PRACTICAL POINTS in PULMONARY DISEASES

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PREFACE

My colleagues and I have written this book to serve as a practical guide for all students of medicine, regardless of age, in order to provide a framework for the logical work-up and management of pulmonary problems encountered in ordinary practice. We have attempted to avoid the "faddist" approach to problems by relating, wherever possible, basic knowledge to the solution of clinical problems. Much of the material is based on the senior author's long experience in teaching undergraduate and graduate students the basis for understanding pulmonary disease. In addition to this teaching material, we have reviewed standard literary sources in radiology and pulmonary disease published within the past five years.

The senior author and editor accepts all responsibility for the contents, and thanks his colleagues for their assistance. He notes with special pride, the constant encouragement of his wife.

D.J.S.

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CONTENTS

CHAPTER I

PRACTICAL ASPECTS OF ANATOMY; TOPOGRAPHICAL ANATOMY OF THE LUNG

The lung is structured with blood vessels, tissue, nerves and muscles, some unique to the lung, for the functions of performing gas exchange and filtering air. Respiration is accomplished with an active inspiratory phase and a passive expiratory phase.

THORAX

The thoracic cage has rigidity which affords protection to the viscera and flexibility that allows change in volume. The ribs are landmarks for fissure lines separating lung lobes. Thus, the oblique fissure separating the upper and lower lobes meets the posterior chest wall at the level of the fifth rib. The horizontal fissure separating the upper and right middle lobe is at the level of the fourth anterior rib (Fig. 1. 1). During normal breathing the diaphragm levels at the eighth to tenth ribs posteriorly and fifth to seventh ribs anteriorly. The muscular intercostal space can be penetrated for diagnostic procedures such as thoracentesis, percutaneous needle lung aspiration, percutaneous lung biopsy and pleural biopsy.

MUSCLES OF RESPIRATION

The primary muscle of respiration is the diaphragm which is innovated by C3, 4, 5. Other muscles of respiration are the intercostals and abdominals. At the end of an inspiration of a normal person, two to three centimeters of positive pressure develop in the abdominal space as a result of the descent of the diaphragms causing slight ballooning of the abdominal wall. The accessory muscles come into play when other muscles are functioning at capacity or their capacity is limited. They are used by the normal person during exercise and during regular breathing in patients with emphysema, arthritis of the thoracic cage and other lung diseases.

TRACHEA

The trachea is composed of cartilagenous rings which are incomplete posteriorly but joined by a flexible membrane. The rings are connected vertically by a tough, fibrous and flexible membrane. This membrane can be penetrated for transtracheal needle aspiration preferably between the thyroid cartilage and the first tracheal ring, cricothyroid membrane (Chapter IV, Fig. 4. 2). Emergency tracheostomies may be done at this intercartilagenous space or the one below it. Permanent tracheostomy, is ordinarily performed between

