Diseases of the respiratory system

- Functional anatomy :the lungs occupy the upper two third of the thorax, bounded medially by the spine , heart & mediastinum, & inferiorly by the diaphragm.
- Breathing occurs by free movement of the lung surface relative to the chest wall facilitated by sliding contact between the parietal & visceral pleura.
- Inspiration is initiated by downward contraction of the dome-shaped diaphragm (innervated by C3,4 & 5) , & upward outward movement of the ribs caused by contraction of the external intercostal muscles (innervated by intercostal nerves) .
- Expiration is mainly a passive action, driven by elastic recoil of the lungs.
- The acinus is the gas exchange unit of the lung and comprises branching respiratory bronchioles & clusters of alveoli.
- The gas to blood distance is < 0.4 μ. total airway cross sectional area is smallest in the glottis & trachea making them vulnerable to obstruction by foreign bodies & tumors.
- The multitude of cross sectional area of the small airways are over 300 cm^2 leading to slow flow rate & normal breath sounds originate mainly from the turbulent flow in major conducting system.

Control of breathing & ventilation perfusion matching

- The respiratory motor neurons in the posterior medulla oblongata are the origin of the respiratory cycle. Their activity is modulated by multiple external inputs , which include:
- 1-Central chemoreceptors. Sense the PH of CSF through rise in PCO_2.
- 2-The carotid bodies sense hypoxemia & activated when arterial PO_2> 8 kPa.
- 3-Muscle spindles sense the changes in the mechanical load.
- 4-Vagal sensory fibers in the lung stimulated mainly by stretch, inhaled toxins or disease of the interstitium.
- 5- Cortical (volitional) & limbic (emotional) influences can override the automatic control of breathing.
- For optimal gas exchange the ventilation perfusion is matched normally in segmental & subsegmental levels. Hypoxemia constricts pulmonary arterioles , while hypercapnia dilates the bronchi , maintaining good regional matching of ventilation & perfusion.

Symptoms & signs of respiratory diseases

- The signs & symptoms of respiratory disorders are:

1-Cough:could be acute or chronic , dry or productive.

2-Dyspnoe: acute or chronic, resting or exertional, orthostatic or not.

3-Hemoptysis: many etiologies, such as infection (TB)., acute bronchitis, pneumonia, . malignancy (bronchogenic Ca., Pulmonary infarction in PE, bronchiectasis,& sever MS.

4-Chest pain: it may have cardiac , pulmonary , aortic , esophageal causes. Can be central or peripheral in location. Usually classified to cardiac & non cardiac causes.

5- Finger clubbing: in cyanotic congenital cardiac diseases, GIT(IBD) & liver cirrhosis, & pulmonary diseases such as suppurative lung disorders (lung abscess & bronchiectasis), pulmonary fibrosis, malignant diseases. It also could be familial in origin.

6-Pleural effusion: could be transudate (protein less than 3 gm\dl) or exudate (protein more than 3 gm\dl) , also could be chylous in nature due to lymphatic duct disruption such in cases of lymphoma.

7-Pneumothotax: air in the pleural cavity., types are open ,closed & tension pneumothorax. The last is an emergency condition & need life-saving intervention.

Types of respiratory failure

- Respiratory failure occurs when the lungs can not meet the oxygen demand of the body tissues either at rest or on exertion. It can be classified by the rapidity with which it can occur , either acute or chronic or by the type of arterial gas derangements which occur during the course of the disease. This has important implications regarding the line of treatment offered to the patient. And in this regard we have two types of respiratory failure:
- 1-Type I respiratory failure: in which the patients arterial blood gas will reveal hypoxemia (arterial blood gas < 8 kPa/ 60mmHg) with normal arterial CO_2 level (<6 kPa / 45 mmHg).
- 2-Type II respiratory failure: in which we get both hypoxemia (PaO_2 < 8 kPa) & hypercapnia ($PaCO_2$ > 6 kPa).
- It is worth to mention that in case of type II respiratory failure , the only drive for respiratory center is the hypoxia , so when we treat the patients , we must use especial masks which supply fixed doses of oxygen (< 30%) to keep the stimulus for respiratory cycle to continue.
- 3-Type III respiratory failure: peri-operative: due to atelectasis in supine positioned patient.
- 4-Type IV respiratory failure: in shock states due to cardiovascular instability.

