SPIROMETRY

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SPIROMETRY

Recording Changes in Pulmonary Volume

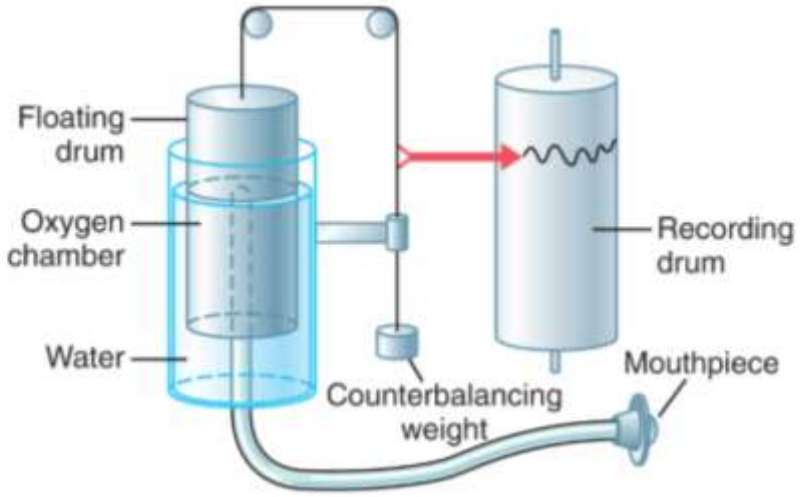
Lung volumes and capacities are anatomic measurements that vary with age, weight, height and sex of an individual.

All pulmonary volumes and capacities are about 20 to 25 percent less in women than in men, and they are greater in large and athletic people than in small and asthenic people.

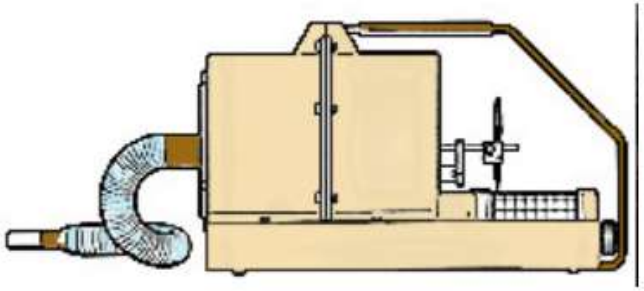
When affected by disease or trauma, the lung volumes and capacities are altered to a certain degree, depending upon the severity of the disorder. Pulmonary tests can show the effects of disease on function, but they cannot be used to give a diagnosis. However these tests do give valuable quantitative data, allowing the progress of a disease to be followed, or the response to a treatment examined.

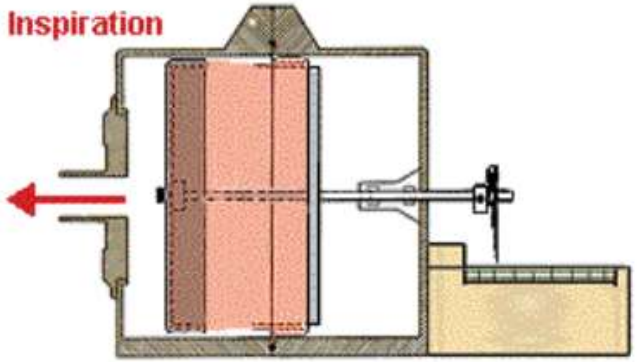
SPIROMETER

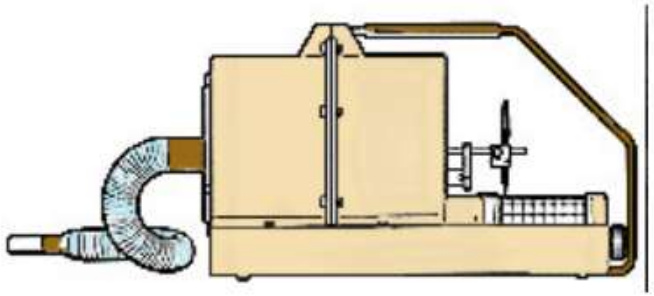
It consists of a drum inverted over a chamber of water, with the drum counterbalanced by a weight. In the drum is a breathing gas, usually air or oxygen; a tube connects the mouth with the gas chamber. When one breathes into and out of the chamber, the drum rises and falls, and an appropriate recording is made on a moving sheet of paper

