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CHAPTER 1: HISTORY AND ADVANCES IN CHEST PHYSIOTHERAPY

Chest physiotherapy aims at improving patient pulmonary function and has a significant role in respiratory medicine. Common techniques involved in respiratory physiotherapy include percussion, vibration, postural drainage and breathing exercises. Chest physical therapy is the term for a group of treatments designed to improve respiratory efficiency, promote expansion of the lungs, strengthen respiratory muscles, and eliminate secretions from the respiratory system.

With chest physical therapy (CPT), the person gets in different positions to use gravity to drain mucus (postural drainage) from the five lobes of the lungs. Each position is designed so that a major part of the lung is facing downward. When combined with percussion, it may be known as postural drainage and percussion (PD&P).

History:

The use of postural drainage was first mentioned by S. H. Quincke in 1898. He recommended "intermittent" use of postural drainage to treat patients with thick secretions. Yet this technique wasn't adapted by the medical community until William Ewart recommended CPT with postural drainage in 1901.

Ewart worked with children with bronchiectasis, and he recommended "continuous postural drainage" as opposed to "intermittent" to these children to promote the removal of thick tenacious secretions. By continuous he meant that it should be done frequently, as opposed to just once a day. Generally, the treatment was prescribed 3-4 times a day for up to 10 minutes, and this is still how it's ordered today for the same reasons.

While Ewart may have spearheaded the idea of CPT and postural drainage for bronchiectasis and eventually cystic fibrosis patients, the use of these techniques was ultimately found to be useful to prevent and treat complications that result from performing surgeries. Physicians noted many of their post-operative patients were developing respiratory complications not related to the surgery itself, and they sought to understand and find a solution. This concept of using CPT to prevent and treat post-operative respiratory complications was first described in 1915 by MacMahon in an article about how to treat post-operative trauma patients. In fact, not only did he recommend the use of CPT, but he also recognized the importance of exercising as soon as possible after a surgery to get the lungs back to normal, or their pre-operative status.

Most of the patients **MacMahon** treated were soldiers injured in battle. He recommended CPT with exercise, and forced exhalation, and reported that the results were "remarkable," particularly within one week. By 1919 there was an increasing body of evidence to suggest that where there is "serious lung collapse and chest deformity following wounds or illness, breathing and physical exercises should, in certain cases, be given as accessories to medical and surgical treatment, if the best possible recovery is to be assured."

Kigin explained that Loius Pasteur first recognized atelectasis in 1908 after "temporary inhibition of muscular activity." In the 1930s studies showed a link between post-operative respiratory distress and hypoxemia (low oxygen in the blood). In 1952 atelectasis was recognized by R.N.V. Palmer and BA Sellick as the most common cause of post-operative complications.

Palmer and Sellick described that some of the best results in treating these complications are by using percussion, postural drainage, and treatments with isoprenaline. They were among the first to recognize the value of using beta adrenergic to treat and prevent post-operative complications. The idea was that anesthesia causes "reflex bronchospasm", and this results in the retention of secretions. They concluded that Isoprenaline given before and during anesthesia treated this *perceived* problem by dilating airways and enhancing secretion clearance in that way.

Till 1960s "gold standard" for preventing post-operative pulmonary complications was chest physiotherapy, then other methods, such as the incentive spirometer, were discovered to also benefit such patients. There were also some mechanical percussors available, yet there was never any conclusive evidence they did any better of a job than CPT. Whether to use cupped hands or a mechanical device was generally left to the institution or therapist.

In 1970 the incentive spirometer (IS) was invented. It was believed to be more effective than any of the other methods used to promote airway clearance because it could be done by the patient alone. Seeing this device on the bedside table acted as a reminder or an incentive to take deep breaths. Likewise, being able to see how high they could make the bellow or balls move up acted as positive feedback. The patient and the physician could also monitor progress.