Respiratory distress syndrome (RDS)

Respiratory distress syndrome occurs in all age groups, but it is classified generally to : 1- Neonatal RDS : which occur in premature neonates due to inadequate respiratory surfactant formation in their lungs . It can be prevented sometimes by treating the mother with dexamethasone for 24-48 to allow maturation of the surfactant .

2-Adult (RDS) : it sometimes called non cardiogenic pulmonary oedema & usually occurs in setting of critically ill patient in intensive care unit , alone or as a part of multio- organ failure. Most important causes of ARDS are:

1- Sever pulmonary infection , especially viral infection (covid) .

2- Sever trauma . 3- Irritant & toxic gases exposure. 4- DIC.

5- Acute hemorrhagic pancreatitis..6- envenomization , (snake bite).

7- Malignant diseases (pancreatic carcinoma). 8- Drugs & chemical agents.

Obstructive versus restrictive lung diseases

Obstructive lung diseases

- 1-Usually the main pathology is in the bronchial tree ,or conducting system of the lung,(hard to exhale).
- 2-The expiratory phase of the respiration is reduce in proportional to the vital capacity of the lung leading to reduced FEV1\FVC ratio , which is usually below 70%.
- 3-The forced vital capacity measurement by spirometry is useful to follow up patients response to therapy.
- 4-Examples of obstructive pulmonary diseases are, asthma , COPD, OSA(obstructive sleep apnea).

Restrictive lung diseases

- 1-usually the main pathology affects the alveolar wall , causing increased thickness with defective gas exchange,(difficult to fully expand the lung).
- 2-The reduction of the expiratory phase is proportional to the reduction in the vital capacity of the lung leading to normal FEV1\FVC ratio, which will be above 70%.
- 3-The diffusion capacity by DLco (diffusion capacity for carbon monoxide) is used to assess the severity of the conditions.
- 4-Examples for restrictive lung diseases are , idiopathic pulmonary fibrosis, pulmonary edema , Goodpasture syndrome.

