PATHOPHYSIOLOGY OF THE RESPIRATORY SYSTEM & COPD

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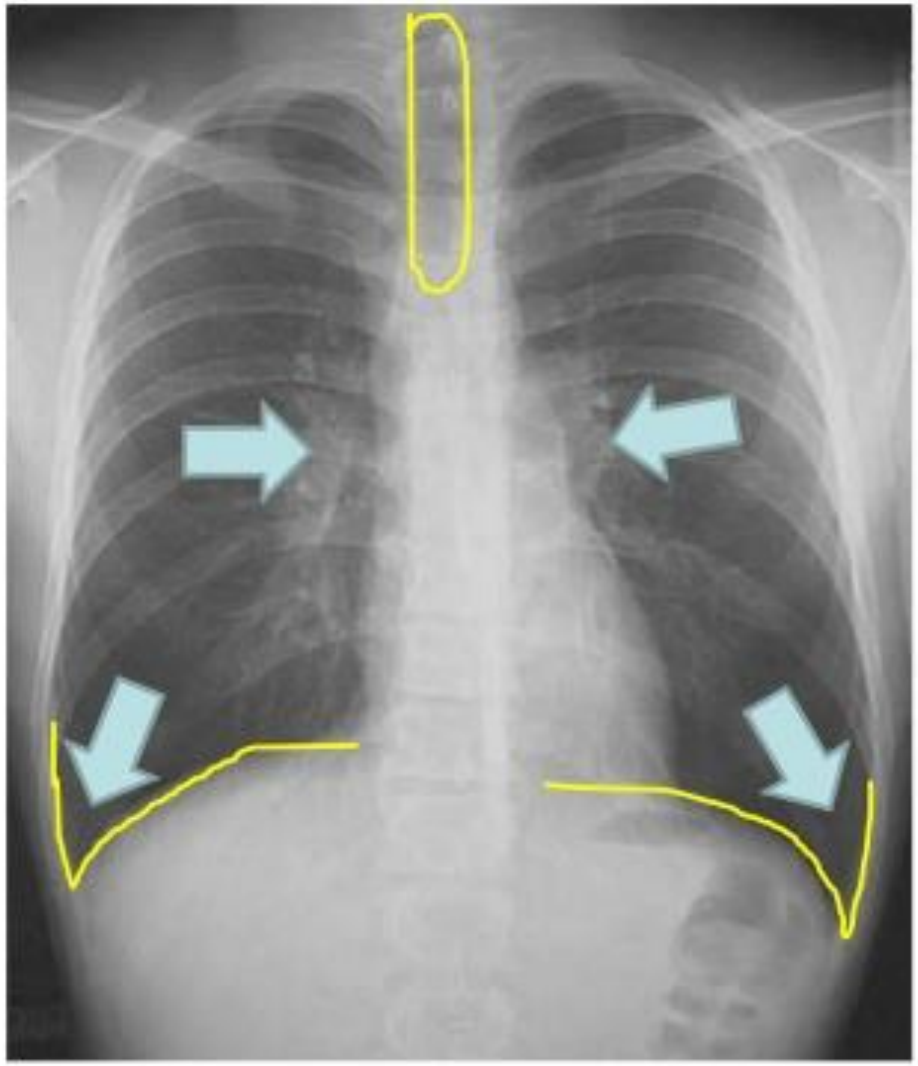
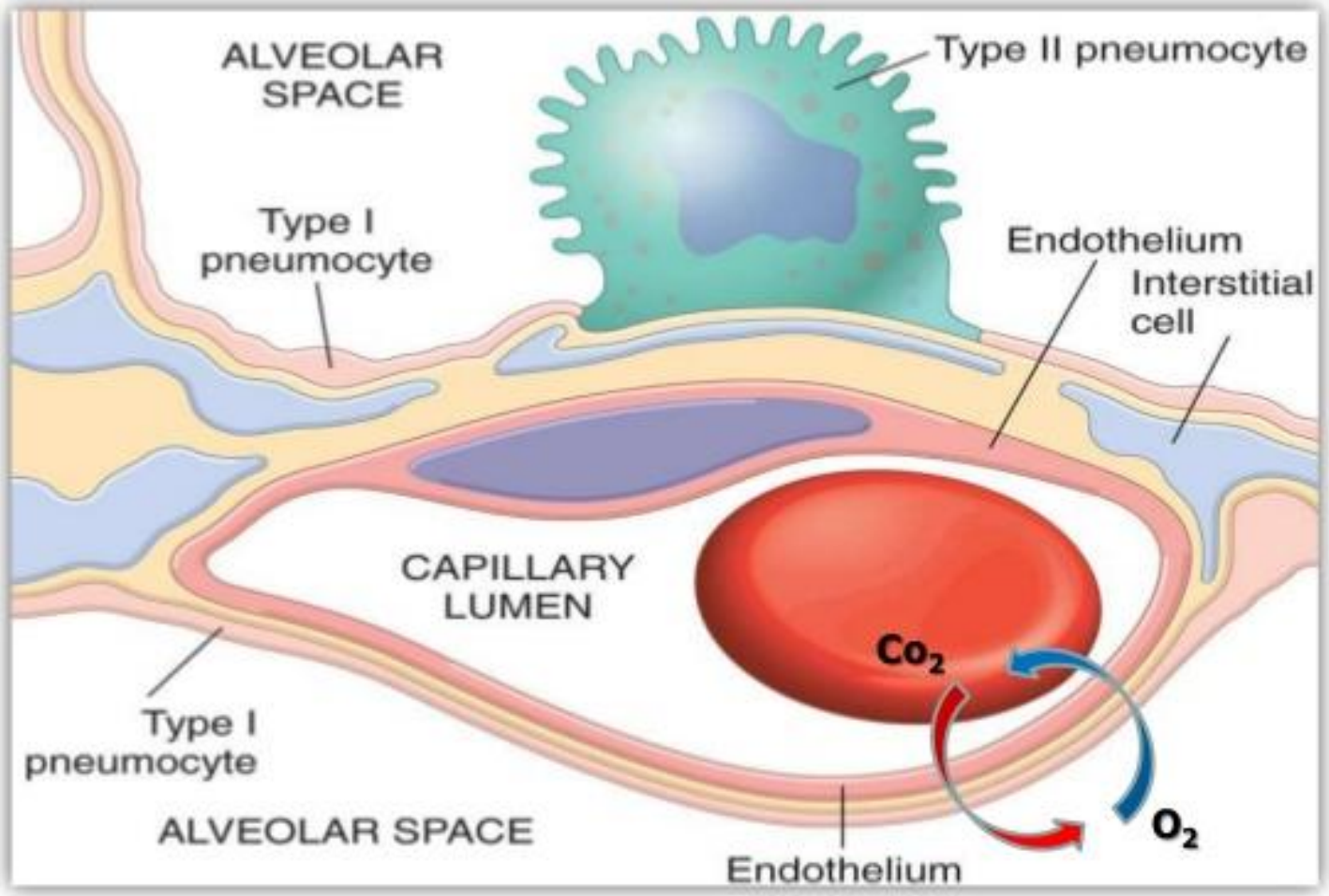
Anatomy and Physiology