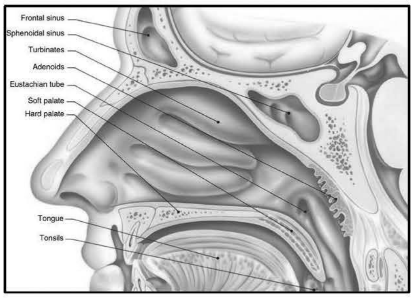
During the 1970s many studies were done to determine the effects of both the incentive spirometer and CPT. A 1974 article in the *British Journal of Surgery* studied a group of post-operative patients that were treated with CPT and another group treated with IS therapy. The CPT was done only twice a day, and the IS every hour. Those in the group receiving CPT had a 63 percent chance of developing post-operative complications, and those in the IS group had only a 37% chance of developing complications. The researchers decided CPT may have been less effective because deep breathing exercises weren't encouraged.

During the early 1990s the flutter device was introduced to the market as an alternative to CPT to help with mucus clearance. It's a handheld device that the patient blows into. This causes ball bearings inside it to "oscillate at a high frequency, resulting in vibrations of the airways and intermittent positive expiration facilitate mucus expectoration." While studies show CPT is a better method of helping patients with cystic fibrosis remove secretions and improve lung volumes, other studies showed that use of a flutter device was even more effective. Studies also showed that CF patients coughed up three times as much with the flutter as compared to CPT.

Yet regardless of all the technology, CPT continues to be the gold standard method of helping patients promote airway clearance. Regardless of what studies say, just having a respiratory therapist in the room moving the patient from side to side assures the physician the patient will be assessed and moved on a regular basis. This alone may all that most patients need for a speedy recovery.

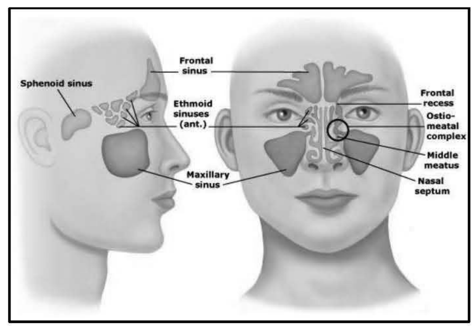
CHAPTER 2: ANATOMY OF RESPIRATORY TRACT

Anatomy of upper respiratory tract: Upper airway structures consist of the nose, sinuses and nasal passages, pharynx, tonsils and adenoids, larynx, and trachea.



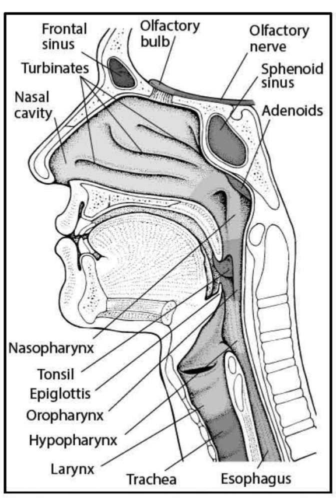
Nose: The nose is composed of an external and an internal portion. The external portion protrudes from the face and is supported by the nasal bones and cartilage. The anterior nares (nostrils) are the external openings of the nasal cavities. The internal portion of the nose is a hollow cavity separated into the right and left nasal cavities by a narrow vertical divider, the septum. Each nasal cavity is divided into three passageways by the projection of the turbinates' (also called conchae) from the lateral walls. The nasal cavities are lined with highly vascular ciliated mucous membranes called the nasal mucosa. Mucus, secreted continuously by goblet cells, covers the surface of the nasal mucosa, and is moved back to the nasopharynx by the action of the cilia (fine hairs). The nose serves as a passageway for air to pass (to and from) the lungs. It filters impurities and humidifies and warms the air as it is inhaled. It is responsible for olfaction (smell) because the olfactory receptors are in the nasal mucosa. This function diminishes with age.

Paranasal Sinuses: The paranasal sinuses include four pairs of bony cavities that are lined with nasal mucosa and ciliated pseudostratified columnar epithelium. These air spaces are connected by a series of ducts that drain into the nasal cavity. The sinuses are named by their location: frontal, ethmoidal, sphenoidal, and maxillary.



