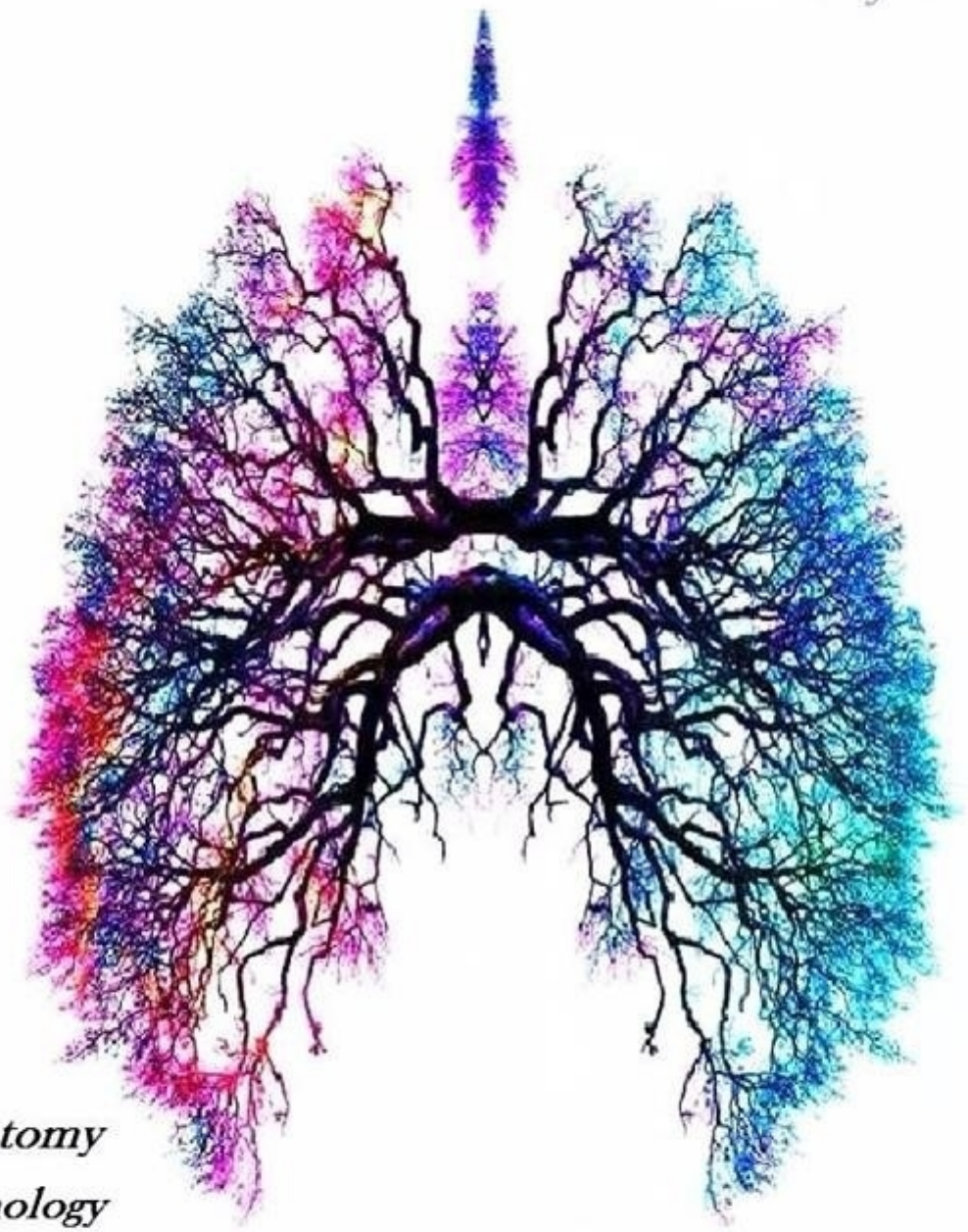
RESPIRATORY SYSTEM

Cover by: Aseil Khatib



- ○ Anatomy
- ○ Pathology
- ● Physiology
- ○ Pharmacology
- ○ Microbiology
- ○ PBL

Dr Name: Dr. Yanal Shafagoj

Lecture # 2 +3

Sheet ☐

Slide ■

Other ☐

Lung Diseases

- **Prevalence of lung disease depends on the population, but in general obstructive is 70%, restrictive is 20-25% and vascular**

Pulmonary Pathology

- Obstructive Diseases
  - Increased resistance to flow
- Restrictive Diseases
  - Decreased expansion of the lungs

Chronic Obstructive Pulmonary Disease

- Chronic pulmonary emphysema
  - infection (secretions)
  - obstruction
  - loss of parenchyma
- Consequences
  - high airway resistance
  - decreased diffusing capacity
  -

Pathology

- resistance to airflow
  - Lumen
    - excessive secretions
    - obstruction due to aspiration
  - Airway
    - contraction of smooth muscle
    - hypertrophy of bronchial wall
  - outside of airway
    - destruction of lung

The work of Breathing:

$W = \Delta P \times \Delta V$

Normally 0.5 L X 5 cm H_2O = 0.25 J……*One Joule is equal to = 10 L X cm H_2O = J*

50% is used be expand the lungs and 50% to expand the chest wall.

The work of breathing is used to overcome:

1) Elastic forces (70%) (Contribution to the total work of breathing): They are under static (no-flow conditions).

A) Elastic fibers (one third)

B) Surface tension (two thirds).

2) Non elastic forces (30%) (Only present during the dynamic phase of breathing air).

A) 20% tissue viscous resistance when tissue movement is occurring. It is frictional R which resists a change in shape. It always opposes motion.

B) 80% air way resistance:

$T_{Total} = E_{Elastic} + P_{Nonelastic}$

$E_{Elastic}$: elastic recoil P

$P_{Nonelastic}$: Is the pressure to overcome resistance to airflow.

When no air movement takes place $T_{Total} = E_{Elastic}$

Flow = pressure difference / resistance = $\Delta P/R$….Ohm's law

It is the pressure difference between the two opposite ends of the airways: $(P_{alv} - P_{atm})$

If R is large then ΔP must be large too to keep flow constant.

Boyle's law: The pressure and the volume of a gas are inversely related if the temperature is constant.

$R_{airways}$ resides mainly in large airways. In contrast, the small airways have small tiny diameter, but large cross sectional area, thus they offer little resistance to airflow.

The French physician Jean Leonard Marie Poiseuille's

$$V = (\Delta P) / \pi r^4 / 8 \eta l$$

Air flow = $(P_{atm} - P_{alv})/R$

Four Take home messages:

1. Normally: R is negligible
2. Normally, it resides in large airways.
3. Small airways are more significant in a disease condition.
4. Manifested mainly during expiration.

Pulmonary Disorders (continued)

- **Emphysema:**
  - **Alveolar tissue is destroyed.**
  - **Chronic progressive condition that reduces surface area for gas exchange.**
    - **Decreases ability of bronchioles to remain open during expiration.**
      - » **Cigarette smoking stimulates macrophages and leukocytes to secrete protein digesting enzymes that destroy tissue.**

Normally Airway R is small

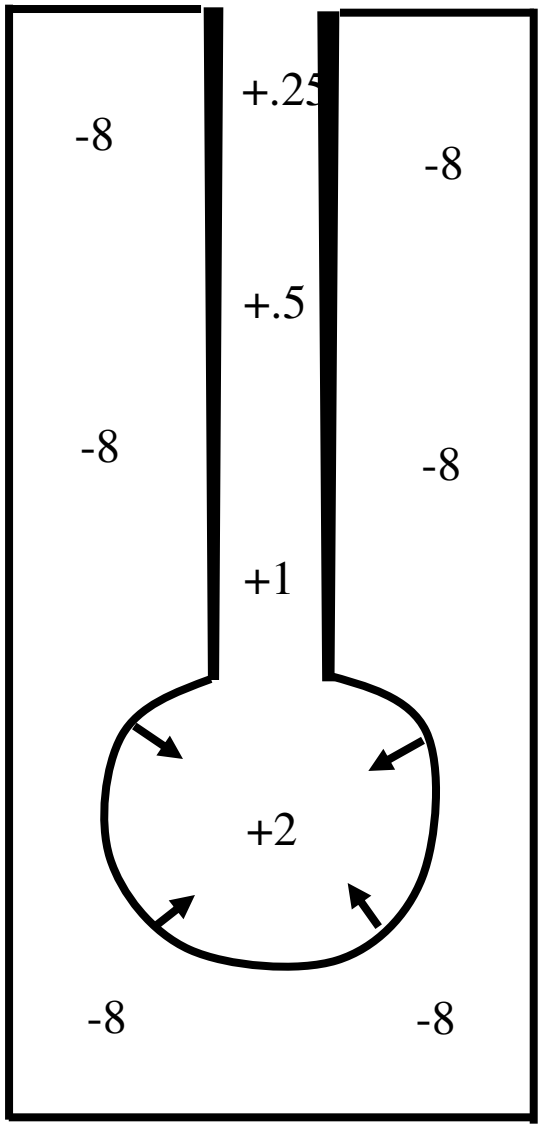
40-50% resides in the upper airways (larynx and above).

