Physiology Practical

Physiology Team 434
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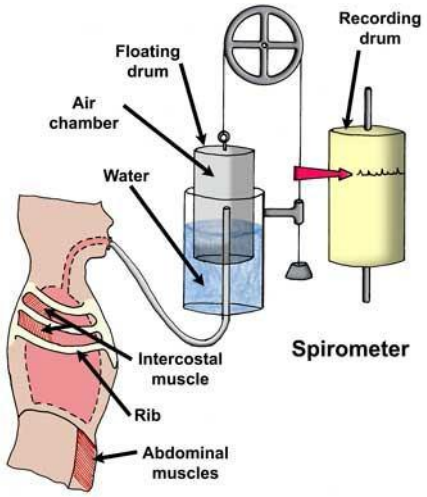
Static Spirometry :

Spirometry is a pulmonary function test preformed without regard to time to measures lung volumes and capacities

- ✓ To determine the cause of shortness of breath.
- ✓ To rule out any kind of obstructive or restrictive disease.
- ✓ To diagnose and monitor lung problems.
- ✓ To monitor how well medications for lung problems are working .

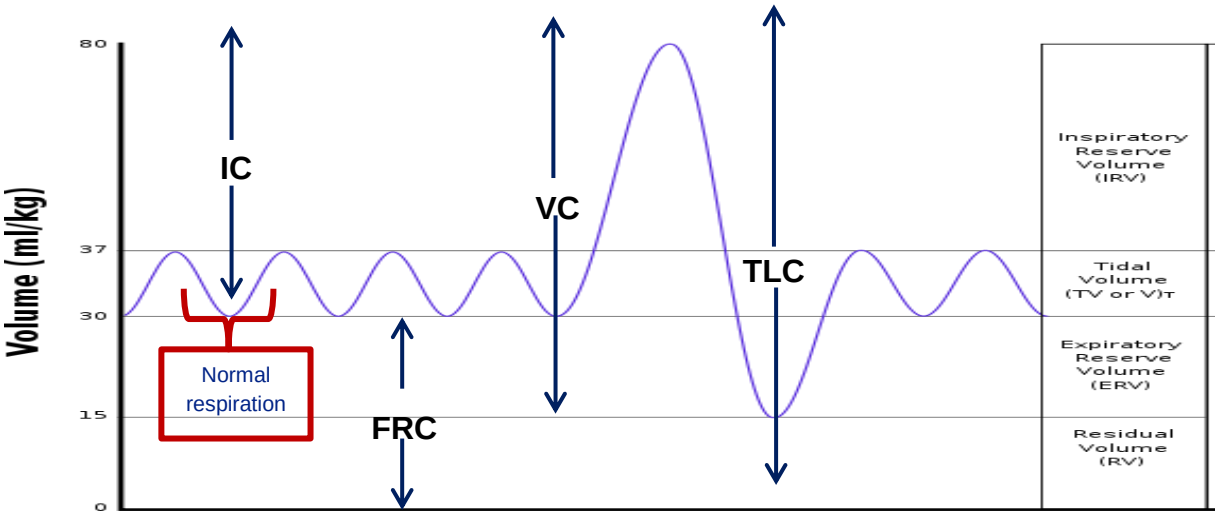
Simple spirometer :

- Drum inverted over a chamber of water with the drum counterbalanced by a weight.
- In the drum is air or Oxygen
- A Tube connects the mouth with the gas chamber
- When one breathes in and out of the chamber, the drum rises and falls and an appropriate recording is made on a moving paper



Method:

1. Insert a sterilized mouthpiece, and then close the nose with the nose clip.
2. Take a normal breath through the mouthpiece for a short time then take a deep inspiration to fill the lungs completely, and then breathe normally for a short time.
3. Expire, forcibly as completely as possible, and then breathe normally for a short time.
4. Take a deep forceful inspiration and immediately expire forcibly and as completely as possible, then breathe normally.
5. The spirogram is recorded on a moving drum.