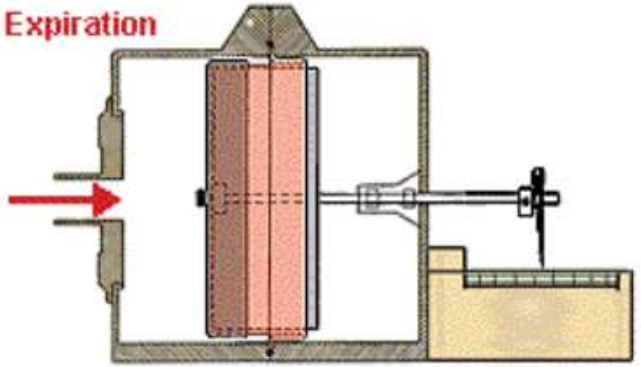


DRY-SEAL SPIROMETER









STATIC LUNG VOLUMES AND CAPACITIES

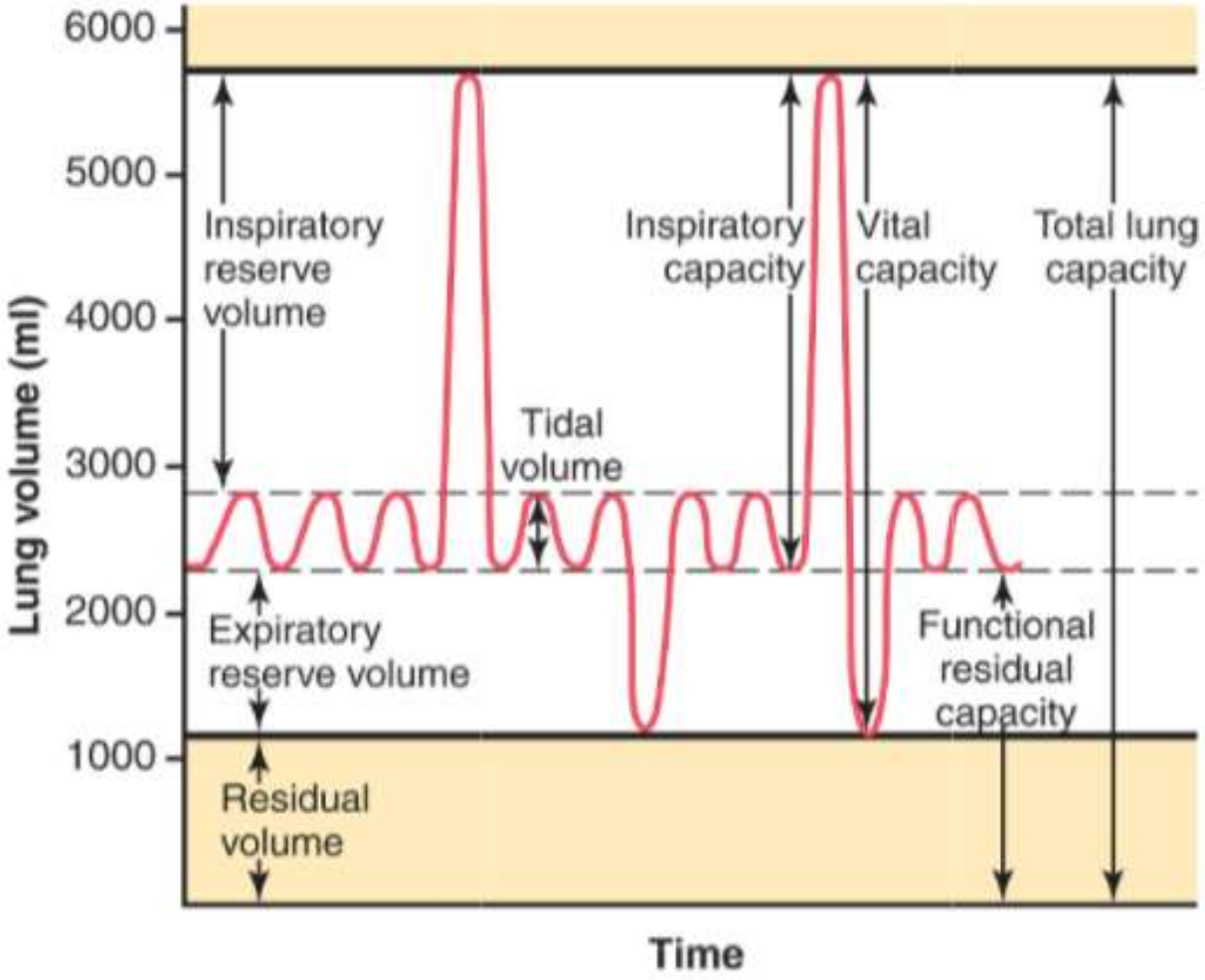
STATIC LUNG VOLUMES

Lung volumes that are **not affected by the rate** of air movement in and out of the lungs.

The following five static lung volumes/cpacities can be measured: VT (tidal volume), IRV (inspiratory reserve volume), ERV (expiratory reserve volume), IC (inspiratory capacity) and VC (vital capacity).

(Residual volume) cannot be measured using spirometry, neither can FRC (functional residual capacity) nor TLC (total lung capacity). These last three volumes can be determined indirectly, as the FRC (functional residual capacity) can be measured using helium gas dilution techniques

STATIC LUNG VOLUMES



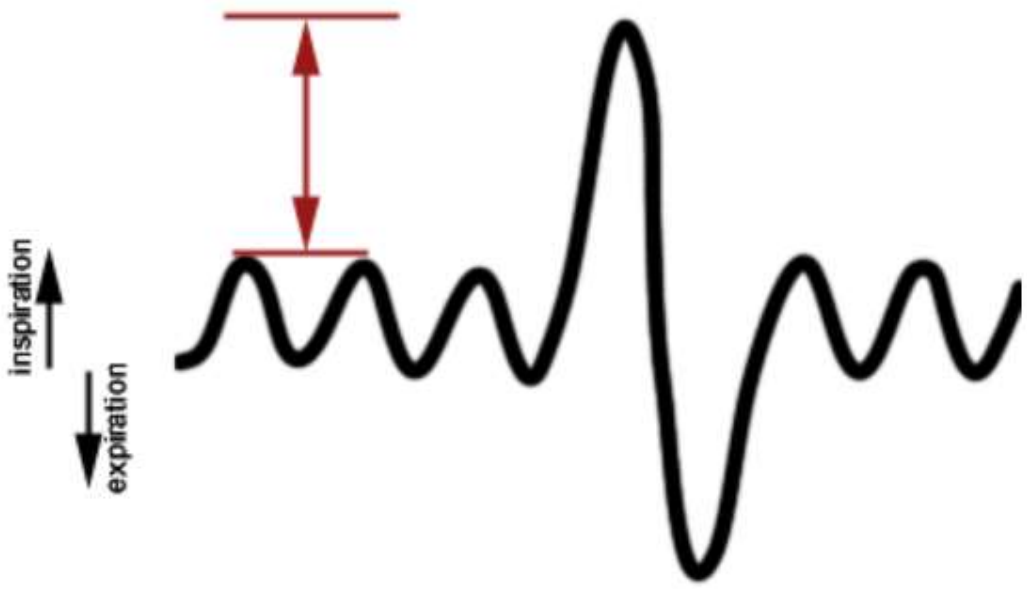
PULMONARY VOLUMES

V_T: TIDAL VOLUME

The *tidal volume* is the volume of air inspired or expired with each normal breath; it amounts to about 500 milliliters in the adult male.