40% in the trachea and up to the first seven generations.

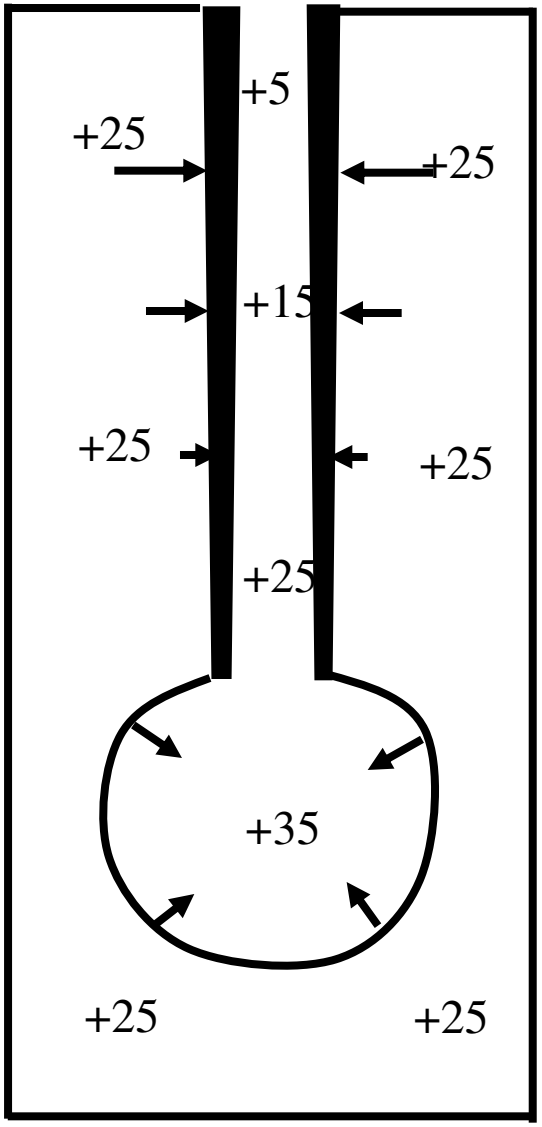
The medium size bronchi (2-4 mm in diameter) around the forth generation are the site for greatest R in the bronchial tree (excluding the upper airways).

10-20% in small airways.

Beyond generation 15th R is almost zero.



Passive Expiration



Forced Expiration

Ventilation

FACTOR	AFFECTED BY	MEDIATED BY
Length of the system	Constant; not a factor	
Viscosity of air	Usually constant; humidity and altitude may alter slightly	
Diameter of airways		
Upper airways	Physical obstruction	Mucus and other factors
Bronchioles	Bronchoconstriction	Parasympathetic neurons (muscarinic receptors), histamine, leukotrienes
	Bronchodilation	Carbon dioxide, epinephrine (β_2-receptors)

Control of Bronchiolar Diameter

- Nervous
  - Sympathetics
    - β_2 receptors dilate(salbutamol, dobutamine, albuterol, fenoterol, terbutaline).
  - Parasympathetics
    - Acetylcholine constrict
- Humoral
  - Histamine, acetylcholine >> Constrict
  - Adrenergic (β agonists) >> Relax

In COPD:

COPD : 1. Emphysema 2. Chronic bronchitis

1. ↑ Compliance: mainly in emphysema, due to destruction of the elastic fibers,
2. ↑ FRC:
3. . ↑ Airway R. more fluctuation during dynamic phases mainly in asthma.

Smoking inhibits cilia → accumulation of mucus → bacterial growth → chronic bronchitis….“Wheeze”.

Smoking induces hyperplasia of Goblet cells → excessive mucus secretion → bacterial growth → chronic bronchitis

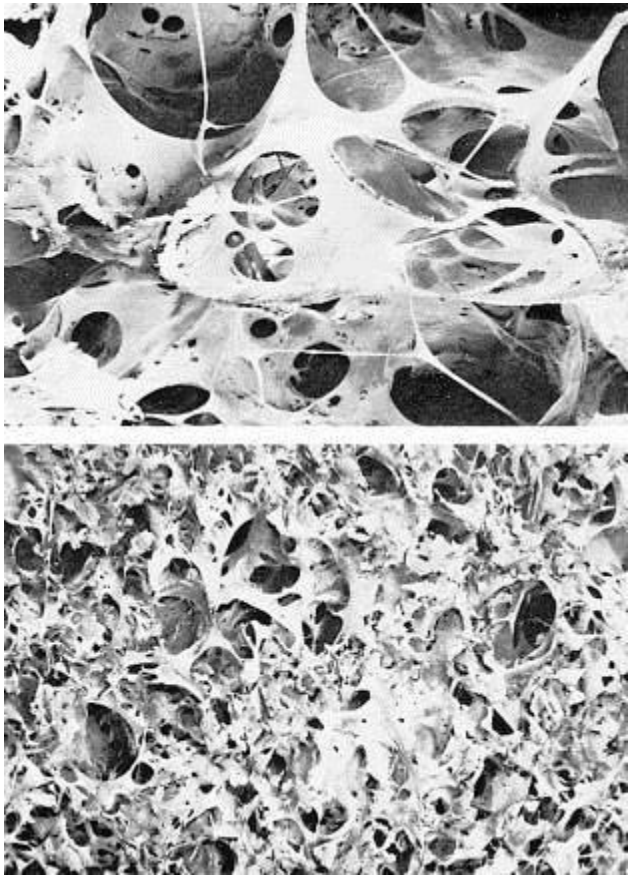
Pursed Lip Breathing

Collapse of your airways on expiration, as your lungs are getting smaller as you breathe out. This is a particularly serious problem in people with Emphysema, as the elastic supporting lung structure helping to keep the airways open is deficient.

Pursed Lip Breathing simply imposes a slight obstruction to expiration air flow at the mouth, which generates a back pressure throughout the airways, and therefore a stenting effect to help prop open the airways and assist expiration and lung emptying. It must be emphasized, the amount of pressure supplied by you by pursing your lips together must, as usually described, be "minimal," or "gentle."

Restrictive Diseases

- Decreased expansion of the lungs
- Lung volumes
  - reduced VC, FRC, normal resistance
- Diffuse Interstitial Pulmonary Fibrosis
  - thick collagen deposits
- Pneumothorax