Lung volumes and CAPACITIES:

- **Lung Volumes:**

  The lungs have <u>4 main volumes:</u>

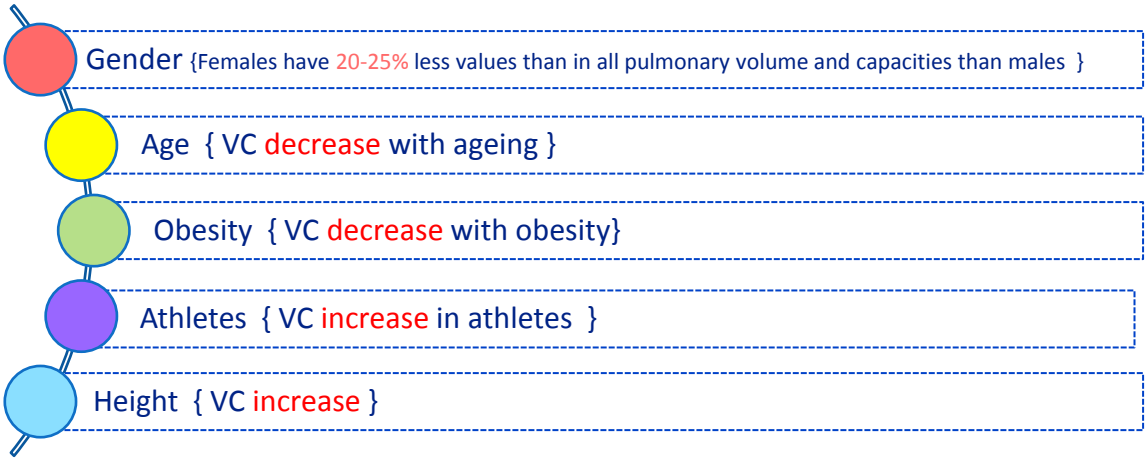
Tidal volume (TV):	Is the volume of air inspired or expired with each normal breath Tidal volume = the volume of air that fills the <u>alveoli</u> + the volume of air that fills the <u>airway.</u>	≈ 500 ml
Inspiratory reserve (IRV):	Is the extra volume of air that can be inspired over and above the normal tidal volume when the person inspires with full force.	≈ 3000 ml
Expiratory reserve (ERV):	Is the maximum extra volume of air that can be expired by forceful active expiration after the end of a normal tidal passive expiration	≈ 1100 ml
Residual volume (RV):	Is the volume of air remaining in the lungs after the most forceful expiration	≈ 1200 ml

- **Lung Capacities (pulmonary capacities) :**

N.B : There are several lung capacities, <u>each lung capacity includes two or more</u> of the previous lung volumes.

Inspiratory capacity (IC)	Is the amount of air a person can breath in, beginning at the normal expiratory level (pose between cycles) and distending the lungs to the maximum amount.	$IC = TV + IRV$ $= 500 + 3000$ $= 3500\ ml$
The functional residual capacity (FRC)	Is the amount of air that remains in the lungs after normal tidal expiration.	$FRC = ERV + RV$ $= 1100 + 1200$ $= 2300\ ml$
The vital capacity (VC) Also called relaxed vital capacity	The maximum amount of air a person can expel from the lungs after filling the lungs to their maximum extent and then expiring to the maximum extent.	$TV + IRV + ERV$ $= 500 + 3000$ $+ 1100 = 4600\ ml$
The total lung capacity (TLC)	is the maximum volume to which the lungs can be expanded with the greatest possible inspiratory effort	$TV + IRV + ERV$ $+ RV$ $= 500 + 3000$ $+ 1100 + 1200$ $= 5800ml$

Physiological factors influencing lung volumes and capacities



Pathological factors that alter lung volumes and capacities

Restrictive lung disease	• inability to fully expand the lungs • Eg. Alveolar fibrosis , • Increase the elastic recoil --> increase the breathing frequency • decrease in VC , IRV , ERV , RV , TV • other examples : pneumonia , pulmonary edema
Obstructive lung disease	• Increase the resistance to airflow • decrease /loss in elastic recoil of the alveoli (Emphysema) • decrease in the VC
Reduced lung volume	• Surgical removal of lung tissue or large tumers