- Chest, lungs, and conducting airways
- Two parts:
  - Upper respiratory system consists of nose, mouth, sinuses, pharynx, and larynx
  - Lower respiratory system consists of trachea, bronchi, and bronchioles and Alveoli - place of carbon dioxide-oxygen exchange
- Inhalation and Exhalation - air movement in and out of lungs

Normal Lung



Alveolar Gas Exchange:



Common Signs and Symptoms

Dyspnea / SOB

Orthopnea

Apnea

Tachypnea

Wheezing, Stridor, Rales, Rhonchi

Coughing

Sputum/mucus

Hemoptysis

Nasal Discharge

Chest Pain

Hypoxemia

Barrel chest

Cyanosis

Clubbing

Hiccups

Diagnostic Tests

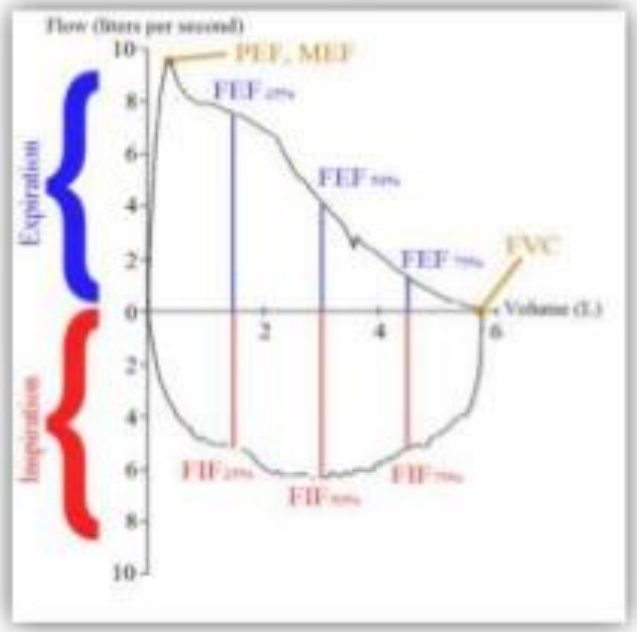
- Auscultation: breathing quality and rate
  - Tachypnea - rapid respirations
  - Rales - musical sounds heard on inhalation and often called “crackles”
  - Rhonchi - rattling sounds in bronchi due to obstruction

