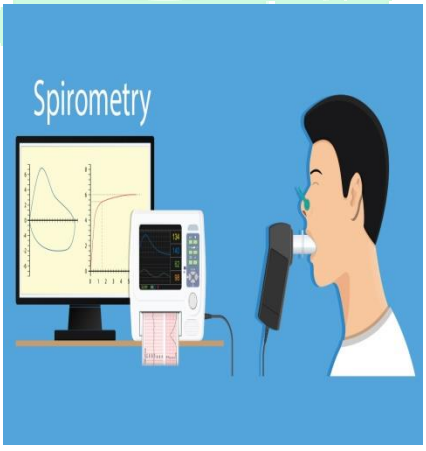
UNIT-3 LUNG VOLUMES AND CAPACITIES TRANSPORT OF RESPIRATORY GASES

PULMONARY FUNCTION TESTS (PFTS)

- Pulmonary function tests (PFTs) are noninvasive tests that show how well the lungs are working.
- The tests measure lung volume, capacity, rates of flow, and gas exchange.
- This information can help the physician to diagnose and decide the treatment of certain lung disorders.
- PFT can be done with 2 methods. These 2 methods may be used together and perform different tests, depending on the information that physician looking for.

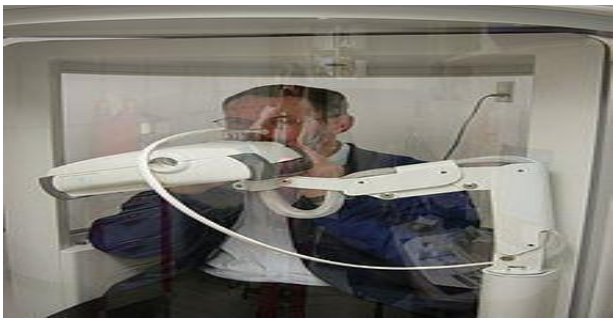
SPIROMETRY

A spirometer is a device with a mouthpiece hooked up to a small electronic machine.



PLETHYSMOGRAPHY:

You sit or stand inside an air-tight box that looks like a short, square telephone booth to do the tests.



PFT MEASURES:

1) Tidal volume (VT) - This is the amount of air inhaled or exhaled during normal breathing.
2) Minute volume (MV) - This is the total amount of air exhaled per minute.
3) Vital capacity (VC) - This is the total volume of air that can be exhaled after inhaling as much as the person can.
4) Functional residual capacity (FRC) - This is the amount of air left in lungs after exhaling normally.
5) Residual volume - This is the amount of air left in the lungs after exhaling as much as the person can.
6) Total lung capacity - This is the total volume of the lungs when filled with as much air as possible.
7) Forced vital capacity (FVC). This is the amount of air exhaled forcefully and quickly after inhaling as much as the person can.
8) Forced expiratory volume (FEV). This is the amount of air expired during the first, second, and third seconds of the FVC test.

9) Forced expiratory flow (FEF). This is the average rate of flow during the middle half of the FVC test.

10) Peak expiratory flow rate (PEFR). This is the fastest rate that you can force air out of the lungs.

LUNG VOLUMES:

TIDAL VOLUME

Tidal volume (TV) is the volume of air breathed in and out of lungs in a single normal quiet respiration. Tidal volume signifies the normal depth of breathing.

Normal Value - 500 mL (0.5 L).

INSPIRATORY RESERVE VOLUME

Inspiratory reserve volume (IRV) is an additional volume of air that can be inspired forcefully after the end of normal inspiration.

Normal Value - 3,300 mL (3.3 L).

EXPIRATORY RESERVE VOLUME

Expiratory reserve volume (EVR) is the additional volume of air that can be expired out forcefully, after normal expiration.

Normal Value - 1,000 mL (1 L).

RESIDUAL VOLUME

Residual volume (RV) is the volume of air remaining in lungs even after forced expiration. Normally, lungs cannot be emptied completely even by forceful expiration. Some quantity of air always remains in the lungs even after the forced expiration.