A prominent function of the sinuses is to serve as a resonating chamber in speech. The sinuses are a common site of infection. Turbinate Bones (also known as Conchae the name suggested by their shell-like appearance). Because of their curves, these bones increase the mucous membrane surface of the nasal passages and slightly obstruct the air flowing through them.

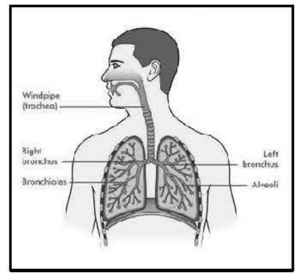
Air entering the nostrils is deflected upward to the roof of the nose, and it follows a circuitous route before it reaches the nasopharynx. It meets a large surface of moist, warm mucous membrane that catches practically all the dust and organisms in the inhaled air. The air is moistened, warmed to body temperature, and brought intocontact with sensitive nerves. Some of these nerves detect odors; others provoke sneezing to expel irritating dust.



Pharynx, Tonsils, and Adenoids: The pharynx, or throat, is a tube-like structure that connects the nasal and oral cavities to the larynx. It is divided into three regions: nasal, oral, and laryngeal. The nasopharynx is located posterior to the nose and above the soft palate. The oropharynx houses the faucial, or palatine, tonsils. The laryngopharynx extends from the hyoid bone to the cricoid cartilage. The epiglottis forms the entrance of the larynx. The adenoids, or pharyngeal tonsils, are in the roof of the nasopharynx. The tonsils, the adenoids, and other lymphoid tissue encircle the throat. These structures are important links in the chain of lymph nodes guarding the body from invasion by organisms entering the nose and the throat. The pharynx functions as a passageway for the respiratory and digestive tracts.

Larynx: The larynx, or voice organ, is a cartilaginous epithelium lined structure that connects the pharynx and the trachea (fig. 4). The major function of the larynx is vocalization. It also protects the lower airway from foreign substances and facilitates coughing. It is referred to as the voice box and consists of the following:

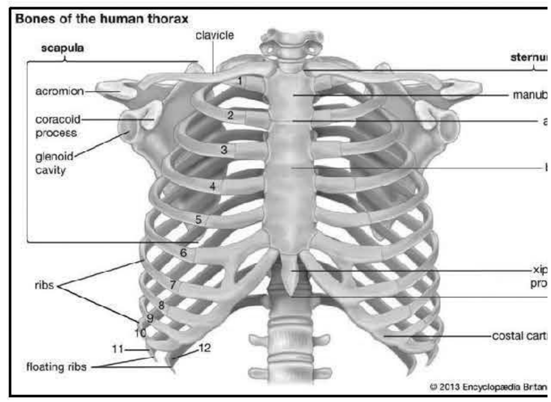
- Epiglottis: a valve flap of cartilage that covers the opening to the larynx during swallowing.



- Glottis: the opening between the vocal cords in the larynx. • Cricoid cartilage: the only complete cartilaginous ring in the larynx (located below the thyroid cartilage).
- Arytenoid cartilages: used in vocal cord movement with the thyroid cartilage.
- Vocal cords: ligaments controlled by muscular movements that produce sounds; located in the lumen of the larynx.

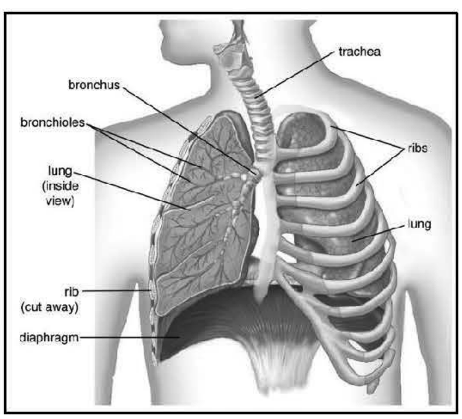
Trachea: The trachea, or windpipe, is composed of smooth muscle with C-shaped rings of cartilage at regular intervals. The cartilaginous rings are incomplete on the posterior surface and give firmness to the wall of the trachea, preventing it from collapsing. The trachea serves as the passage between the larynx and the bronchi.