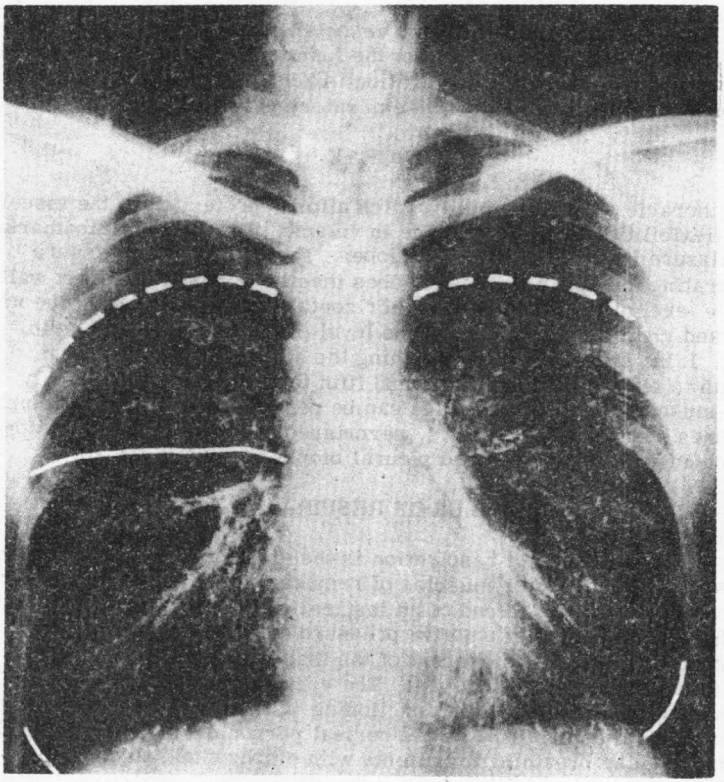

FIG. 1.1A: Posterior-anterior bronchogram view showing in solid white lines the horizontal fissure separating the right upper and middle lobes and the curved anterior basal portion of the oblique fissures. The dashed lines represent the junction of the oblique fissures posteriorly at the level of the fifth rib.

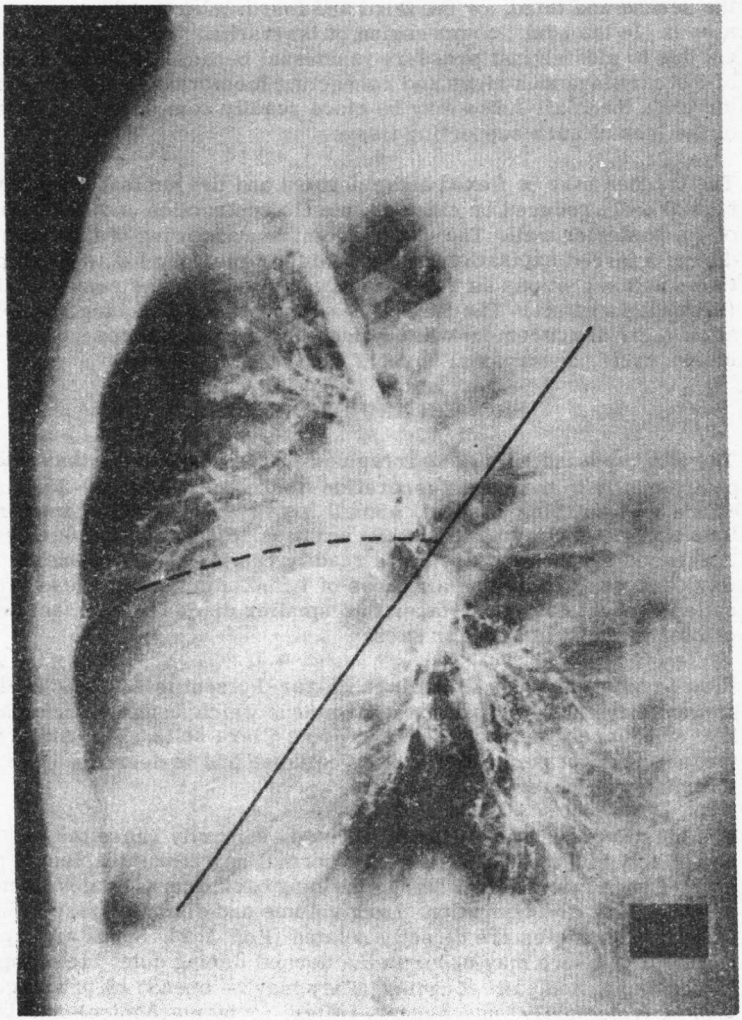

FIG. 1.1B: Left lateral bronchogram view showing by a solid black line the oblique fissure (right and left lung) and by a dashed line the horizontal fissure of the right lung.

the second and third, or the third and fourth intercartilagenous spaces. In the adult, compression of the trachea and mainstem bronchi due to mediastinal pressure is unusual because of the strength of the cartilagenous rings and connecting membranes. Whereas in the child these air tubes may be more readily compressed because of the lack of such supporting tissue.