Residual volume is significant because of two reasons:

1. It helps to aerate the blood in between breathing and during expiration

2. It maintains the contour of the lungs.

Normal Value - 1,200 mL (1.2 L)

LUNG CAPACITIES

- Static lung capacities are the combination of two or more lung volumes.
- Static lung capacities are of four types:

1. Inspiratory capacity
2. Vital capacity
3. Functional residual capacity
4. Total lung capacity.

INSPIRATORY CAPACITY

Inspiratory capacity (IC) is the maximum volume of air that is inspired after normal expiration (end expiratory position). It includes tidal volume and inspiratory reserve volume.

IC = TV + IRV = 500 + 3,300 = 3,800 mL

VITAL CAPACITY (VC)

Vital capacity (VC) is the maximum volume of air that can be expelled out forcefully after a deep (maximal) inspiration.

Vital capacity includes inspiratory reserve volume, tidal volume and expiratory reserve volume.

Normal value

VC = IRV + TV + ERV = 3,300 + 500 + 1,000 = 4,800 mL.

FUNCTIONAL RESIDUAL CAPACITY

FRC is the Volume of air remaining in the lungs at the end of passive expiration.

FRC = ERV + RV = 2200mL

Normal value – 1800-2200mL

TOTAL LUNG VOLUME

TLV is the Volume of air in the lungs after a maximum inspiration.

TLC = IRV + TV + ERV + RV (VC+RV) = 6000mL

Normal value - 6000mL

FORCED VITAL CAPACITY

Forced vital capacity (FVC) is the volume of air that can be exhaled forcefully and rapidly after a maximal or deep inspiration. It is a dynamic lung capacity.

Normally FVC is equal to VC. However in some pulmonary diseases, FVC is decreased.

FORCED EXPIRATORY VOLUME OR TIMED VITAL CAPACITY

Forced expiratory volume (FEV) is the volume of air, which can be expired forcefully in a given unit of time (after a deep inspiration). It is also called timed vital capacity or forced expiratory vital capacity (FEVC). It is a dynamic lung volume.

FEV1 = Volume of air expired forcefully in 1 second

FEV2 = Volume of air expired forcefully in 2 seconds

FEV3 = Volume of air expired forcefully in 3 seconds.

Normal values

Forced expiratory volume in persons with normal respiratory functions is as follows:

FEV1 = 83% of total vital capacity

FEV2 = 94% of total vital capacity

FEV3 = 97% of total vital capacity

After 3rd second = 100% of total vital capacity.

Significance of determining FEV

- Vital capacity may be almost normal in some of the respiratory diseases. However, the FEV has great diagnostic value, as it is decreased significantly in some respiratory diseases.
- It is very much decreased in obstructive diseases like asthma and emphysema.
- It is slightly reduced in some restrictive respiratory diseases like fibrosis of lungs .

RESPIRATORY MINUTE VOLUME

Respiratory minute volume (RMV) is the volume of air breathed in and out of lungs every minute. It is the product of tidal volume (TV) and respiratory rate (RR).

RMV = TV × RR = 500 × 12 = 6,000 mL.

Normal value - 6 L.

Variations:

Respiratory minute volume increases in physiological conditions such as voluntary hyperventilation, exercise and emotional conditions.

It is reduced in respiratory diseases.

MAXIMUM BREATHING CAPACITY OR MAXIMUM VENTILATION VOLUME

Maximum breathing capacity (MBC) is the maximum volume of air, which can be breathed in and out of lungs by forceful respiration (hyperventilation: increase in rate and force of respiration) per minute.

It is also called maximum ventilation volume (MVV).

MBC is a dynamic lung capacity and it is reduced in respiratory diseases.

Normal value-In healthy adult male, it is 150 to 170 L/minute and in females, it is 80 to 100 L/minute.

PEAK EXPIRATORY FLOW RATE

Peak expiratory flow rate (PEFR) is the maximum rate at which the air can be expired after a deep inspiration.

Normal value In normal persons, it is 400 L/minute.

Significance of determining PEFR

- Determination of PEFR rate is useful for assessing the respiratory diseases especially to differentiate the obstructive and restrictive diseases.
- Generally, PEFR is reduced in all type of respiratory disease. However, reduction is more significant in the obstructive diseases than in the restrictive diseases.
- Thus, in restrictive diseases, the PEFR is 200 L/minute and in obstructive diseases, it is only 100 L/minute.