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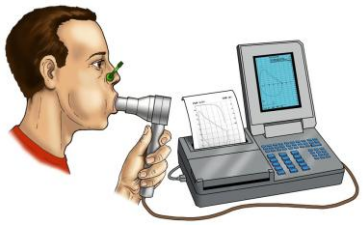
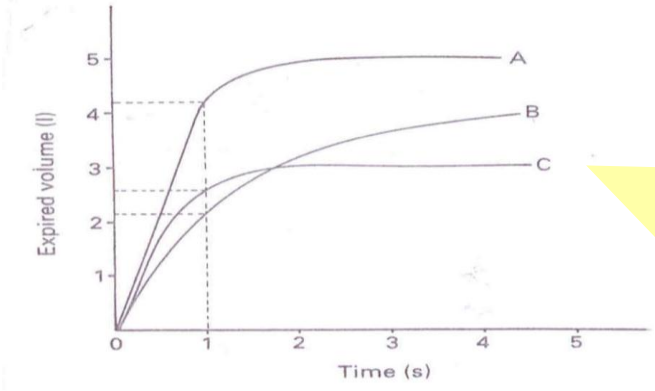
DYNAMIC SPIROMETRY:

Preformed at forcible and max effort against time , It mesures rate at which lung changes volume during forceful breathing . used mainly to differentiate between restrictive and obstructive lung diseases.



Two types of curves can be obtained:

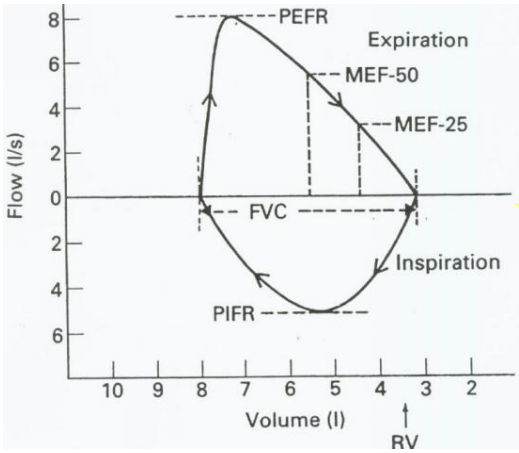
1. **Forced expiratory volume curve (FEV).**



Terminology you need to know:

- **Relaxed Vital Capacity:** Relaxed Vital capacity: Volume of expired air measured after a maximal inspiration.
- **Forced Vital Capacity (FVC):** The max volume of air that can be forcibly and rapidly exhaled following a max inspiration.
- **Forced Expiratory volume in one second (FEV_1)**=the volume of air exhaled in the 1st sec of forceful expiration starting from full inspiration .

2. **Flow-volume curve (Loops)[1].**



Terminology you need to know:

- **Peak expiratory flow rate (PEFR):** is a person's maximum speed of expiration, normally = 6-12L/s
- **Maximal Expiratory Flow at 50% (MEF50):** max expiratory flow at 50% of FVC, normally = 4-6L/s

[1] Loop measures expiration and inspiration flow as a function of exhaled volume rather than against time

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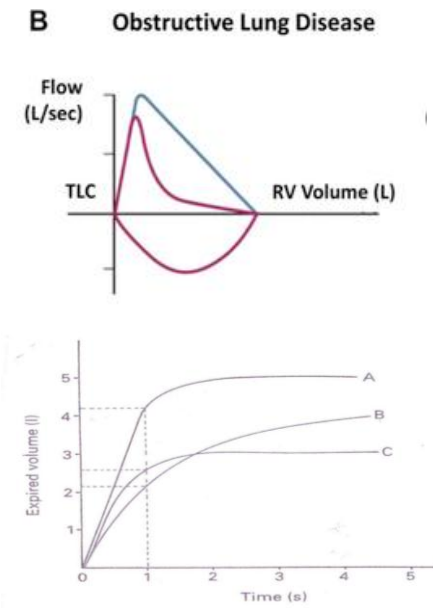
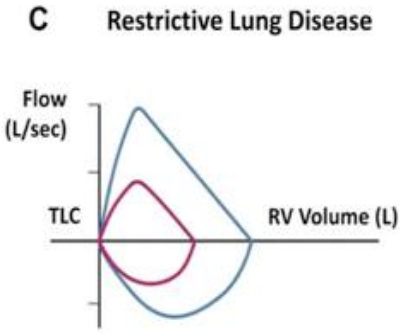
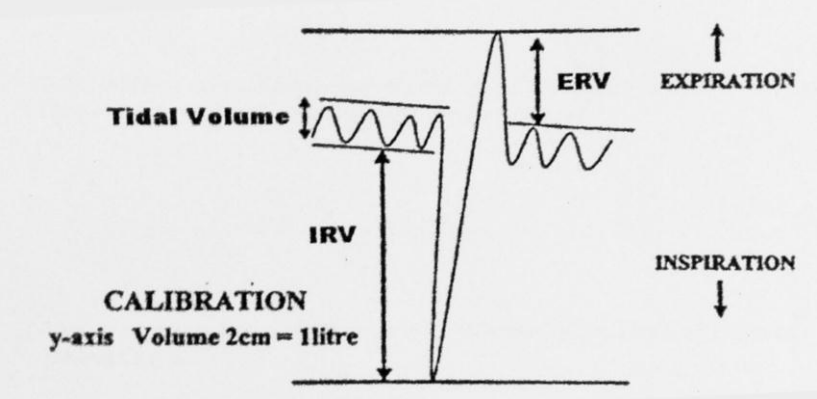
RESTRICTIVE AND OBSTRUCTIVE LUNG DISEASES