The trachea may be flexed and elongated and the luminal size may be markedly reduced by circular muscle contraction and invagination of the posterior wall. The marked luminal narrowing of the trachea during a forced expiration or cough aids in clearing the lungs of particles and secretions as they are directed towards the center of flow (Bernoulli's effect). The flexibility of the trachea and large bronchi allow their displacement without destruction from encroaching tumors, cysts, aneurysmal vessels, and other growths.

BRONCHI AND BRONCHIOLES

The adult (not the child) has irregular plates of cartilage that extend peripherially to the eighth generation (there being about 20-25 generations of branching bronchi). Small airways of 2 mm. diameter or less begin at the fourth to sixth generation. Small airways lack cartilagenous support and are more readily compressed by dynamic airway changes. Conducting air tubes of 1 mm. diameter or less are called bronchioles; these taper into smaller diameter terminal bronchioles that end in alveolar sacs.

Flow in small airways is laminar (Hager-Poiseuille's Law). These airways have at least two layers of mucus which contain surfactant-like substances, possibly secreted from Clara cells. This material tends to prevent peripheral airway collapse and is decreased in inflammatory disease.

The elastic properties of the lung would ordinarily cause the lung to completely collapse were it not for normal negative intrapleural pressure. Lung elastic recoil brings the lung back to end tidal volume position after an inspiration. Lung volume and diameter size of bronchi and bronchioles are directly related (Fig. 1. 2). Small airway narrowing or closure may occur in the normal during quiet breathing, forced expiration, and coughing. They may be opened by yawning, sighing (voluntarily, unconscious reflex, or by mechanical ventilation) and deep breathing. Small airways may be abnormally narrowed or closed by disease such as atelectasis, bronchitis, obesity and asthma. Bronchodilator drugs may be effective in dilating airways of the normal but more so of the patient with disease causing bronchospasm.

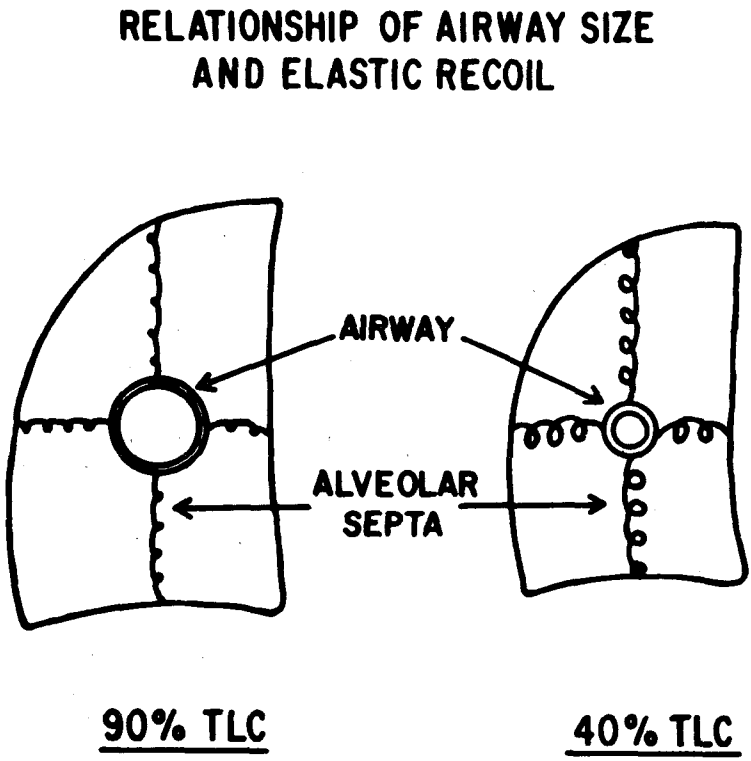

FIG. 1. 2: Lung volume, airway size, and elastic recoil are related. As lung volume and airway size decreases there is an increase in elastic recoil.