Emphysematous Lung

Normal Lung

Figure 42-4

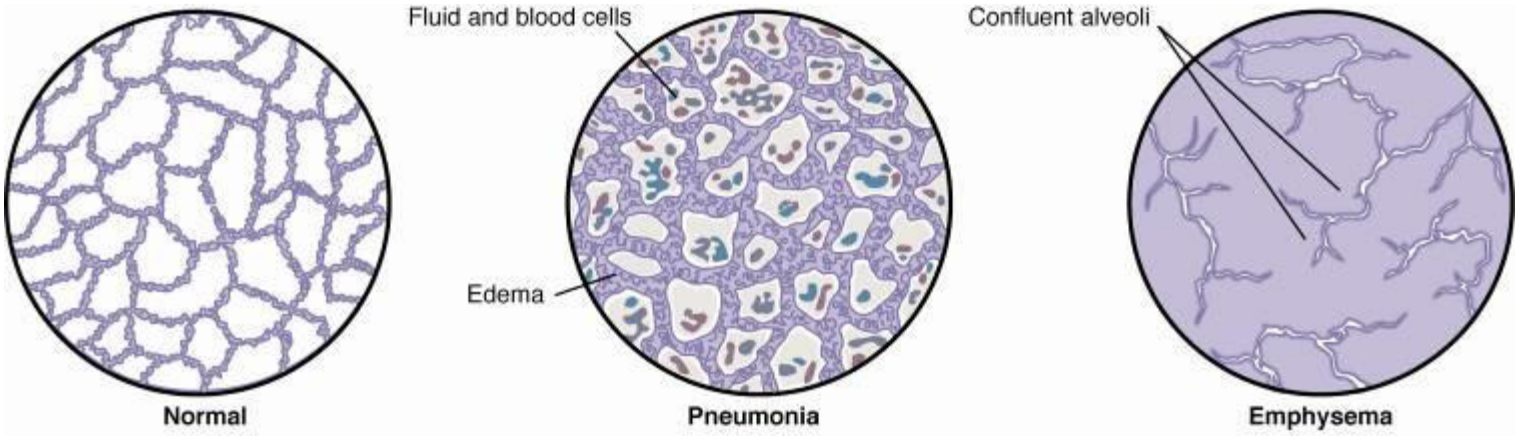

Fluid and blood cells
Edema
Confluent alveoli
Normal
Pneumonia
Emphysema

Figure 42-5

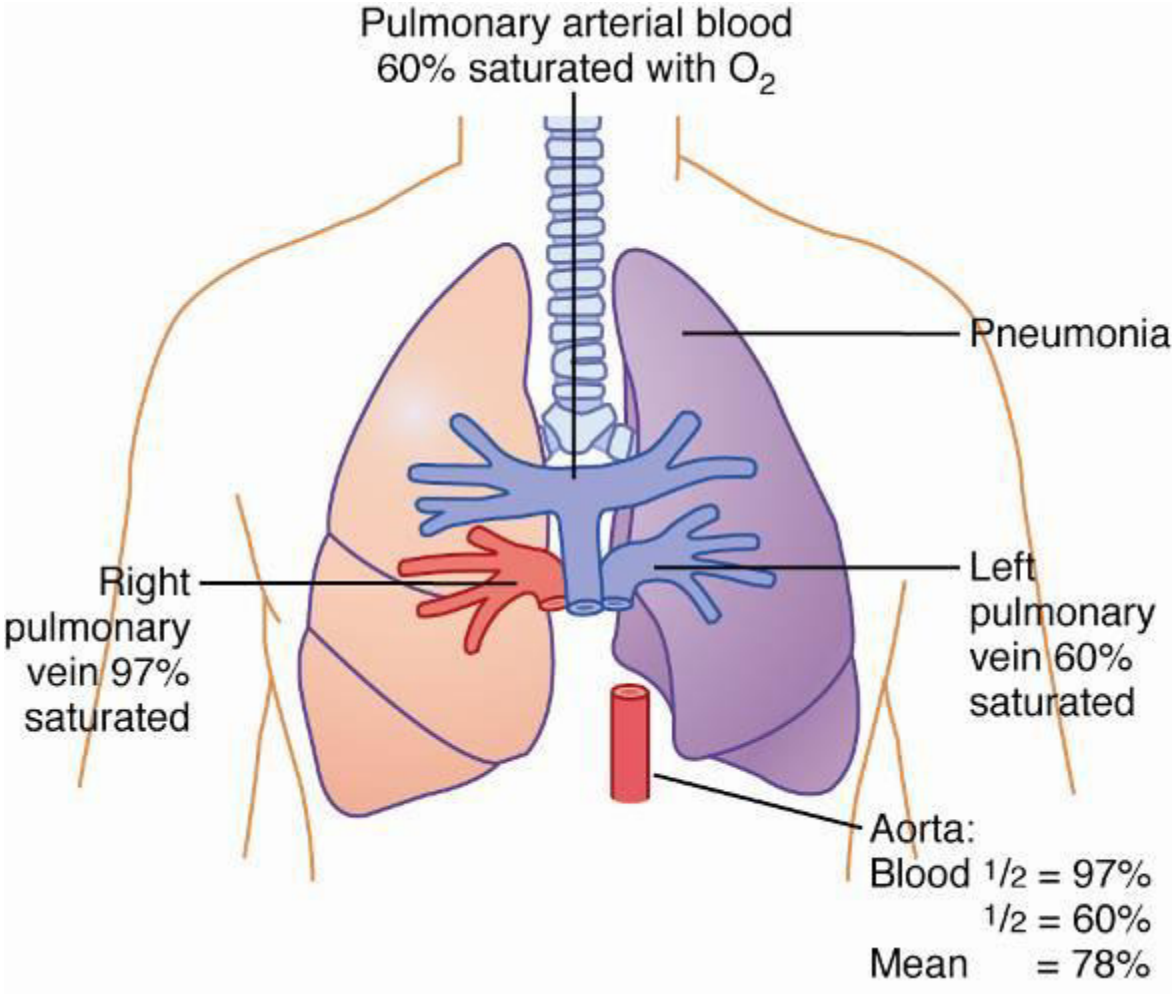

Pulmonary arterial blood
60% saturated with O_2
Pneumonia
Right
pulmonary
vein 97%
saturated
Left
pulmonary
vein 60%
saturated
Aorta:
Blood 1/2 = 97%
1/2 = 60%
Mean = 78%

Figure 42-6

Pathology

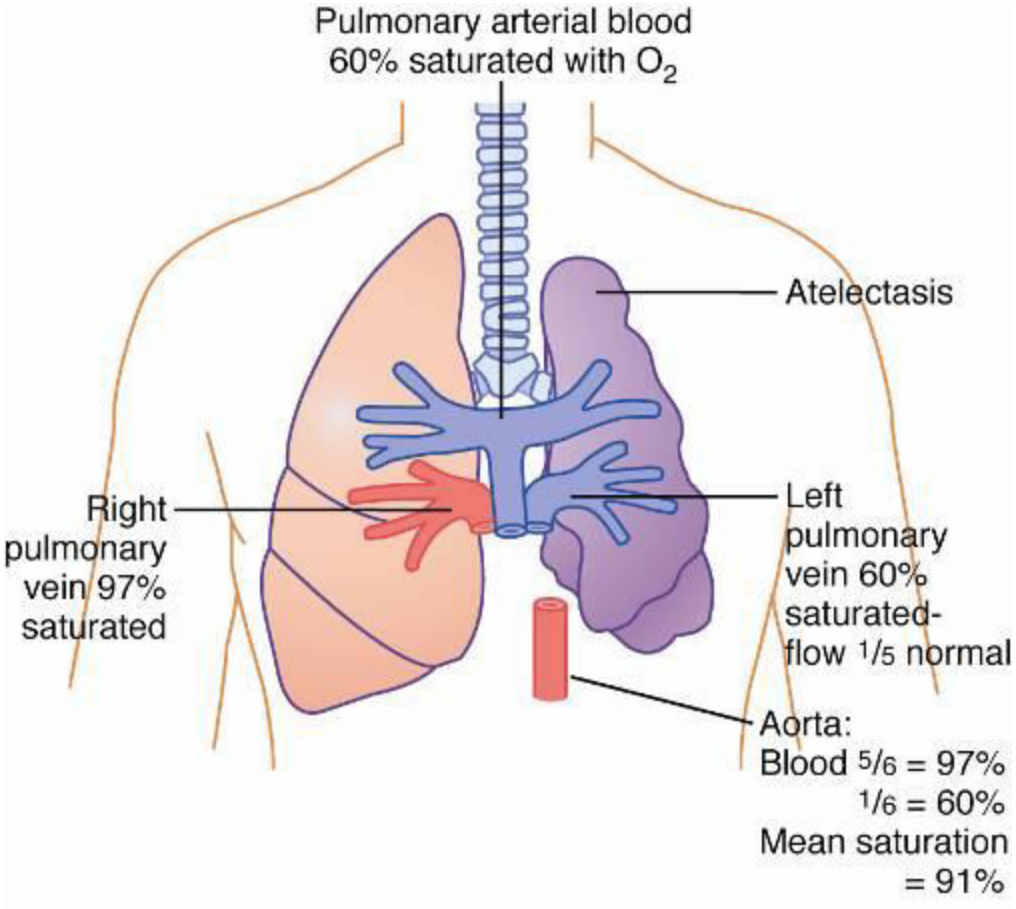
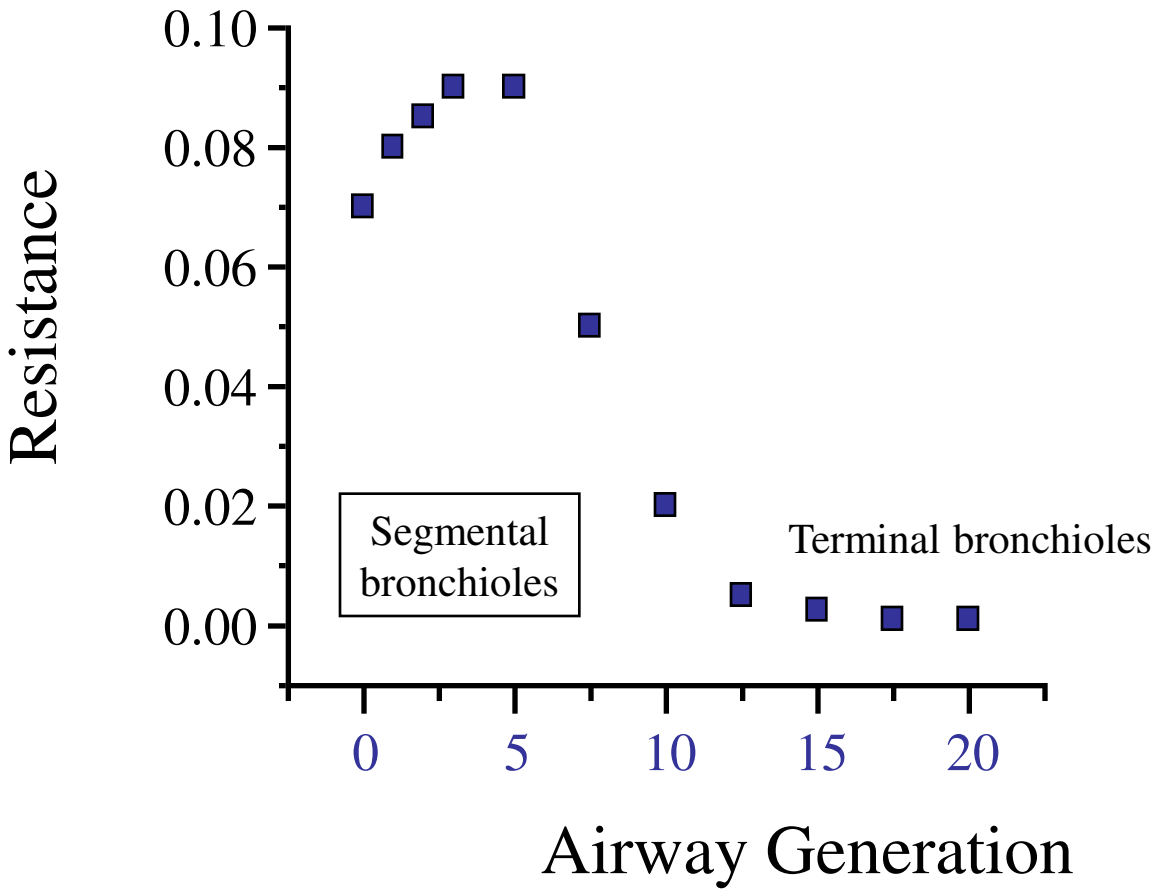