Obstructive pulmonary disease	Restrictive pulmonary disease:
	
✓ ↑ airway resistance ✓ ↓↓↓↓ FEV1 ✓ ↓ FVC {it may be equal to normal value} ✓ ↓ FEV1/FVC (Flow volume curve) ✓ ↓ PEFR and ↓ MEF50 ✓ Effort independent part of curve is concave As seen in B , The FVC = 4L and FEV1 = 2L , So FEV1/FVC = 50% Which below normal .	✓ ↓ Lung Compliance ✓ ↓↓ FEV1 ✓ ↓↓ FVC ✓ ↑ FEV1/FVC {it may be equal to normal value} (Flow volume curve) ✓ ↓ All Flow parameters ✓ Miniature loop (elliptical) As seen in C , The FVC = 3L and FEV1 = 2.5L , So FEV1/FVC = 80.3% Which higher than normal .

Check Your Understanding:



1. Define the following terms and calculate their values: If(TV = 1 cm, IRV = 6 cm, ERV = 2 cm)note:2 cm=1L

a) Tidal Volume:

1 cm = 0.5 L (500 ml)

b) Inspiratory reserve volume:

6 cm = 3 L (3000 ml)

c) Expiratory reserve volume:

2 cm = 1 L (1000 ml)

d) Vital capacity:

VC = TV + IRV + ERV VC = 0.5 + 3 + 1 = 4.5 L (4500 ml)

e) Inspiratory capacity:

IC = TV + IRV IC = 0.5 + 3 = 3.5 L (3500 ml)

2. A number of physiological factors influence lung volumes and capacities. What are they and how do they exert their effects?

1. Sex: female 20-25% less.
2. Age: less in older people.
3. Obesity: more width less in lung function.
4. Height: more height more lung function.

3. Lung volumes and capacities are altered in variety of pathological conditions. Name few of them and explain how these changes are produced.

- Lung tumors: will lead to decrease lung volumes by effect on normal function of lung.
- Pneumonia: Restrict lung expansion, resulting in a decreased total lung capacity.
- Chronic bronchitis: block airflow and make breathing difficult by mucus hyper-secretion and sub mucosal gland hypertrophy.
- Emphysema: Abnormal dilation of air space lead to reduced in elasticity.

4. What is the physiological significance of Residual Volume and Functional residual capacity?

Residual Volume: Prevents collapsing of lungs.

Functional Residual capacity: Helps to determine obstructive and restrictive pulmonary diseases.

5. Functional residual volume cannot be measured directly by spirometry . If residual volume is given (1200 ml), calculate FRV.