ALVEOLI

The alveoli are about 0. 1 to 0. 2 mm. in diameter and vary in shape. This is where pulmonary gas exchange occurs and is known as the functional unit of the lung. The alveoli make up more than 50% of the lung by volume. In both lungs there are about 300 million alveoli. Were the alveolar surface to be spread flat it would be equal to the area of a tennis court.

COLLATERAL VENTILATION

Pores of Köhn are holes in the alveolar walls allowing communication between air sacs other than via air tubes. These pores may prevent alveolar collapse by ventilating an alveolar air sac via its adjacent air space when its air tube is obstructed. In partial airway obstruction collateral ventilation may lessen atelectasis. However, edema or infection may also spread thru the pores of Köhn.

PULMONARY CIRCULATION

PULMONARY ARTERIES: The muscular coat of arteries lessen as they taper in size to arterioles. The radiographic appearance of the large pulmonary artery branches arising from the hilum may be confused with enlarged lymph nodes, tumors or other structures. Chest fluoroscopy utilizing the Valsalva and Mueller manuevers (see Chapter XI, Mediastinal Tumors) and pulmonary angiography may be needed to make these distinctions.

PULMONARY CAPILLARIES: The lungs contain about 80 square meters of capillary network in alveolar walls resulting in a large surface for gas exchange. By proximity their function is affected by diseases of the alveolar wall.

PULMONARY VEINS: Pulmonary venules drain into segmental veins that enlarge and join other branches and end as four large veins that enter the left atrium. The chest radiograph may show dilated central pulmonary veins in mitral stenosis and other conditions which cause pulmonary venous hypertension. Vascular anatomy is best visualized by angiography and sometimes by tomography.

BRONCHIAL CIRCULATION

This arterial system supplies oxygenated blood to the airways, pleura and walls of the pulmonary arteries and veins. The bronchial arteries arise from the aorta at the level of the first rib, one supplies the right lung and two go to the left lung. Bronchial venous blood drains into the azygous vein which empties into the superior vena cava. Twenty-five percent of the bronchial arterial blood drains into the bronchial venous system, while the remaining seventy-five percent empties into

the pulmonary venous system via tiny anamatosing vessels. When there is pulmonary hypertension the shunting may be from the pulmonary system to the bronchial system.

The bronchial circulation normally constitutes less than 1% of the cardiac output. However, in lung disease where the pulmonary circulation is considerably compromised, the bronchial circulation increases to as much as 10-30% of the cardiac output. Dilated bronchial vessels resulting from increased flow may compress air tubes such as bronchi and trachea. In children this may result in wheezing or compromised airway function.

LYMPHATIC CIRCULATION

Lymph capillaries are beneath the pleura and around the bronchi. They empty into vessels that traverse with bronchial veins but in a more complex network. Valves prevent backflow. Lymph drains into nodes surrounding the bronchi and trachea and is then carried via channels to the thoracic duct and then to the venous circulation. The lymphatic system may be visualized by the radiograph when dilated with increased lymph flow as occurs in congestive heart failure, from lymphatic obstruction of leukemia or by perilymphatic failure. This may be observed on radiographs seen as the Kerley "B" line (Fig. 1. 3), and more centrally as a larger 2 cm. or more curvilinear Kerley "A" line. Internal mammary lymph node or mediastinal lymph node biopsies may reflect diseases of the lymphatic system of the lung, and especially the pleura, as in diseases due to malignancy or granuloma.

CELL POPULATION

CILIATED EPITHELIUM: This unique cell has about 200 cilia of 3-6 micra in length. The cilia beat with whip-like action with a frequency of about 1,000 per minute. Organized waves of contraction pass rhythmically from cell to cell. The cilia are immersed within a thin fluid layer and are covered by a more viscous layer of mucus secreted from goblet cells. The mucous sheet moves upward with the flow of about 1. 5 cm. per minute. Ciliary function is impaired by inflammatory disease, inhaled noxious agents, cigarette smoke, hypoxemia and drying of secretions.