Figure 42-7

Airway Resistance



Chronic Obstructive Pulmonary Disease

- Chronic bronchitis
  - excessive mucous production
- Asthma
  - bronchiole constriction

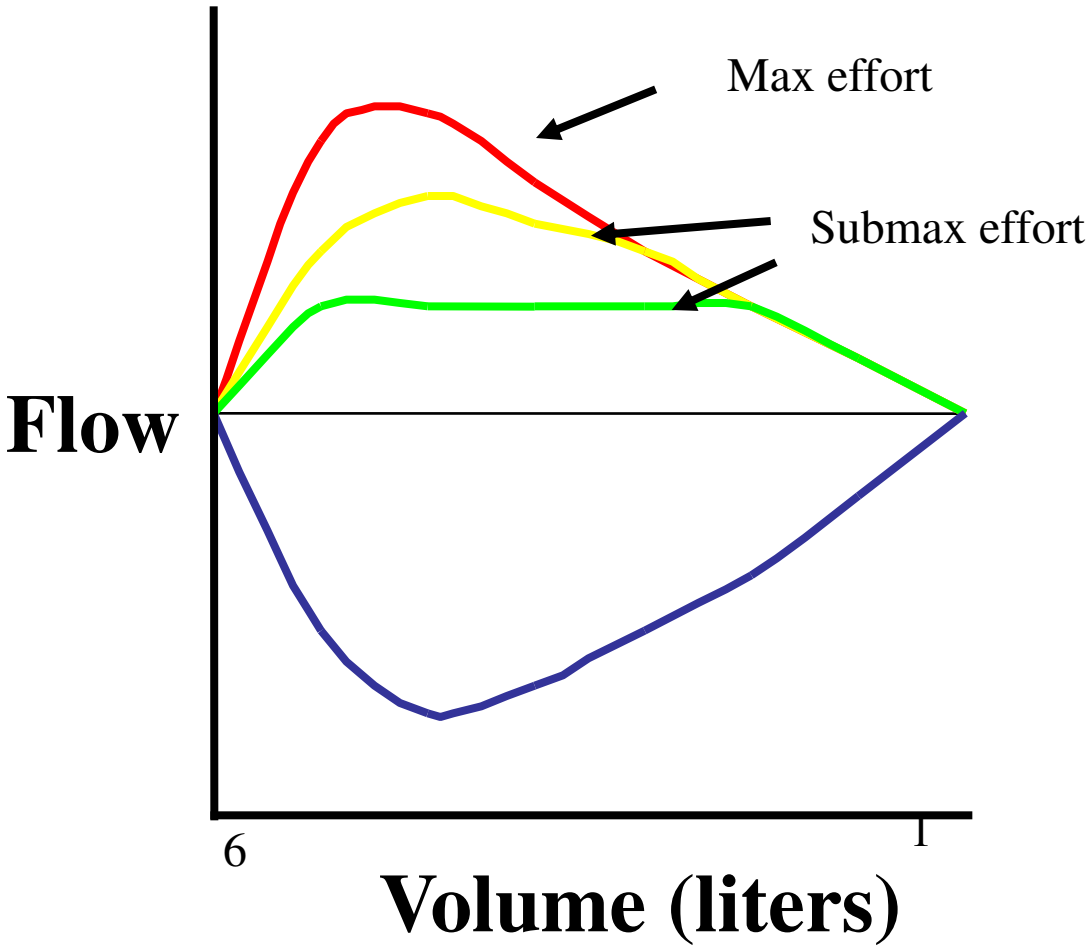
honary Function Tests

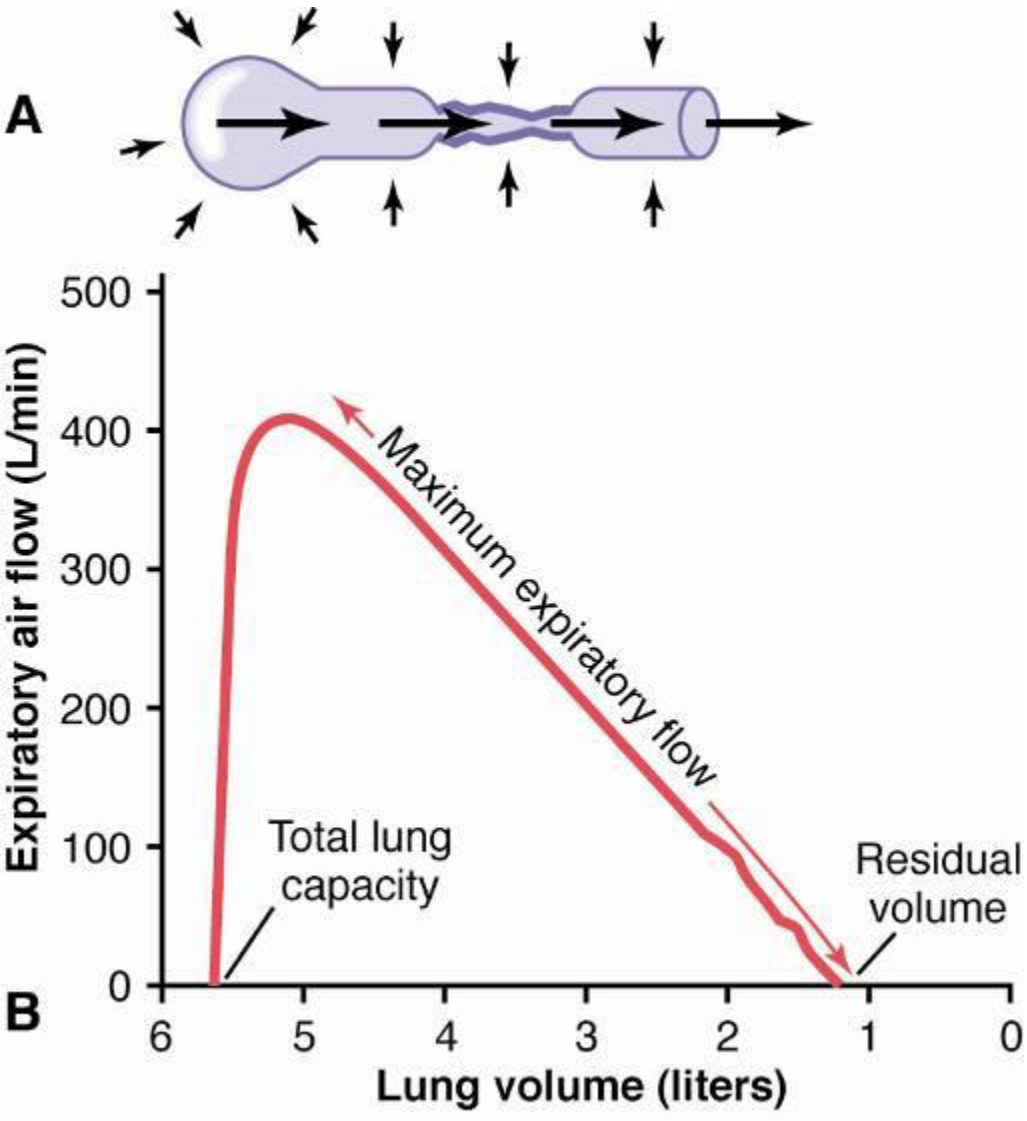
des an objective assessment of airflow obstruction and is important in staging asth
on initial diagnosis of asthma, after treatment is started and symptoms have stabili
d. Spirometry is used to measure the rate of airflow during maximal expiratory effo
be useful in differentiating between obstructive and restrictive lung disorders. In a
disorder) the forced expiratory volume in 1 second (FEV1) is usually decreased, **th**
is usually normal and the ratio FEV1/FVC is decreased. In restrictive disorders th
sed, leaving a normal FEV1/FVC.
surements are usually done before and after administration of a β_2 agonists (salbu
rol, terbutaline).. Reversibility with the use of a bronchodilator is defined as an incr
Patients with severe asthma may need a short course of oral steroid therapy
versibility.

s in Spirometry

mple of a volume-time curve. It shows the amount of air expired from the lungs as

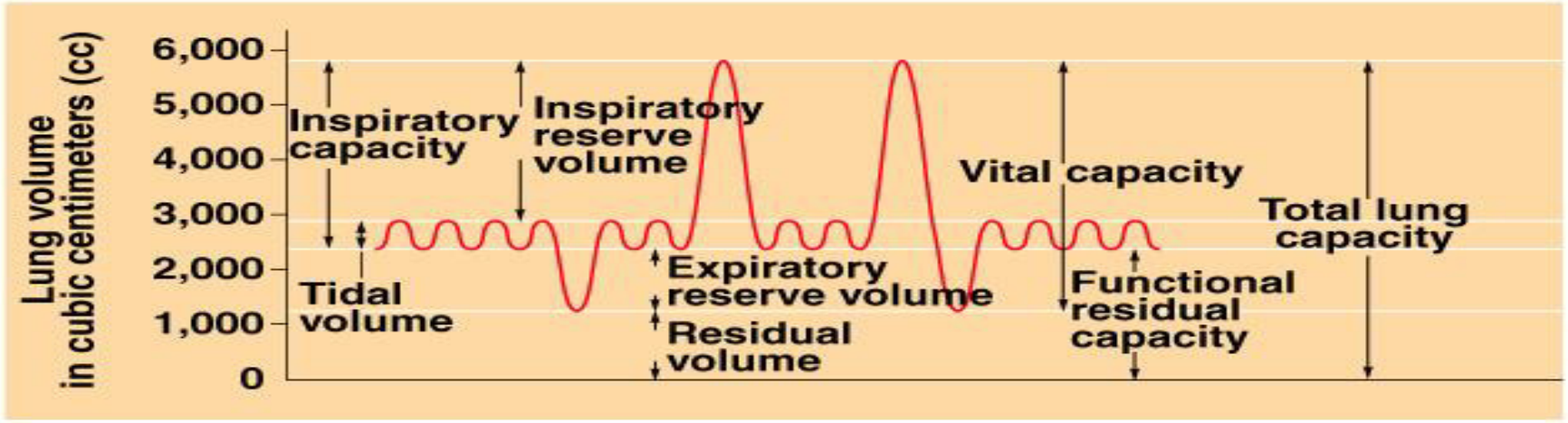
Flow-volume Curve




A
B
500
400
300
200
100
0
Expiratory air flow (L/min)
Maximum expiratory flow
Total lung capacity
Residual volume
6
5
4
3
2
1
0
Lung volume (liters)

Pulmonary Function Tests