FRV = Residual Volume + ERV FRV = 1200 + 1000 = 2200 ml (2.2 L)

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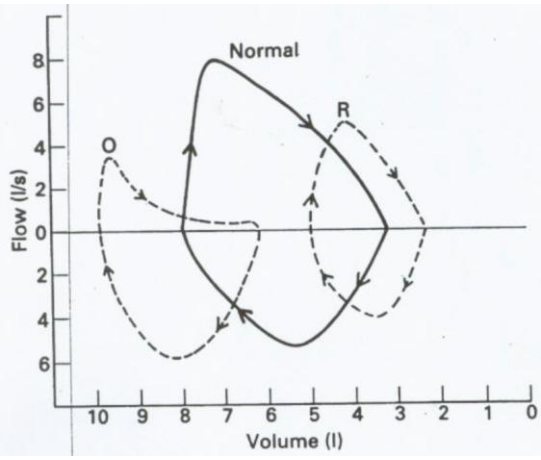

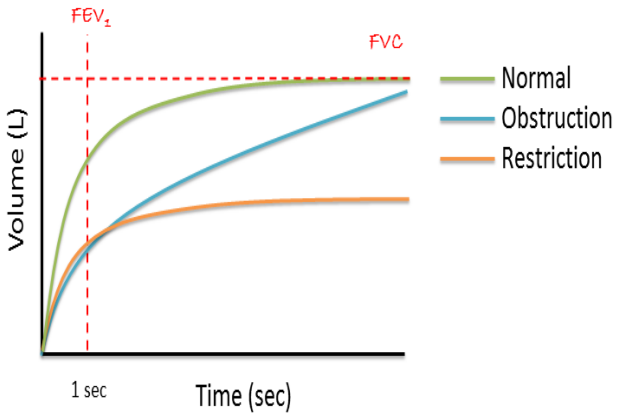

1. From the FEV1 curve produced, calculate for each one:-

a) Forced vital capacity:

Normal FVC = 5 L

Obstructive FVC = 3.5 L

Restrictive FVC = 2.8 L

b) Forced expiratory volume in the first second:

Normal FEV_1= 4.3 L

Obstructive FEV_1= 2.4 L

Restrictive FEV_1= 2.5 L

c) $FEV1\% = \frac{FEV1}{FVC} \times 100$:

Normal $FEV_1\%$= $\frac{4.3}{5} \times 100 = 86\%$

Obstructive $FEV_1\%$ = $\frac{2.4}{3.5} \times 100 = 68\%$

Restrictive $FEV_1\%$= $\frac{2.5}{2.8} \times 100 = 89\%$

Q2: The FEV_1 is a good index of airway resistance while expiring.

a) What values would be expected for a normal person?

Normal FEV_1 = 4L , Normal FVC = 5L , Normal $FEV_1\%$ = 70% -80%

b) How long does it take for a healthy people to expire their vital capacities?

1 Second OR 3 seconds.

c) Explain what happens to FEV_1 and FEV_1% measurements in patients with obstructive and restrictive diseases?

Obstructive diseases: FEV_1 decreased , FEV_1% **<**70%

Restrictive diseases: FEV_1 increased , FEV_1% **>** 80%

3. From the Flow-volume loop produced, calculate for each one:-

a) Vital Capacity:

Normal FVC = 3.3 L/s , Obstructive FVC = 2.6 L/s , Restrictive FVC = 1.9 L/s

b) Peak expiratory flow rate (PEFR):

Normal PEFR= 8 L/s , Obstructive PEFR = 2.9 L/s , Restrictive PEFR = 5 L/s

c) Peak in spiratory flow rate(PIER):

Normal PIFR= 5L/s , Obstructive PIFR = 6 L/s , Restrictive PIFR= 4L/S

d) MEF50 (maximum expiratory flow at 50% vital capacity):

Normal MEF50 = 6 L/s , Obstructive MEF50 = 1 L/s , Restrictive MEF50= 5 L/S

e) MIF25 (maximum inspiratory flow at 25% vital capacity):

Normal MEF25 = 4.9L/s , Obstructive MEF25= 0.7 L/s , Restrictive MEF25=2.9 L/S

4. What is importance of flow-volume loop in healthy person?

This measure expiration and inspiration flow as a function of exhaled volume rather than against time.

5. Why is the force-independent part of the expiratory loop curvilinear in obstructive lung disease?

Because the smaller airways are narrowed due to either spasm or accumulation of secretions, so they provide resistance to the airflow during expiration; therefore, the airflow slows down and the force-independent part of the expiratory loop becomes curvilinear.

6**. What is the clinical significance of MEF50 measurements?**

MEF50 becomes greatly reduced in obstructive lung diseases (less than 4 L/sec). FVC is the Main marker for restrictive.

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