Anatomy of lower respiratory tract:



Thoracic cavity, also called **chest cavity**, the second largest hollow space of the body. It is enclosed by the ribs, the vertebral column, and the sternum, or breastbone, and is separated from the abdominal cavity (the body's largest hollow space) by a muscular and membranous partition, the diaphragm. It contains the lungs, the middle and lower airways—the tracheobronchial tree—the heart, the vessels transporting blood between the heart and the lungs, the great arteries bringing blood from the heart out into general circulation, and the major veins into which the blood is collected for transport back to the heart. The heart is covered by a fibrous membrane sac called the pericardium that blends with the trunks of the vessels running to and from the heart. The thoracic cavity also contains the esophagus, the channel through which food is passed from the throat to the stomach.

The chest cavity is lined with a serous membrane, which exudes a thin fluid. That portion of the chest membrane is called the parietal pleura. The membrane continues over the lung, where it is called the visceral pleura, and over part of the esophagus, the heart, and the great vessels, as the mediastinal pleura, the mediastinum being the space and the tissues and structures between the two lungs. Because the atmospheric pressure between the parietal pleura and the visceral pleura is less than that of the outer atmosphere, the two surfaces tend to touch, friction between the two during the respiratory movements of the lung being eliminated by the lubricating actions of the serous fluid. The pleural cavity is the space, when it occurs, between the parietal and the visceral pleura.



Lungs: The lower respiratory tract consists of the lungs, which contain the bronchial and alveolar structures needed for gas exchange. The lungs, which is the organ for respiration is a paired cone shaped organs lying in the thoracic cavity separated from each other by the heart and other structures in the mediastinum. Each lung has a base resting on the diaphragm and an apex extending superiorly to a point approximately 2.5 cm superior to the clavicle. It also has a medial surface and with three borders- anterior, posterior, and inferior. The broad coastal surface of the lungs is pressed against the rib cage, while the smaller mediastinal surface faces medially. The lungs receive the bronchus, blood vessels, lymphatic vessels, and nerves through a slit in the mediastinal surface called the helium, and the structures entering the helium constitutes the lungs root.

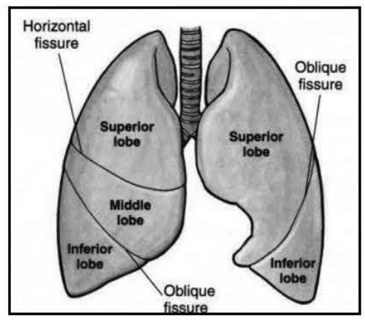
The right lung is larger and weighs more than the left lung. Since the heart tilts to the left, the left lung is smaller than the right and has an indentation called the cardiac impression to accommodate the heart. This indentation shapes the inferior and anterior parts of the superior lobe into a thin tongue-like process called the lingual.

Ventilation requires movement of the walls of the thoracic cage and of its floor, the diaphragm. The effect of these movements is alternately to increase and decrease the capacity of the chest. When the capacity of the chest is increased, air enters through the trachea (inspiration) because of the lowered pressure within and inflates the lungs. When the chest wall and diaphragm return to their previous positions (expiration), the lungs recoil and force the air out through the bronchi and trachea. The inspiratory phase of respiration normally requires energy; the expiratory phase is normally passive.

Pleura: The lungs and wall of the thorax are lined with a serous membrane called the pleura (fig. 5). The visceral pleura covers the lungs; the parietal pleura lines the thorax. The visceral and parietal pleura and the small amount of pleural fluid between these two membranes serve to lubricate the thorax and lungs and permit smooth motion of the lungs within the thoracic cavity with each breath.

Mediastinum: The mediastinum is in the middle of the thorax, between the pleural sacs that contain the two lungs. It extends from the sternum to the vertebral column and contains all the thoracic tissue outside the lungs.