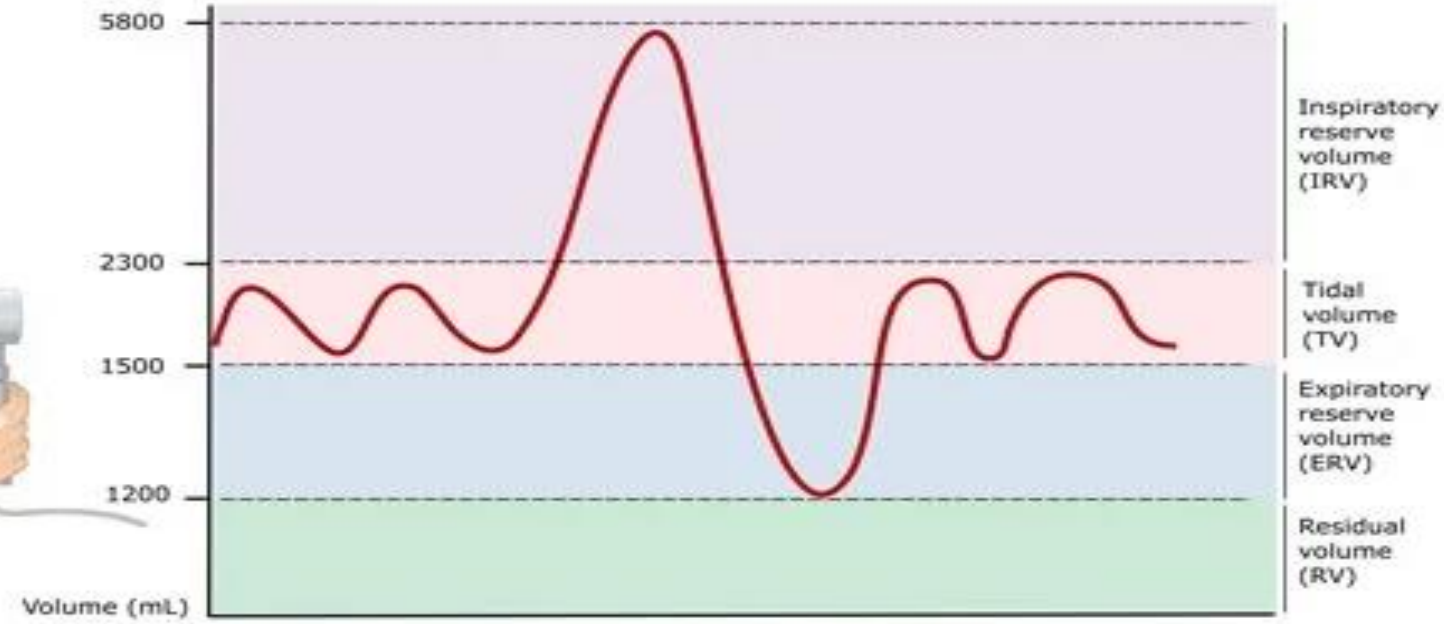
Sleep apnea

- Sleep apnea are syndromes related mainly to sleep , in which the patient get deterioration in gas exchange capacity due to cessation or reduced respiration during sleeping time , with development of hypoxia with or without hypercapnia. The patient also will have other features such as daytime sleepiness, reduced concentration & thinking ability, hypertension, pulmonary artery hypertension, obesity, with more susceptibility for cardiovascular disorders.
- It has two types:
- 1-Obstructive sleep apnea (OSA): in which the patient develops obstruction of the main & upper airway passages , the patient usually sleeps with loud snoring & periods of non respiratory phase. The throat muscles relax during sleep causing obstruction to air flow.
- 2-Central sleep apnea (CSA): due to defective control of respiratory cycle at sleep by any disorder affecting the respiratory center in the brain which dose not send proper signals to the respiratory muscles that control breathing. There are some types of complex sleep apnea, in which both pathophysiology play some role in its manifestation.
- Nocturnal polysomnography or , apnea-hypopnea index could be used to diagnose & differentiate between the two types of sleep apnea.