- Subject breathes into a closed system in which air is trapped within a bell floating in H_20.
- The bell moves up when the subject exhales



Terms Used to Describe Lung Volumes and Capacities

Table 16.3 Terms Used to Describe Lung Volumes and Capacities

Term	Definition
Lung Volumes	The four nonoverlapping components of the total lung capacity
Tidal volume	The volume of gas inspired or expired in an unforced respiratory cycle
Inspiratory reserve volume	The maximum volume of gas that can be inspired during forced breathing in addition to tidal volume
Expiratory reserve volume	The maximum volume of gas that can be expired during forced breathing in addition to tidal volume
Residual volume	The volume of gas remaining in the lungs after a maximum expiration
Lung Capacities	Measurements that are the sum of two or more lung volumes
Total lung capacity	The total amount of gas in the lungs after a maximum inspiration
Vital capacity	The maximum amount of gas that can be expired after a maximum inspiration
Inspiratory capacity	The maximum amount of gas that can be inspired after a normal tidal expiration
Functional residual capacity	The amount of gas remaining in the lungs after a normal tidal expiration

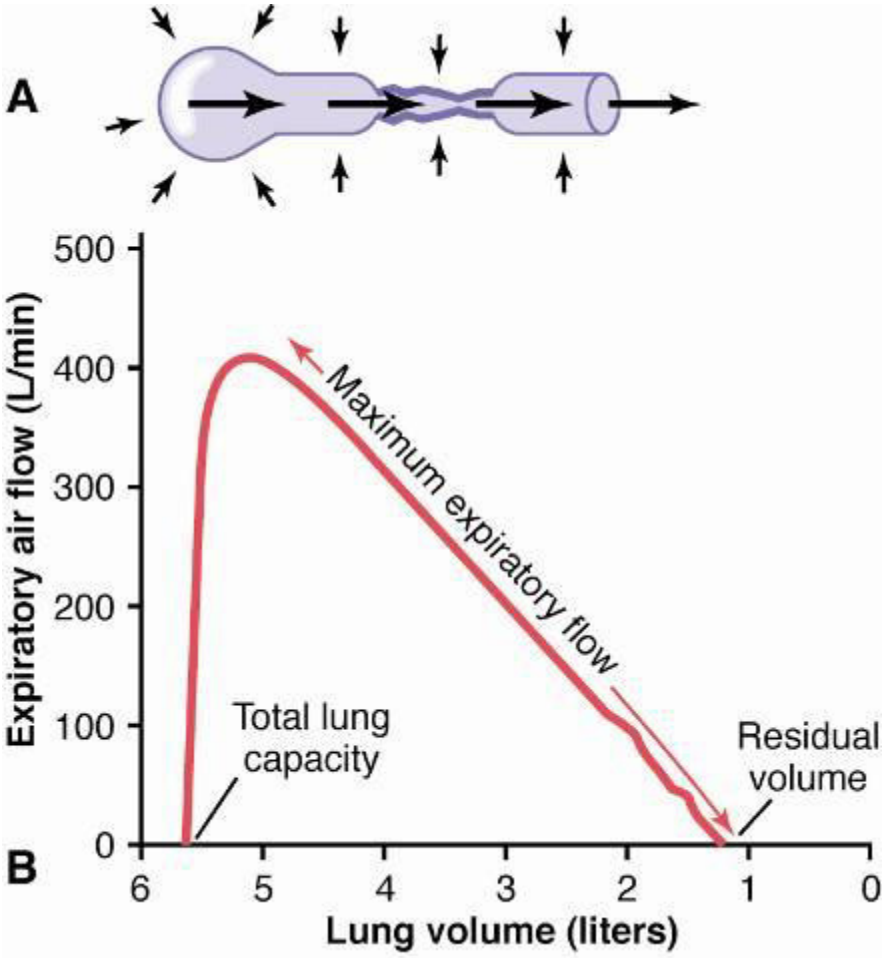

A
B
Expiratory air flow (L/min)
500
400
300
200
100
0
Maximum expiratory flow
Total lung capacity
Residual volume
6
5
4
3
2
1
0
Lung volume (liters)