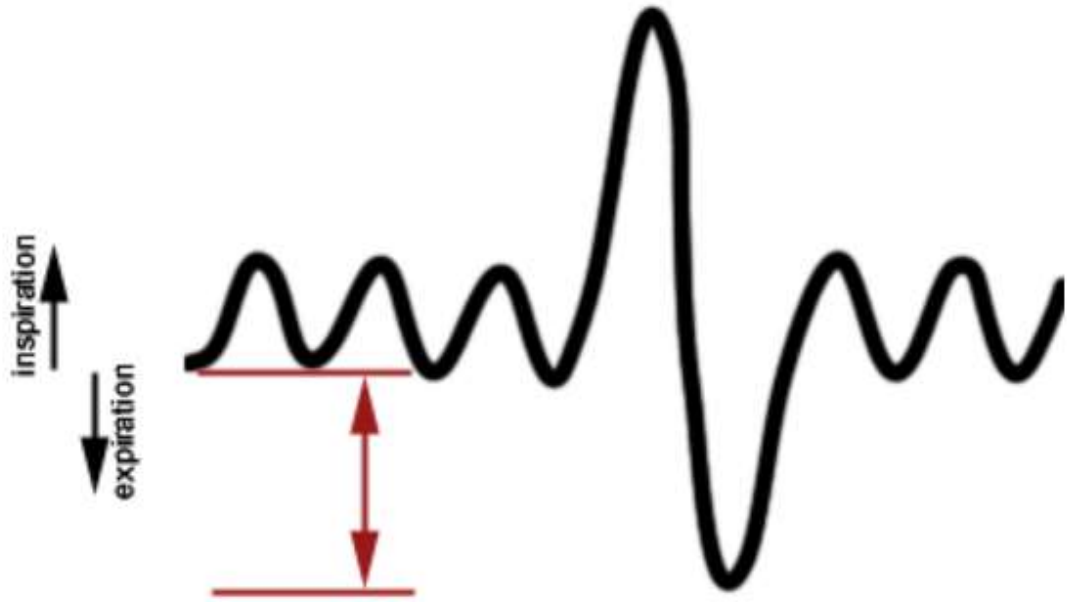
IRV: INSPIRATORY RESERVE VOLUME

The *inspiratory reserve volume* is the extra volume of air that can be inspired over and above the normal tidal volume when the person inspires with full force; it is usually equal to about 3000 milliliters.



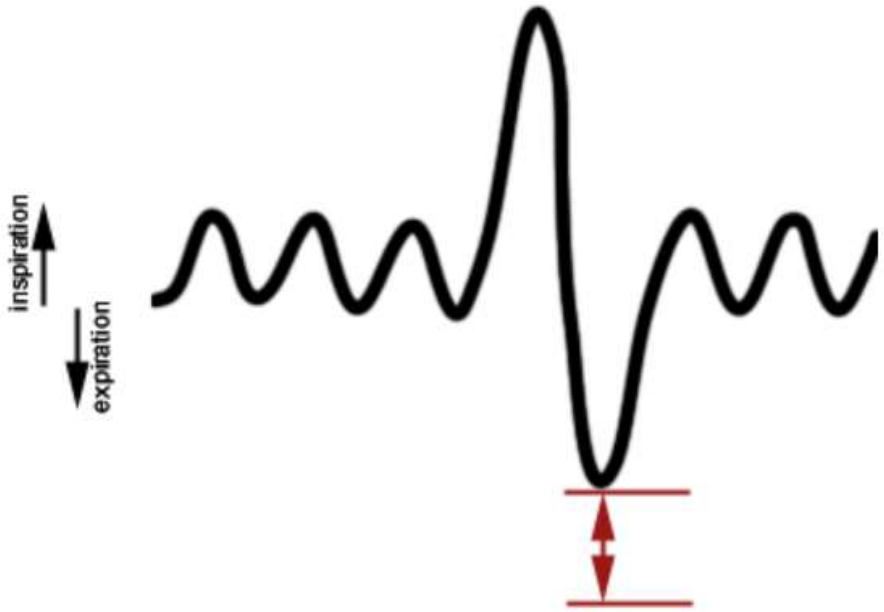
ERV: EXPIRATORY RESERVE VOLUME

The *expiratory reserve volume* is the maximum extra volume of air that can be expired by forceful expiration after the end of a normal tidal expiration; this normally amounts to about 1100 milliliters.



RV: RESIDUAL VOLUME

The *residual volume* is the volume of air remaining in the lungs after the most forceful expiration; this volume averages about 1200 milliliters.

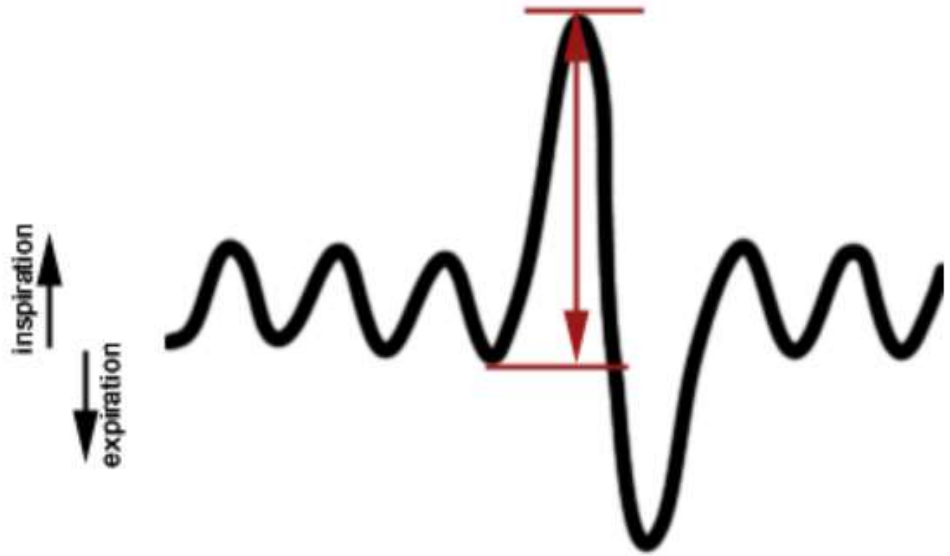


PULMONARY CAPACITIES

combinations of two or more volumes together.

IC: INSPIRATORY CAPACITY

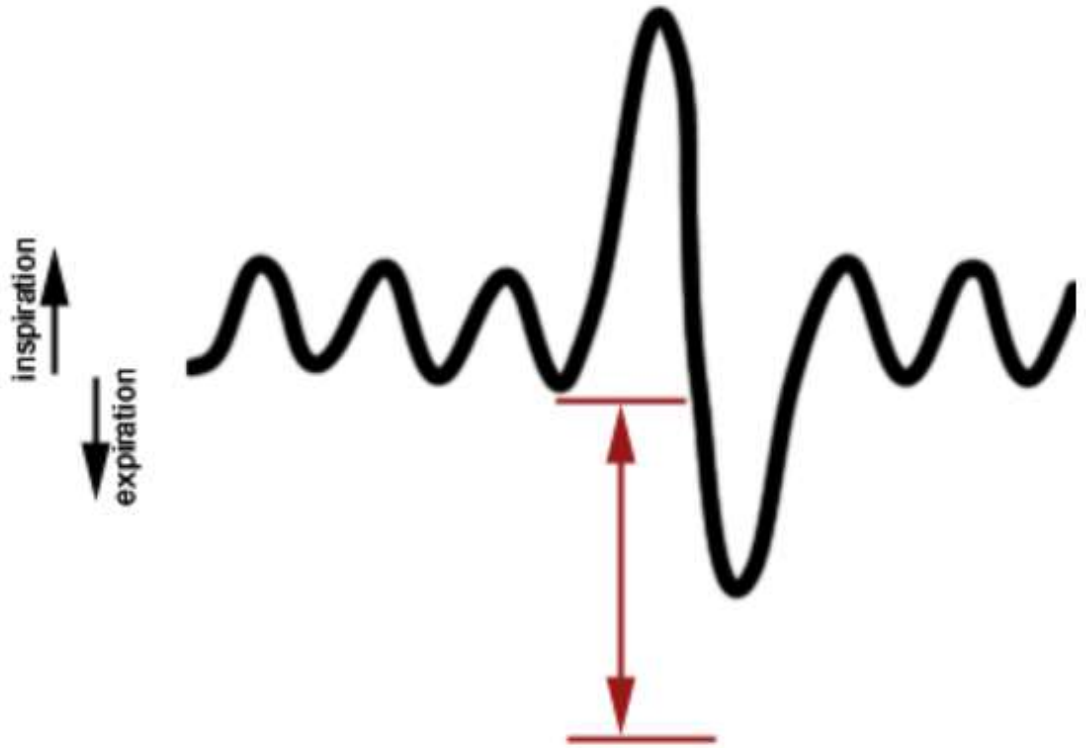
The *inspiratory capacity* equals the *tidal volume* plus the *inspiratory reserve volume*. This is the amount of air (about 3500 milliliters) a person can breathe in, beginning at the normal expiratory level and distending the lungs to the maximum amount.