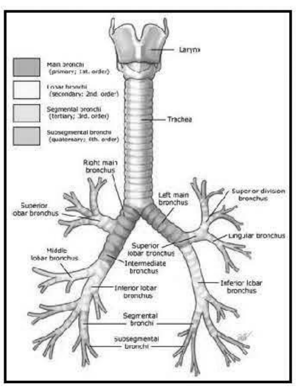
Lobes and Fissures of the Lung:



Each lung is divided into lobes by fissures.

- Both lungs have oblique fissure, and the right is further divided by a transverse fissure. The oblique fissure in the left lung separates the superior and the inferior lobe. The oblique and horizontal fissure divides the lungs into superior, middle, and inferior lobes. Thus, the right lung has three lobes while the left has two.
- Each lobe is supplied by a lobar bronchus. The lobes are subdivided by bronchopulmonary segments which are supplied by the segmental bronchi.

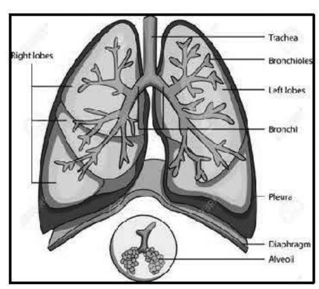
Tracheobronchial Tree:



All the respiratory passages from the trachea to the respiratory bronchioles are called the tracheobronchial tree. The trachea divides at the sternal angle into right and left primary bronchus which goes into the right and left lungs. Each bronchus enters the lung at a notch called the **hilum**. Blood vessels and nerves also connect with the lungs here and together with the bronchus forms a region called the root of the lungs.

The right main bronchus is larger in diameter and more vertical making it directly in line with the trachea than the left main bronchus. Thus, swallowed objects that accidentally enter the lower respiratory tract are most likely to become lodged in the right main bronchus.

The main bronchi divide into lobar or secondary bronchi within each lung. Two lobar bronchi exist in the left lung, and three exist in the right lung. The lobar bronchi, in turn give rise to segmental or tertiary bronchi. The tertiary bronchi supply the bronchopulmonary segments.



Bronchi and Bronchioles: There are several divisions of the bronchi within each lobe of the lung. First are the lobar bronchi (three in the right lung and two in the left lung). Lobar bronchi divide into segmental bronchi (10 on the right and 8 on the left), which are the structures identified when choosing the most effective postural drainage position for a given patient. Segmental bronchi then divide into subsegmental bronchi. These bronchi are surrounded by connective tissue that contains arteries, lymphatics, and nerves. The subsegmental bronchi then branch into bronchioles, which have no cartilage in their walls. Their patency depends entirely on the elastic recoil of the surrounding smooth muscle and on the alveolar pressure.

The bronchioles contain submucosal glands, which produce mucus that covers the inside lining of the airways. The bronchi and bronchioles are lined also with cells that have surfaces covered with cilia. These cilia create a constant whipping motion that propels mucus and foreign substances away from the lung toward the larynx. The bronchioles then branch into terminal bronchioles, which do not have mucous glands or cilia. Terminal bronchioles then become respiratory bronchioles, which are the transitional passageways between the conducting airways and the gas exchange airways. Up to this point, the conducting airways contain about 150 mL of air in the tracheobronchial tree that does not participate in gas exchange. This is known as physiologic dead space. The respiratory bronchioles then lead into alveolar ducts and alveolar sacs and then alveoli. Oxygen and carbon dioxide exchange takes place in the alveoli.

Alveoli: The lung is made up of about 300 million alveoli, which are arranged in clusters of 15 to 20. These alveoli are so numerous that if their surfaces were united to form one sheet, it would cover 70 square meters—the size of a tennis court. There are three types of alveolar cells. Type I alveolar cells are epithelial cells that form the alveolar walls. Type II alveolar cells are metabolically active. These cells secrete surfactant, a phospholipid that lines the inner surface and prevents alveolar collapse. Type III alveolar cell macrophages are large phagocytic cells that ingest foreign matter (e.g., mucus, bacteria) and act as an important defense mechanism.