Figure 42-1

Dynamic Flow - Volume Loops

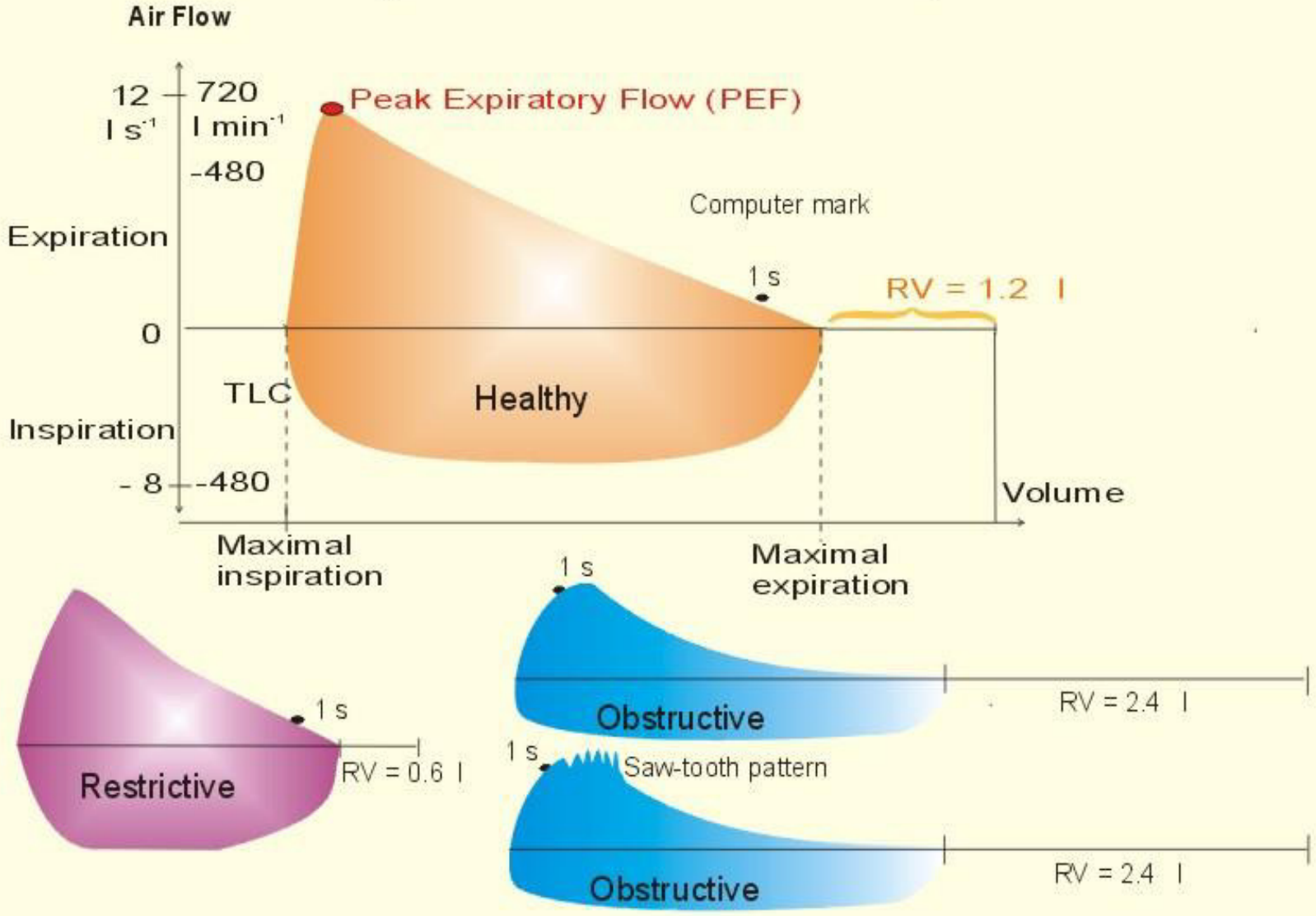


Fig. 13-6

KMc

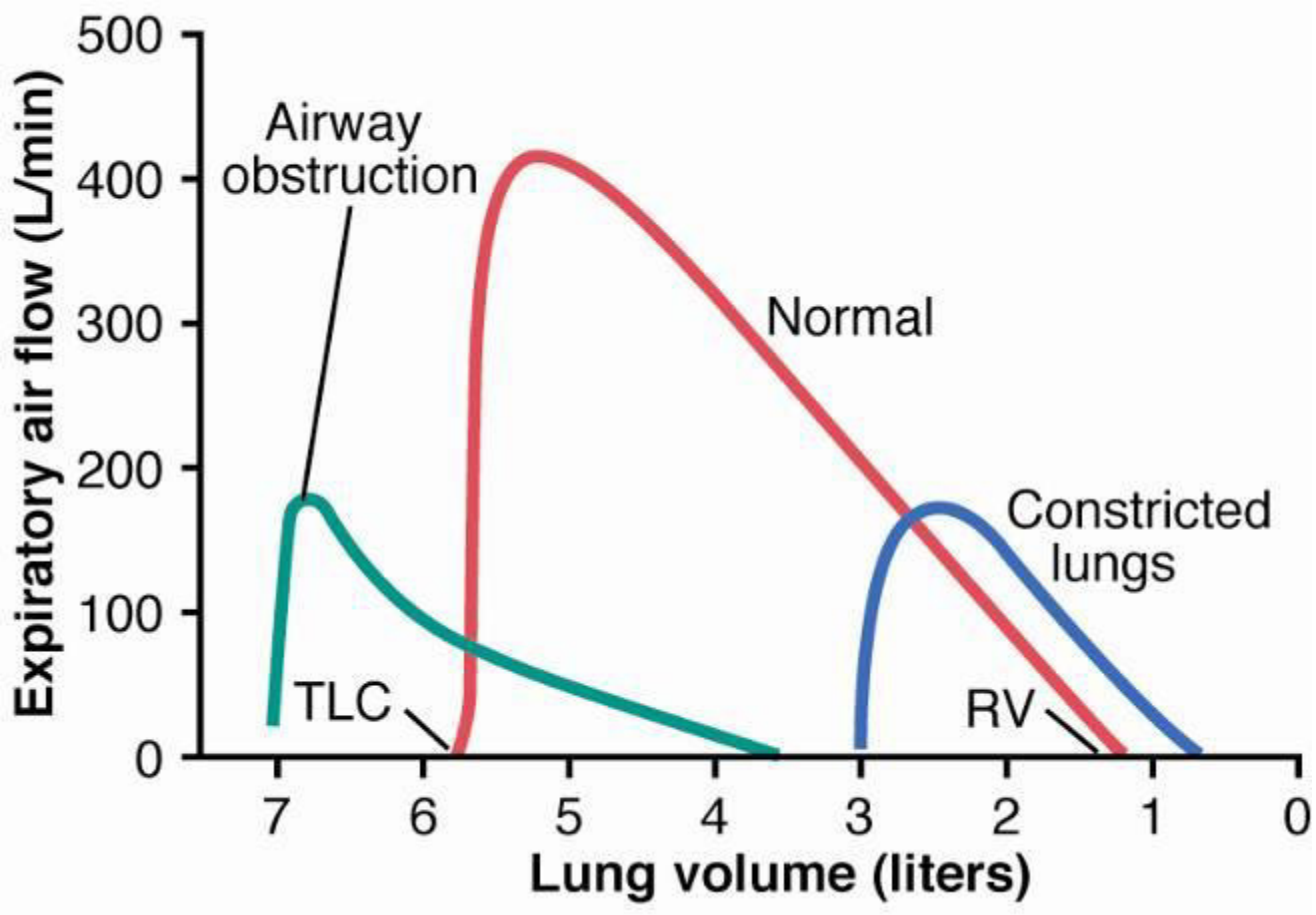

500
400
300
200
100
0
Expiratory air flow (L/min)
Airway obstruction
Normal
Constricted lungs
TLC
RV
7
6
5
4
3
2
1
0
Lung volume (liters)