FRC: FUNCTIONAL RESIDUAL CAPACITY

The *functional residual capacity* equals the *expiratory reserve volume* plus the*residual volume*. This is the amount of air that remains in the lungs at the end of normal expiration (about 2300 milliliters).

FRC = ERV + RV

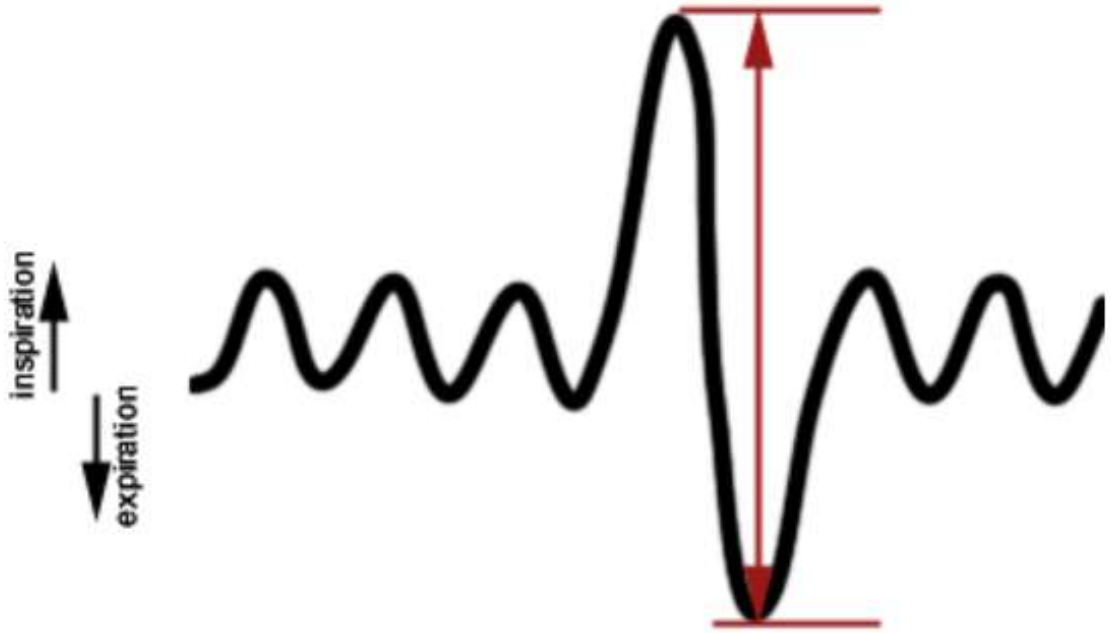


VC: VITAL CAPACITY

The *vital capacity* equals the *inspiratory reserve volume* plus the *tidal volume*plus the *expiratory reserve volume*. This is the maximum amount of air a person can expel from the lungs after first filling the lungs to their maximum extent and then expiring to the maximum extent (about 4600 milliliters.

$VC = IRV + V_T + ERV$

$VC = IC + ERV$

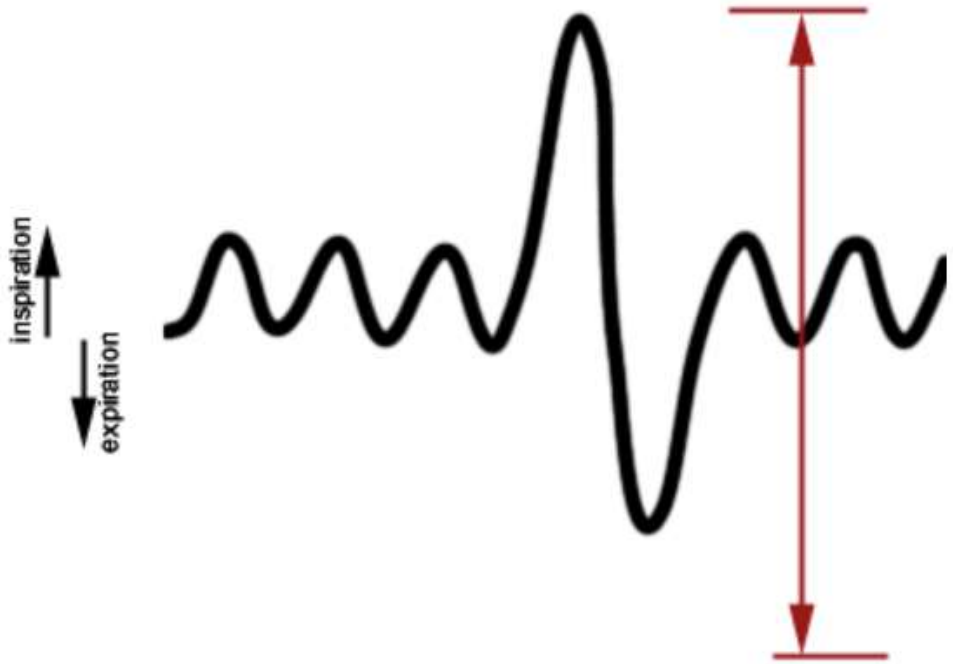


TLC: TOTAL LUNG CAPACITY

The *total lung capacity* is the maximum volume to which the lungs can be expanded with the greatest possible effort (about 5800 milliliters); it is equal to the *vital capacity* plus the *residual volume*.