TRACHEA AND BRONCHI: The trachea is lines with such ciliated epithelium and goblet cells. The bronchi also have ciliated epithelial cells and goblet cells, the latter becoming more numerous peripherally.

FIG. 1.3: Section of posterior-anterior chest radiograph showing the left basal lung field area. The arrow points to one of several Kerley "B" lines.

BRONCHIOLES: The bronchioles have columnar or cuboidal epithelial cells as a single layer with microvilli but no cilia. Goblet cells are occasionally found in the normal but may become more numerous in inflammatory diseases such as chronic bronchitis and asthma. During disease, their ability to secrete mucus is enhanced.

Clara cells are interspersed among bronchial epithelial cells and are suspected of secreting a surfactant-like substance that may add stability to airways and lessen small airway collapse.

CELLS OF ALVEOLI: The alveoli are completely lined by a layer of cells which are of two types:

Type I Pneumocyte: This is a flat squamous epithelial cell that covers most of the surface of the alveolus. Light microscopy identifies only the nuclei, but not the extensive flattened processes of these cells.

Type II Pneumocyte: This is a cuboidal cell with granular cytoplasm. They are less numerous and considered to be the source of the surface active phospholipid material known as surfactant which helps to maintain normal alveolar dimension.

PHAGOCYTIC CELLS: These have ameboid porperties and are scattered throughout lung tissue. They are usually found between capillaries but may be free in the alveolar space. They are of two types:

a) Vacuolated cells with less tendency to phagocytosis of particulate matter.
b) Nonvacuolated alveolar cells are the principal phagocytes of the lung.

CAPILLARY ENDOTHELIAL CELLS: These are the predominant cells of respiratory tissue. They are supported by a thin reticulin membrane, the so called capillary membrane. This is the most sensitive cell to injury from chemicals, organic agents and other causes.

MIGRATORY BLOOD CELLS: These are mostly leukocytes that penetrate the capillary walls by diapedesis and enter the interstitial tissue. Such cells are the chief component of purulent secretions from infected lung tissue.

LUNG EMBRYOLOGY

The bronchial tree is developed by the 16th fetal week. Alveolar development continues after birth until about 8 years of age. Blood vessels increase in number and dimensions as new alveoli form. This process continues until lung maturation is complete.

CHAPTER II

A GUIDE TO HISTORY & PHYSICAL EXAMINATION

The assessment of the patient suspected of respiratory disease is initiated with a thorough history and complete physical examination. During history taking the student or physician begins to obtain an impression of possible disease entities, and some type of differential diagnosis is developed which is expanded upon with the findings of the chest physical examination.

The following sections are intended to offer appropriate questions of the pulmonary history that consider differential diagnostic features as well as techniques of the chest physical examination.

THE PULMONARY HISTORY

SHORTNESS OF BREATH OR DYSPNEA: This may be defined as an awareness of increased respiratory effort which is unpleasant and recognized as inappropriate. It may simply be a feeling of disordered or inadequate breathing.

The evaluation of dyspnea is better understood by questioning the patient concerning shortness of breath in comparison with most people of his age, when hurrying on level ground or walking up a slight hill, on exertion now compared to two years ago, when walking about the house and undertaking light activity such as washing, showering, dressing and eating, and when at rest.

The dyspnea of chronic obstructive lung disorders is progressive over many years. Associated symptoms such as cough and wheezing most often occur on arising, lessening when the patient clears his chest of accumulated secretions.

COUGH AND SPUTUM PRODUCTION: Coughing is a difficult symptom to evaluate since everyone coughs on occasion. It is important to quantify the complaint. Questioning the patient for cough symptoms should include the time of day that the cough usually occurs, are there months in which the cough occurs on most days, the duration of the cough, the effect of weather and seasons upon the cough, the comparison of a present cough with that of two years ago.

Questioning the patient for sputum production should include information such as the production of sputum or mucus from the chest when the patient does not have a cold, the time of day that sputum production usually occurs, months in which there is sputum production, the