Figure 42-2

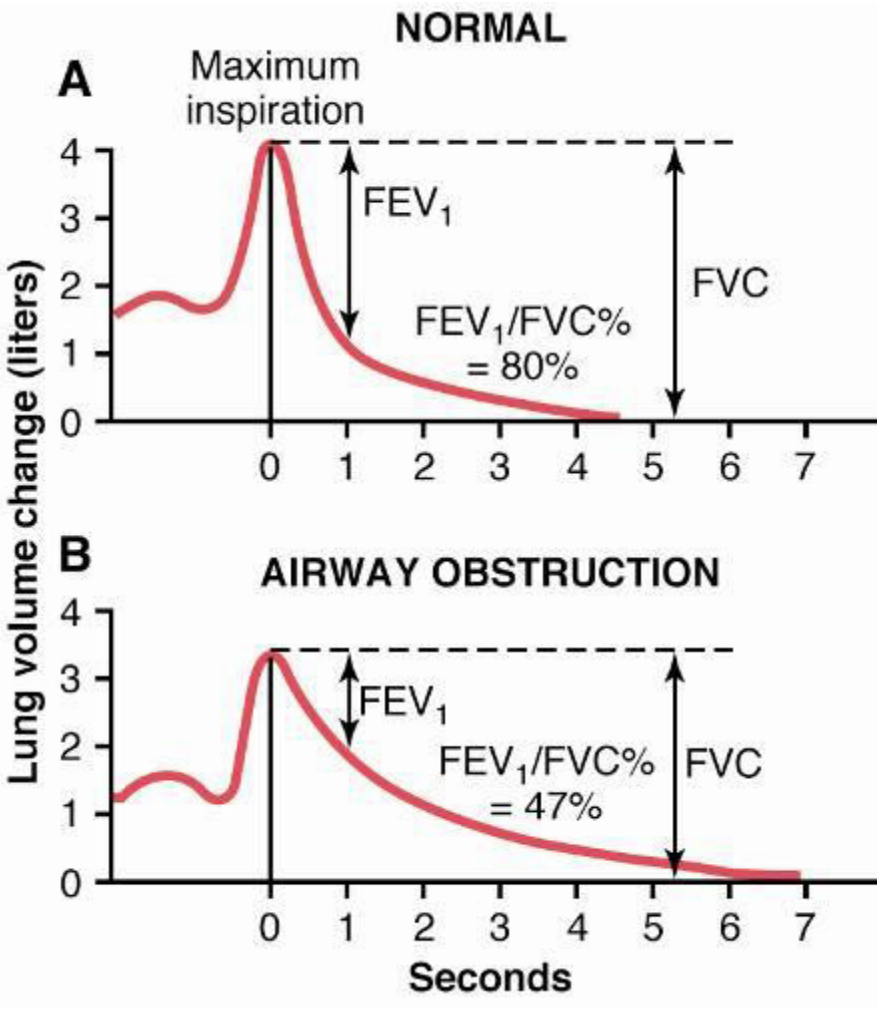

NORMAL
A
Maximum inspiration
FEV1
FVC
FEV1/FVC% = 80%
B
AIRWAY OBSTRUCTION
FEV1
FEV1/FVC% = 47%
FVC
Lung volume change (liters)
Seconds
0
1
2
3
4
5
6
7

Figure 42-3

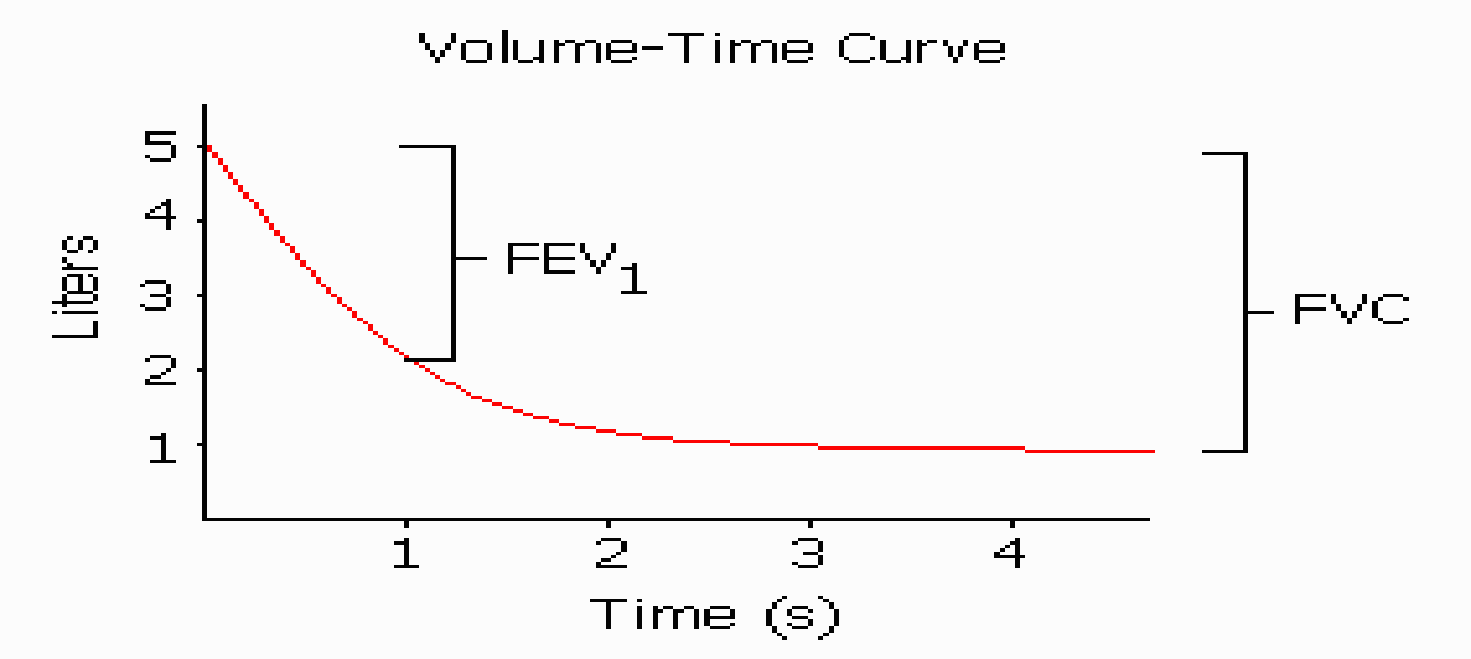
Chronic Obstructive Pulmonary Disease

FEV_1 values (expressed as a percentage of **predicted**) may classify the severity of the COPD