TLC = VC + RV

TLC = IC + FRC



NOTE

The following five static lung volumes/cpacities can be measured by spirometer: VT (tidal volume), IRV (inspiratory reserve volume), ERV (expiratory reserve volume), IC (inspiratory capacity) and VC (vital capacity).

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HELIUM GAS DILUTION TECHNIQUE

HELIUM DILUTION METHOD

Before breathing from the spirometer, the person expires normally. At the end of this expiration, the remaining volume in the lungs is equal to the functional residual capacity. At this point, the subject immediately begins to breathe from the spirometer, and the gases of the spirometer mix with the gases of the lungs. As a result, the helium becomes diluted by the functional residual capacity gases, and the volume of the functional residual capacity can be calculated from the degree of dilution of the helium, using the following formula:

$C1 \times V1 = C2 \times V2$

$C1 \times V1 = C2 \times (V1 + FRC)$

$FRC = ((C1 \times V1)/C2) - V1$

$FRC = V1\ (C1 / C2 - 1)$

$$FRC = \left(\frac{Ci_{He}}{Cf_{He}} - 1 \right) Vi_{Spir}$$

HELIUM DILUTION METHOD

Once the FRC has been determined, the residual volume (RV) can be determined by subtracting expiratory reserve volume (ERV), as measured by normal spirometry, from the FRC. Also, the total lung capacity (TLC) can be determined by adding the inspiratory capacity (IC) to the FRC.

$$RV = FRC - ERV$$

and

$$TLC = FRC + IC$$

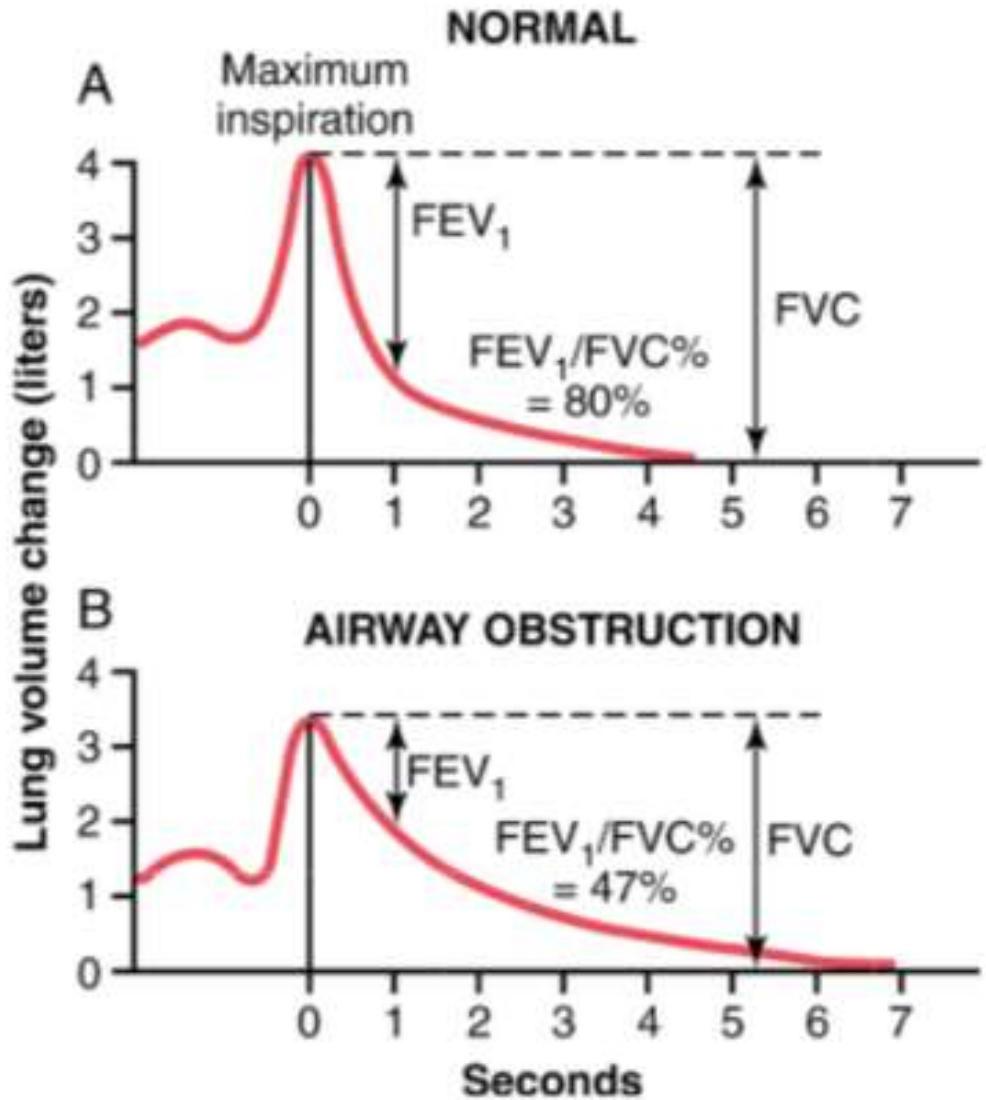
DYNAMIC LUNG VOLUMES

Lung volumes that depend upon the rate at which air flows out of the lungs are termed dynamic lung volumes, like the **Forced Vital Capacity**

FVC: FORCED VITAL CAPACITY
FEV1: FORCED EXPIRATORY VOLUME DURING THE FIRST SECOND

The person first inspires maximally to the total lung capacity and then exhales into the spirometer with maximum expiratory effort as rapidly and as completely as possible. The total distance of the downslope of the lung volume record represents the FVC.

Normally (FEV_1/FVC%) is 80 percent.


NORMAL
A
Maximum inspiration
FEV1
FVC
FEV1/FVC% = 80%
B
AIRWAY OBSTRUCTION
FEV1
FEV1/FVC% = 47%
FVC
Lung volume change (liters)
0
1
2
3
4
5
6
7
Seconds

