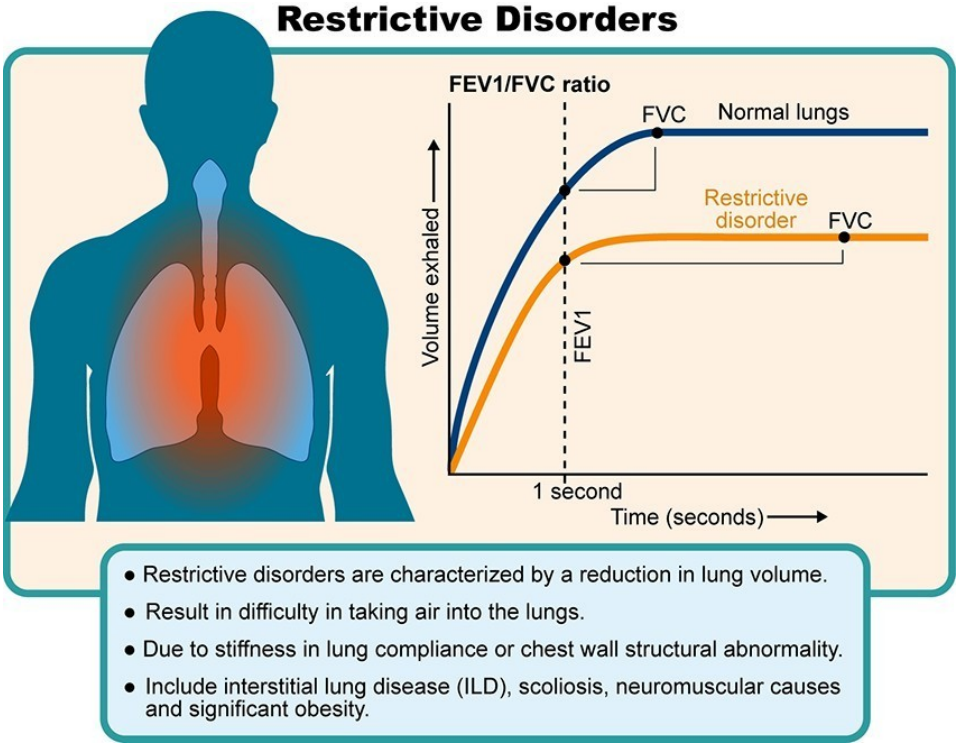
Obstructive disorders are characterized by obstruction to airflow during expiration. This can be related to conditions that increase mucus production leading to mucus plugs as in the case of chronic bronchitis or the loss of surface area of the lung that decreases areas of gas exchange as a result in inflammatory processes that destroys the lung's elastic resulting in decreased recoil. Regardless of the cause of the obstruction, there is an increased work of breathing (WOB), which requires more energy and effort to create airflow. This eventually results in a ventilation-mismatch where not enough CO_2 is being expelled and not enough oxygen being brought in for gas exchange. In using emphysema as an example, the defect is destruction of the lung's elastic tissue caused by inflammation after the person has been exposed to smoking and other irritants over a long period of time. The lung is infiltrated with inflammatory cells that release cytokines that contribute to airway damage and mucus production. When elastin is destroyed, the lung loses its recoil ability that is necessary to expel air out. This leads to air trapping and enlarged alveoli that results in increased lung compliance and decreased elasticity. Ultimately, the lungs become overstretched without the ability to recoil. Individuals with an obstructive disorder will have less than 70% on their PFT. Both the FEV1 and FVC will be decreased.



Restrictive Disorders

Restrictive disorders occur because of a decreased compliance of the lung tissue. Unlike emphysema, as discussed above, there is normal amount of elastin. So, the issue is not related to recoil in the restricted lung. The issue is with compliance, which is decreased in a restrictive disorder. Using pulmonary fibrosis as an example, fibrous or scarred tissue increases the elasticity of the lung, but compliance decreases due to the scarring caused by the fibrosis which prevents the lungs from expanding. With low

compliance, the lungs do not ventilate adequately because there is limited air that is able to enter the lung on inhalation. If there is not sufficient air going in, then there cannot be sufficient air going out. Therefore, the FVC will be lower while FEV1 increases.



Chronic Obstructive Pulmonary Disease (COPD)

COPD consists of chronic bronchitis and emphysema and is characterized by an airflow limitation that is not fully reversible. Risk factors for COPD include smoking whether it is via cigarette, pipe, cigar or second-hand exposure. Airborne irritants may also contribute to the development of COPD such as air pollutants, chemical fumes or dust. Additionally, anything that affects the lung growth during gestation can also contribute to the development of COPD such as smoking, antibiotic use, preterm birth, and air pollution. Finally, the inherited mutation in the alpha-antitrypsin gene in patients who have never smoked, is a genetic cause of COPD.

COPD, as its name implies, is an obstructive disorder. COPD patients have difficulty in fully expiring air from the lungs (decreased FVC) due to expiratory airway obstruction caused by mucus, edema, and loss of elastic recoil, which causes the airway to collapse. This results in the ability of the lung to passively expire air. Air trapping causes the chest to hyper-expand which leads to increased work of breathing. As a result, patients will develop hypoventilation and hypercapnia. Bronchoconstriction may also occur due to ongoing inflammation, which may be partially reversible with bronchodilators. Chronic inflammation can lead to systemic effects of weight loss, muscle weakness and increased susceptibility to infection.

COPD is diagnosed through history, physical exam and diagnostic testing. On respiratory exam, hyperresonance will be identified due to air-trapping. Pulmonary function tests will show a FEV1/FVC ratio <70% with a decreased FEV1 % predicted. Additionally, bronchodilator challenge will result in no change in the obstructive pattern. Arterial blood gas measurements may reveal hypoxemia with activity