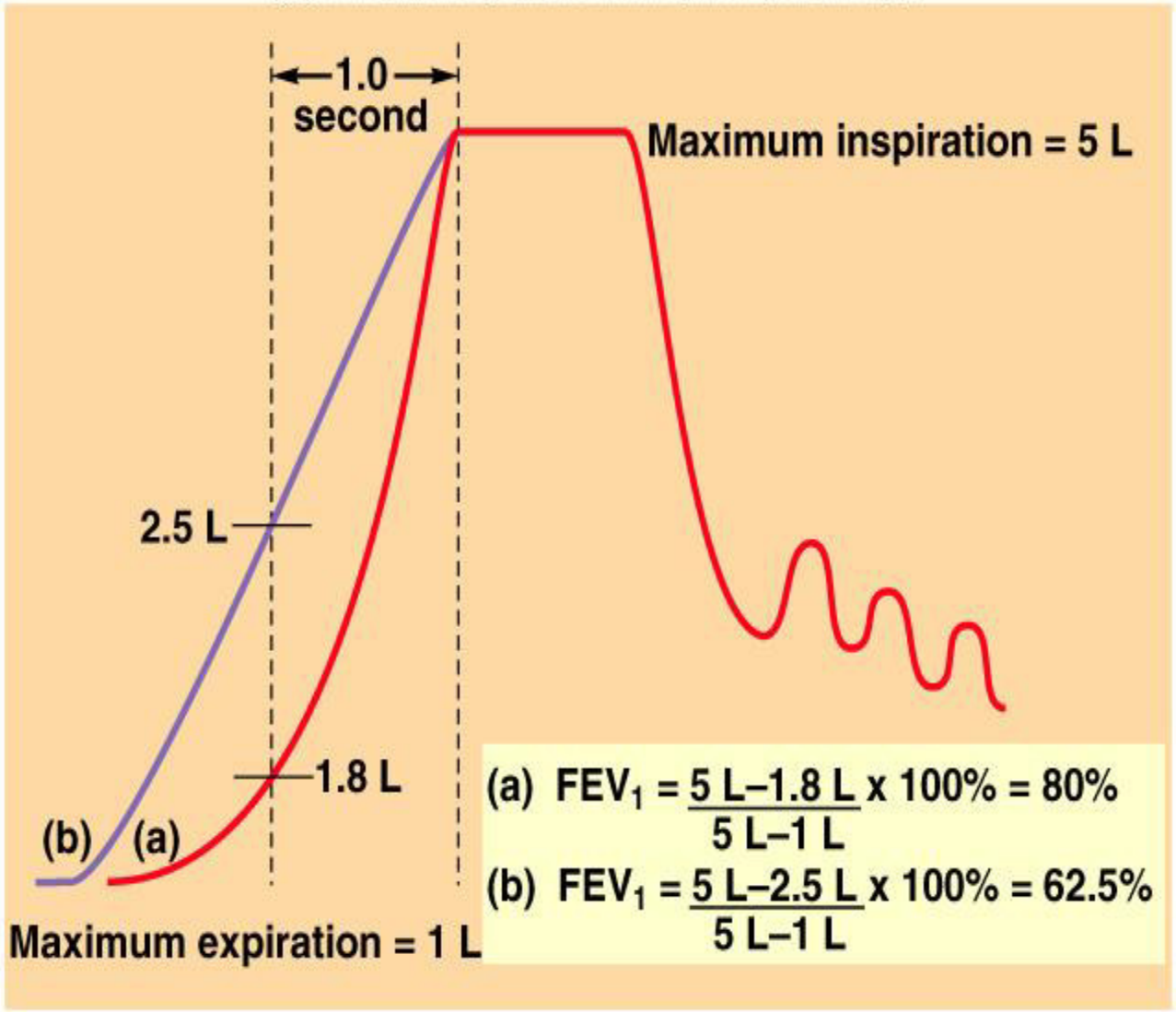
60% - 79% predicted: MILD COPD

40% - 59% predicted: MODERATE COPD

Less than 40% predicted: SEVERE COPD



Restrictive and Obstructive Disorders



Closing volume (CV) *is the volume of air that can be exhaled after the gravitationally dependent airways have closed down. The point at which the closure begins during expiration is called the closing point which is normally reached near to residual volume. If its reached before the end of normal* V_T*, then the V/Q ratio falls sharply. By the mid-forties, CV equals FRC in the lying position and by the mid-sixties it equals FRC in the erect position. It increases in smokers, pulmonary congestion, pulmonary edema, chronic bronchitis, and excessive bronchial secretions. Any condition which interfere with diaphragmatic movement such as, tight clothing, obesity, pregnancy, ascites, phrenic paralysis, obesity, pneumothorax*

ABG

- An **arterial blood gas** (**ABG**) is a blood test that is primarily performed using blood from an artery. It involves puncturing an artery with a thin needle and syringe and drawing a small volume of blood. The most common puncture site is the radial artery at the wrist, but sometimes the femoral artery or other sites are used. The blood can also be drawn from an arterial catheter

- The test is used to determine the pH of the blood, the partial pressure of carbon dioxide and oxygen, and the bicarbonate level. Many blood gas analyzers will also report concentrations of lactate, hemoglobin, several electrolytes, oxyhemoglobin, carboxyhemoglobin

Components of the Arterial Blood Gas

The arterial blood gas provides the following values:

pH

Measurement of acidity or alkalinity, based on the hydrogen (H+) ions present.

The normal range is 7.35 to 7.45

PaO2

The partial pressure of oxygen that is dissolved in arterial blood.

The normal range is 80 to 100 mm Hg.

SaO2

The arterial oxygen saturation.

The normal range is 95% to 100%.

PaCO2

The amount of carbon dioxide dissolved in arterial blood.

The normal range is 35 to 45 mm Hg.

HCO3

The calculated value of the amount of bicarbonate in the bloodstream.

The normal range is 22 to 26 mEq/liter

B.E.

The base excess indicates the amount of excess or insufficient level of bicarbonate in the system.

The normal range is –2 to +2 mEq/liter.

(A negative base excess indicates a base deficit in the blood.)

Oxygen Therapy

- Atmospheric
- Hypoventilation
- impaired alveolar membrane
- anemia, abnormal hemoglobin
- inadequate

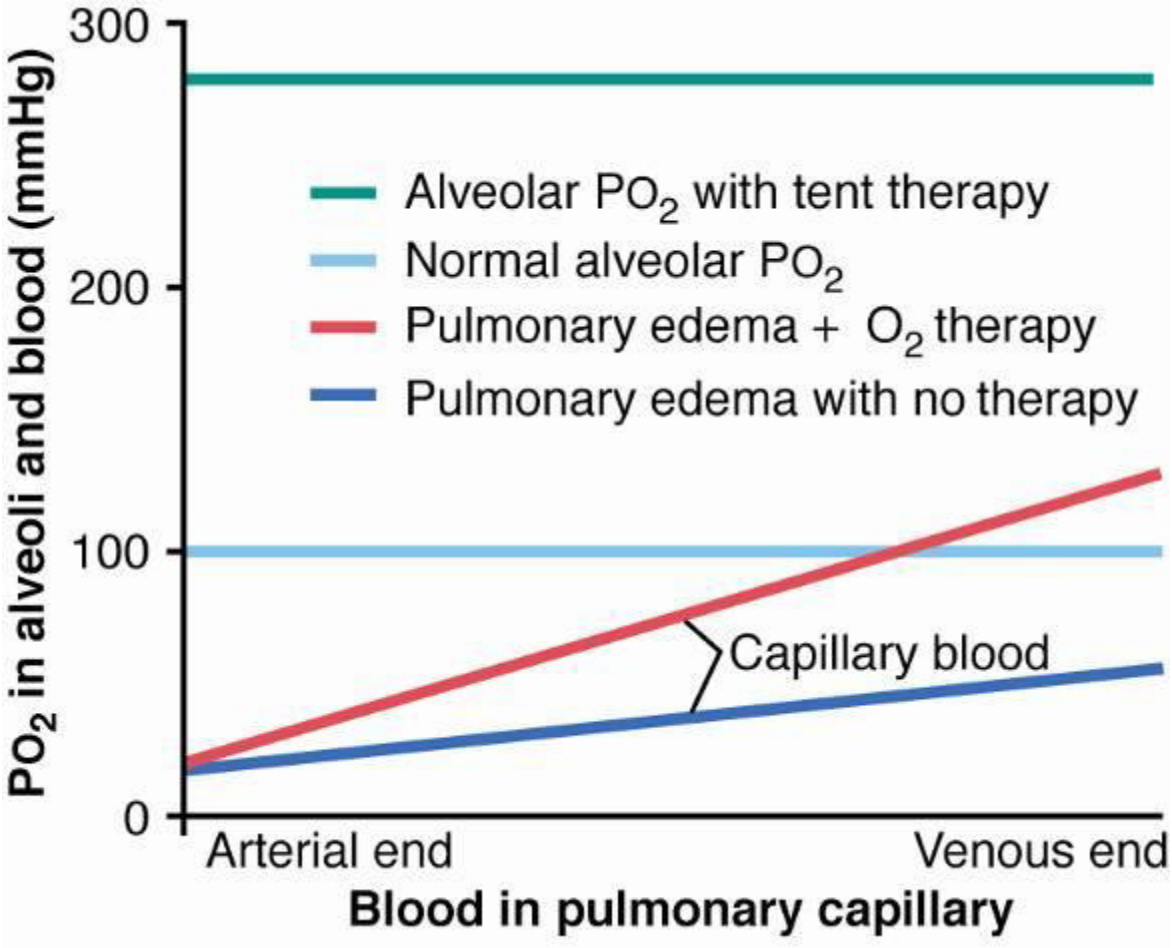

300
200
100
0
PO_2 in alveoli and blood (mmHg)
Alveolar PO_2 with tent therapy
Normal alveolar PO_2
Pulmonary edema + O_2 therapy
Pulmonary edema with no therapy
Capillary blood
Arterial end
Venous end
Blood in pulmonary capillary

Figure 42-8

THANK YOU

Next Time…

- Compliance