Investigations of respiratory diseases

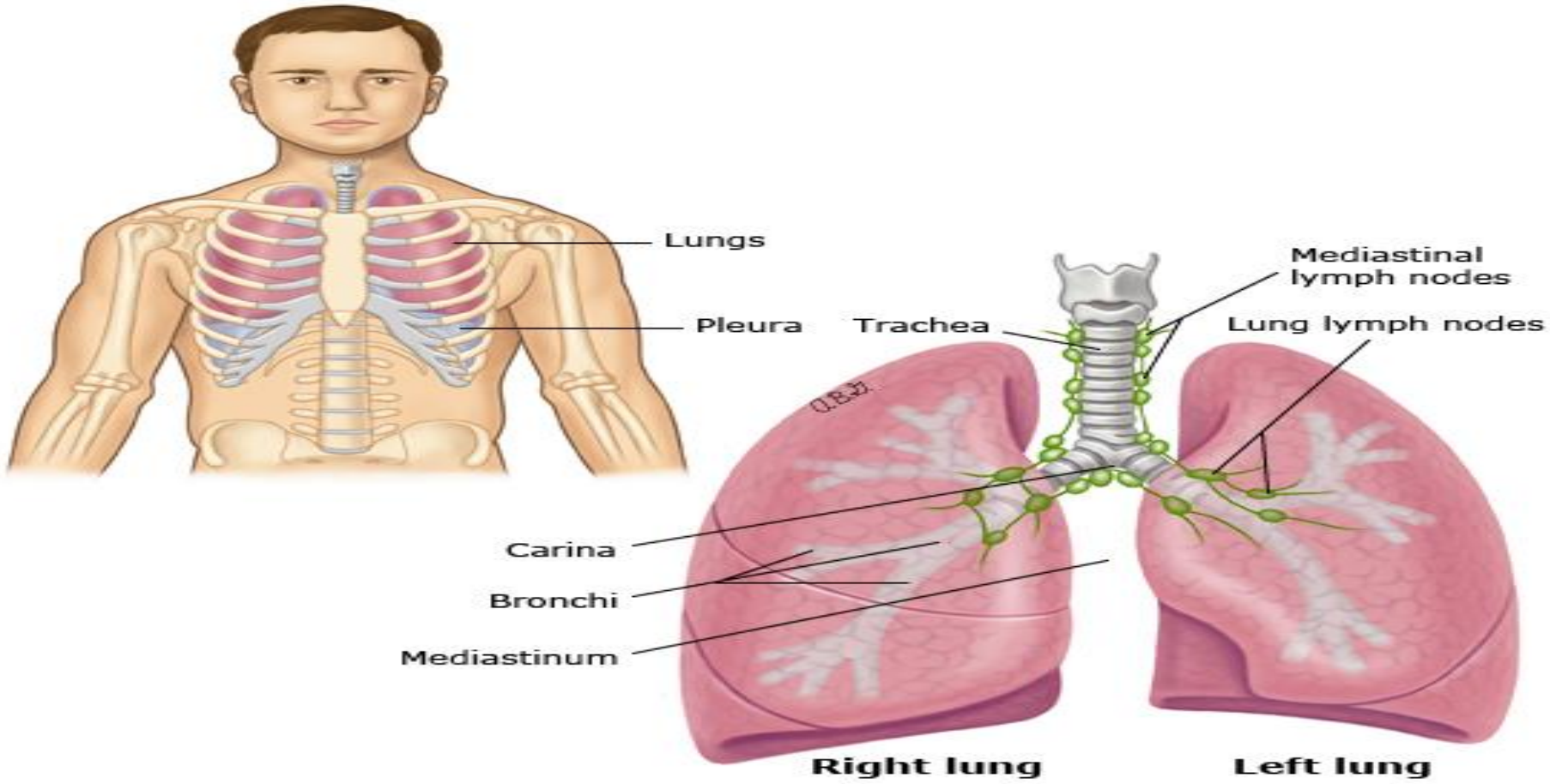
- 1- Imaging studies : such as plain CXR , CT chest, MRI, US, PET.
- 2-Endoscopic examinations : such as Laryngoscopy, Bronchoscopy, Endobronchial US, Thoracoscopy. Also can use BAL for mRDT(multiples rapid diagnostic tests).
- 3-Immunological & serological tests: such as IgE level in asthmatic patients. Auto antibodies , pneumococcal antigens in the sputum, Aspergillus antigens , immunofluorescence , & urine antigens for Legionella.
- 4-Microbiological & cytological studies: for infection : mRDT, or by direct sputum specimen , or from bronchoalveolar lavage , also from plural aspiration samples for gram staining , Acid fast staining (TB). Fungal staining , Or cytology for suspected malignant diseases of the lung.
- 5-Respiratory function tests , volumes & lung capacities are useful to differentiate different types of respiratory diseases (FEV1\FVC if less than 70% , it indicates obstructive pulmonary diseases),pulse oximetry, transfer factor arterial blood gases & PH , exercise tests. These tests are also used for follow up of the patients & their response to treatment.