LUNG DISEASES

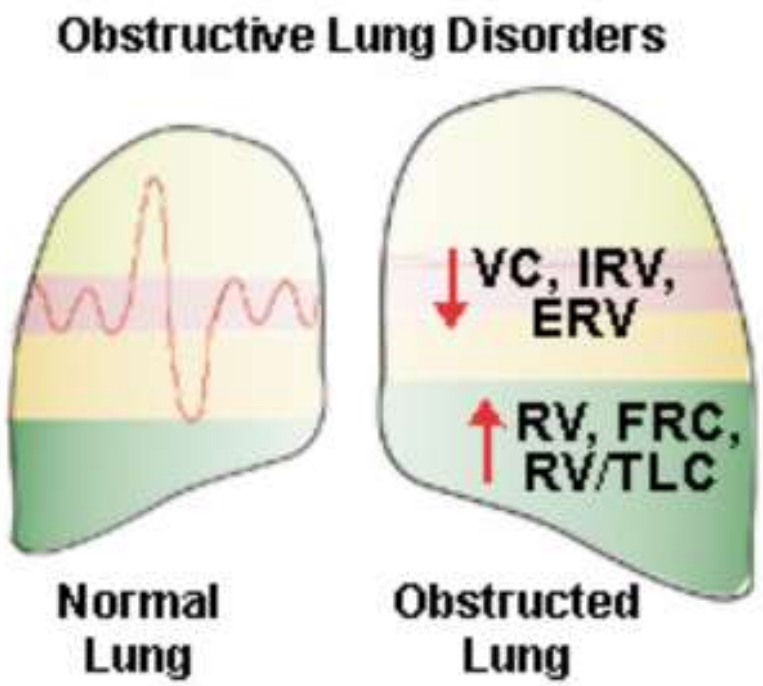
Obstructive

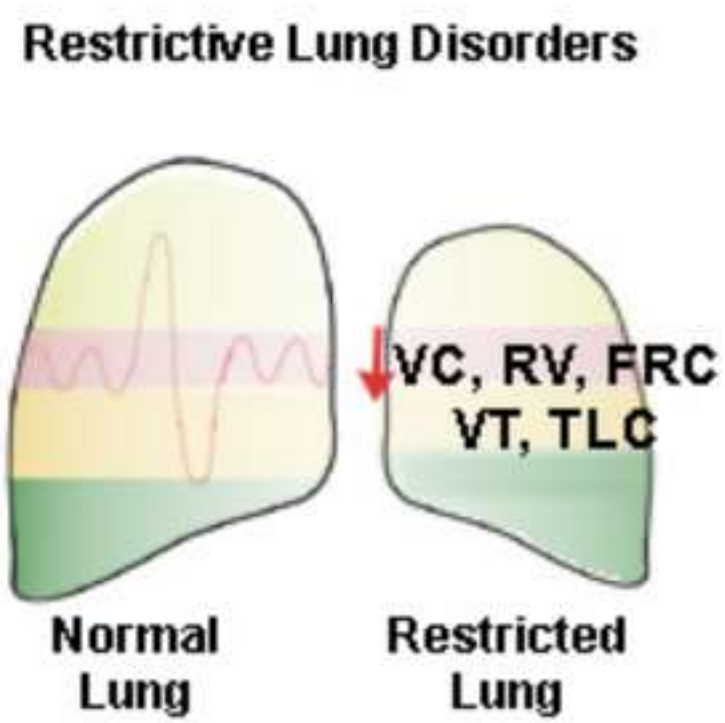
- airway obstruction causes an **increase in resistance.**
- Common obstructive diseases include asthma, bronchitis, and emphysema.

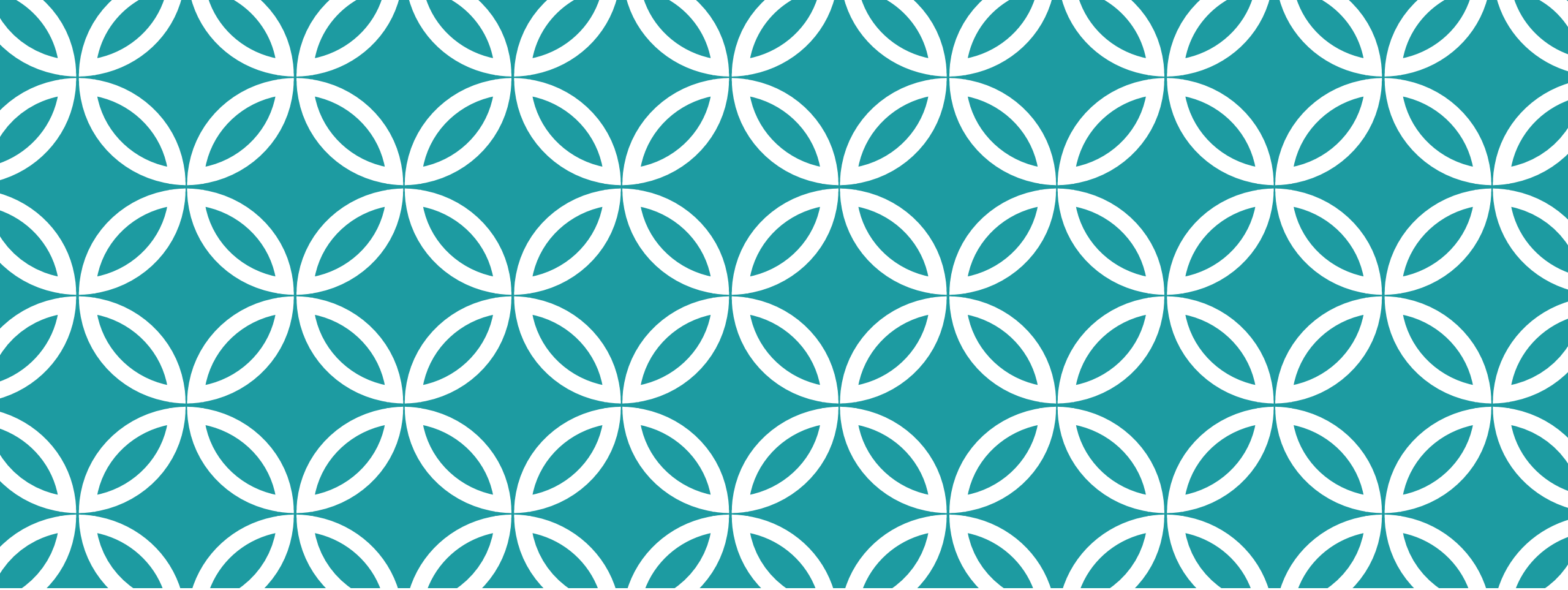
Restrictive

- the **compliance of the lung is reduced.**
- which increases the stiffness of the lung and limits expansion.
- fibrotic diseases of the lung itself, such as *tuberculosis* and *silicosis*, and diseases that constrict the chest cage, such as *kyphosis, scoliosis*, and *fibrotic pleurisy*