Lung volumes & capacities



Male	Female
3000	1900
500	500
1100	700
1200	1100
5800 mL	4200 mL

Respiratory surface anatomy



Respiratory anatomy

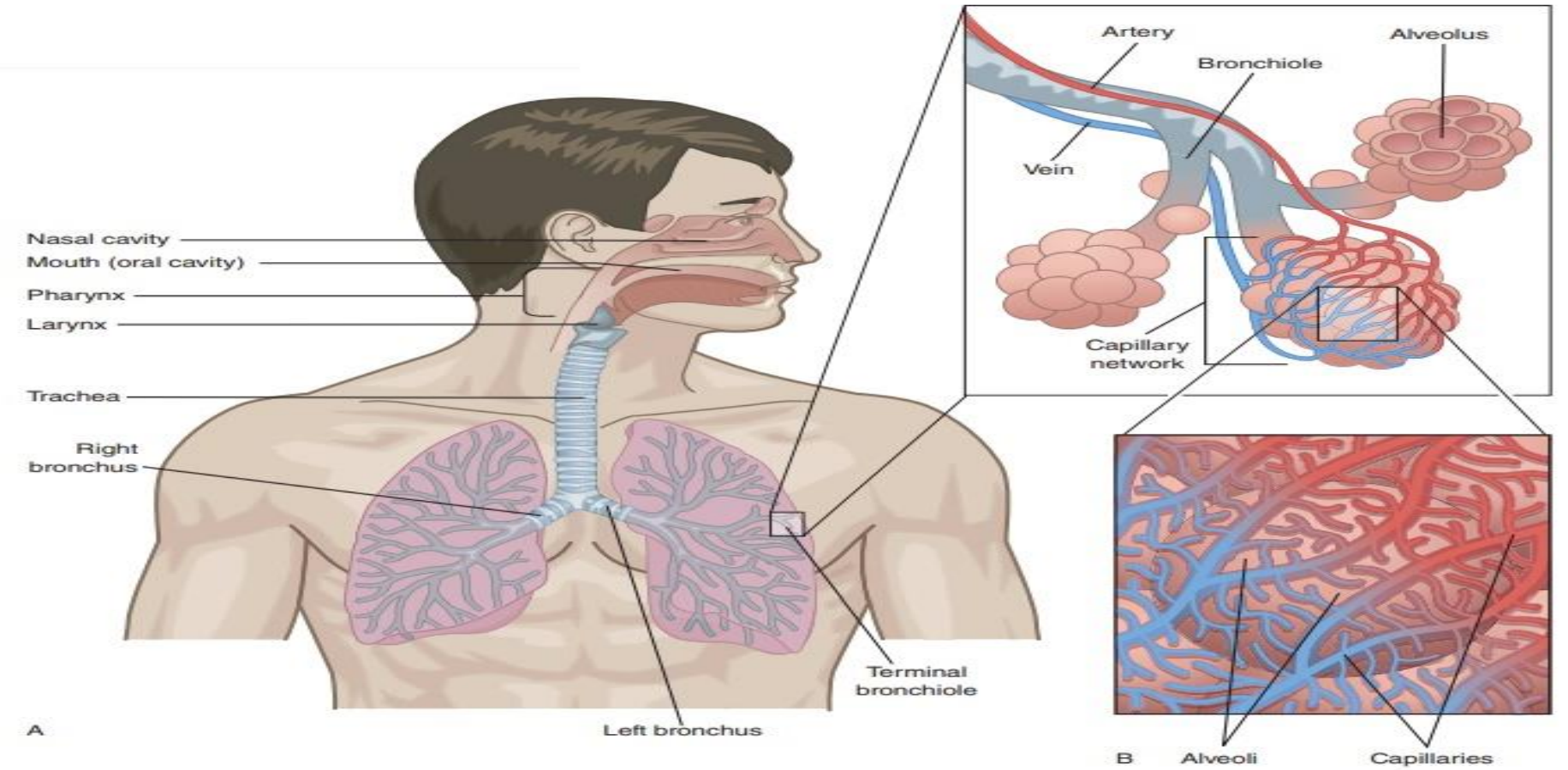


FIGURE 21-1 The respiratory system. (**A**) The air conducting portion and the gas exchange portion of the human respiratory system. The inset shows a higher magnification of the alveoli where oxygen and carbon dioxide exchange occurs. (**B**) A scanning electron micrograph of the alveoli showing the rich capillary network surrounding them.

Surface anatomy