LUNG DISEASES



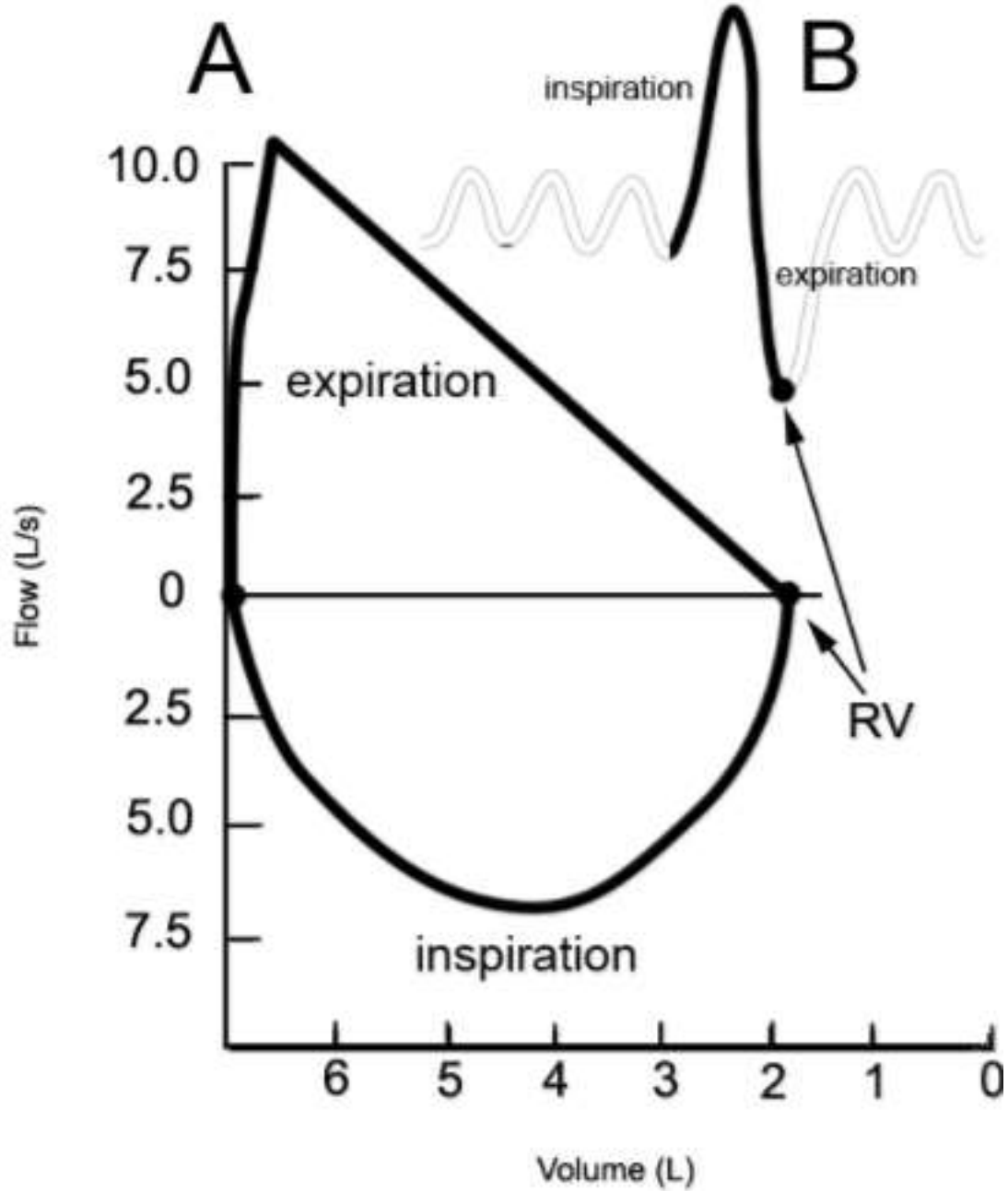


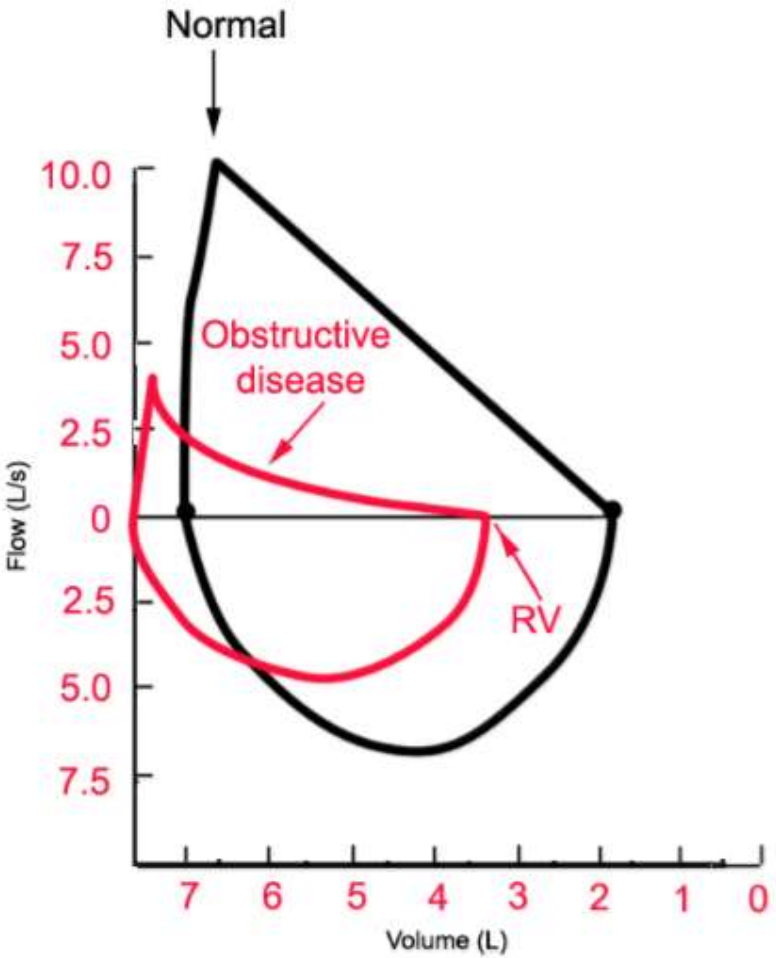


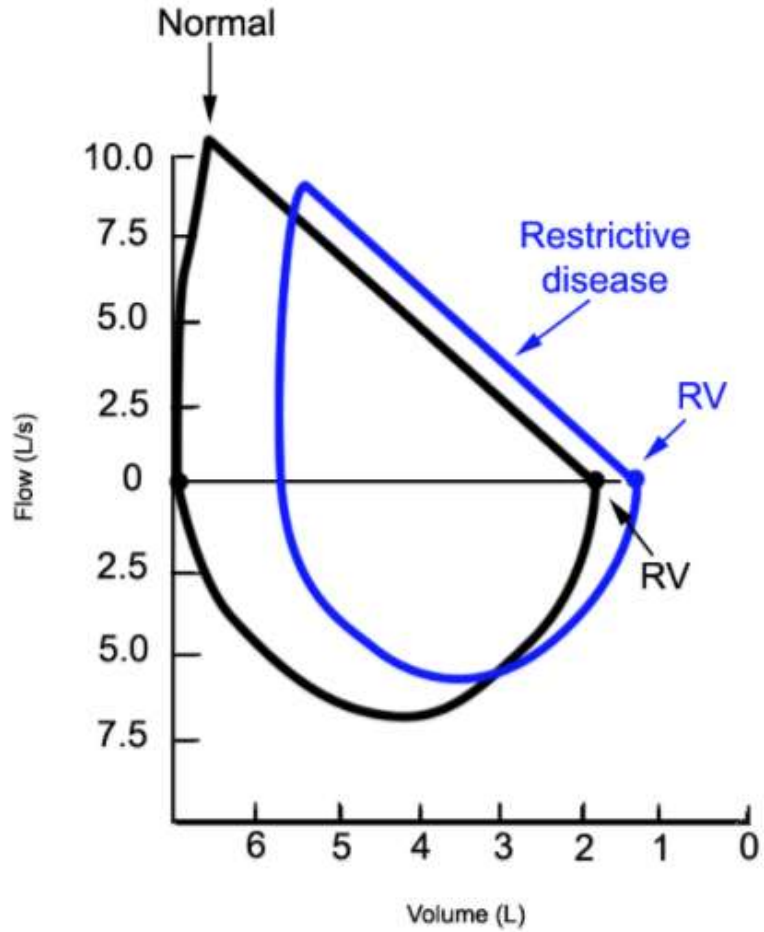
FLOW-VOLUME LOOP

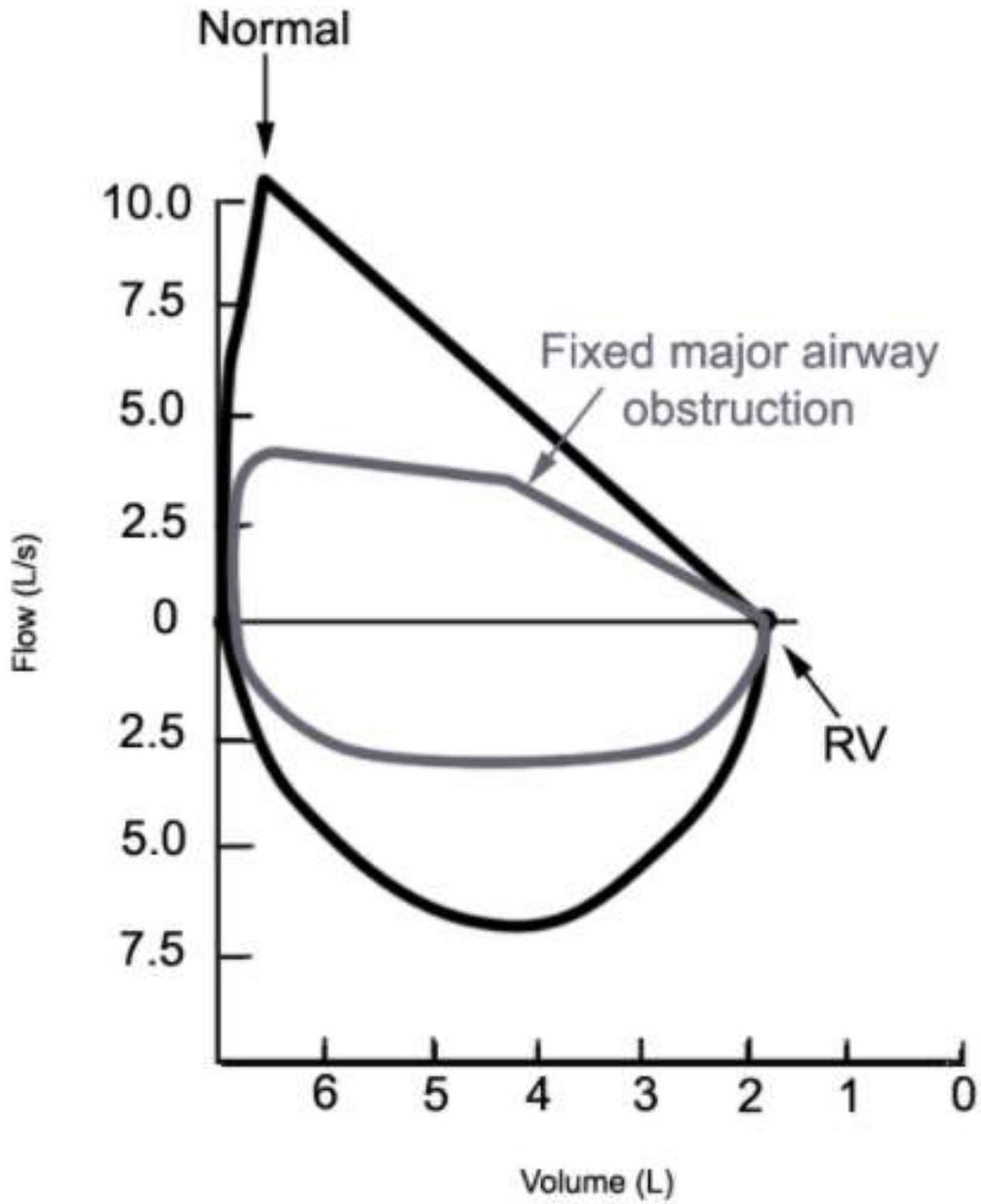
FLOW-VOLUME LOOP

It is the graph produced by plotting the instantaneous flow of respiratory gas against the simultaneous lung volume. The principal advantage of the flow-volume loop is that it can show whether flows are appropriate for a particular lung volume.


A
B
inspiration
expiration
10.0
7.5
5.0
2.5
0
2.5
5.0
7.5
expiration
inspiration
RV
Flow (L/s)
6
5
4
3
2
1
0
Volume (L)


Normal
10.0
7.5
5.0
2.5
0
2.5
5.0
7.5
Obstructive disease
RV
Flow (L/s)
7 6 5 4 3 2 1 0
Volume (L)


Normal
10.0
7.5
5.0
2.5
0
2.5
5.0
7.5
Restrictive disease
RV
RV
Flow (L/s)
6 5 4 3 2 1 0
Volume (L)


Normal
10.0
7.5
5.0
2.5
0
2.5
5.0
7.5
Flow (L/s)
Fixed major airway obstruction
RV
6
5
4
3
2
1
0
Volume (L)