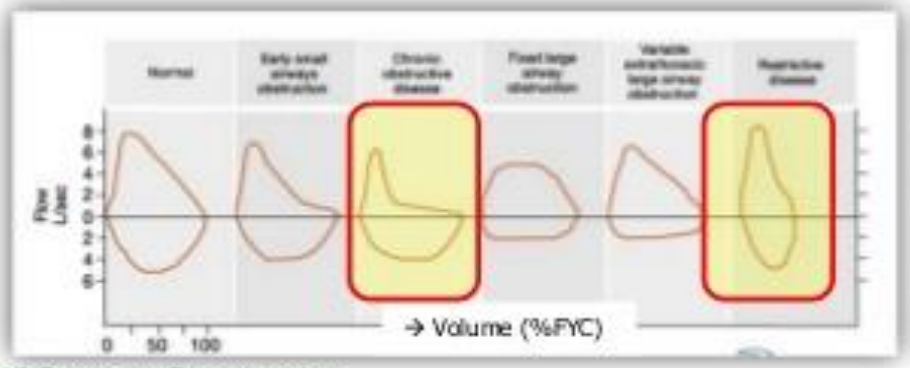
- Chest X-ray
- Sputum culture
- Tissue biopsy
- Bronchoscopy
- Arterial blood gases
- Pulmonary function tests

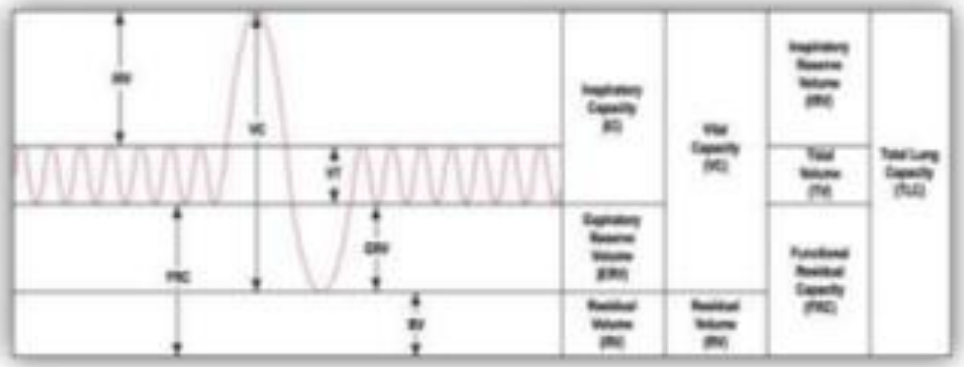
Lung Function Testing:

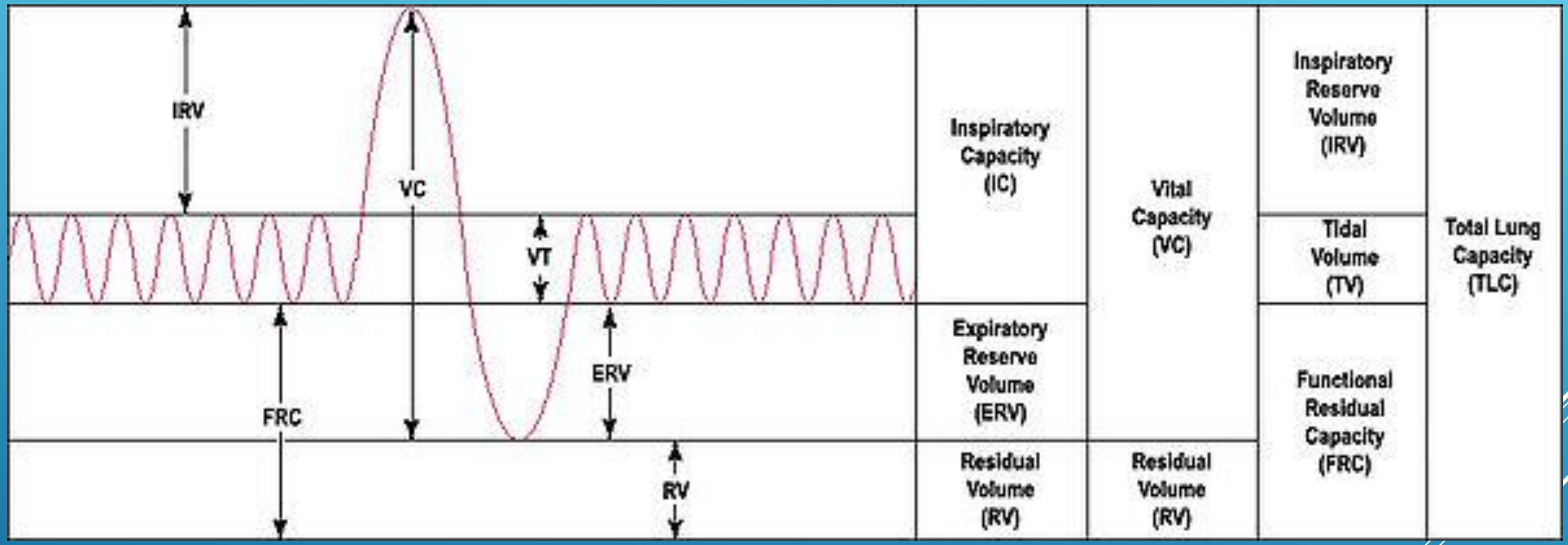
- Total Lung Capacity (TLC) 6L male/4.7L fem.
- Tidal Volume (TV) – 500 / 390ml
- Forced Vital Capacity (FVC) 4.8L / 3.7L
- Forced Expiratory Volume in 1 Sec - **FEV1**
- FEV1/FVC (FEV1%) - 75–80% normal.

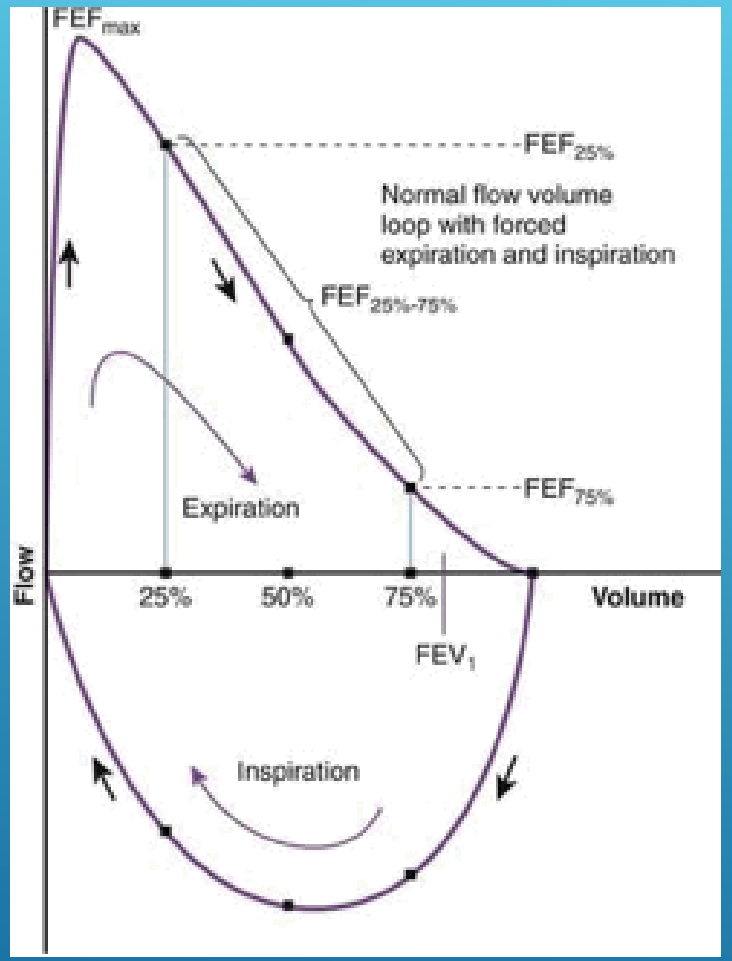
1. In Obstructive diseases (COPD) FEV1 low & FVC high. So FEV1/FVC is low (<80%).
2. In Restrictive diseases (fibrosis) the FEV1 and FVC are both low proportionally and the FEV1/FVC value normal or high.

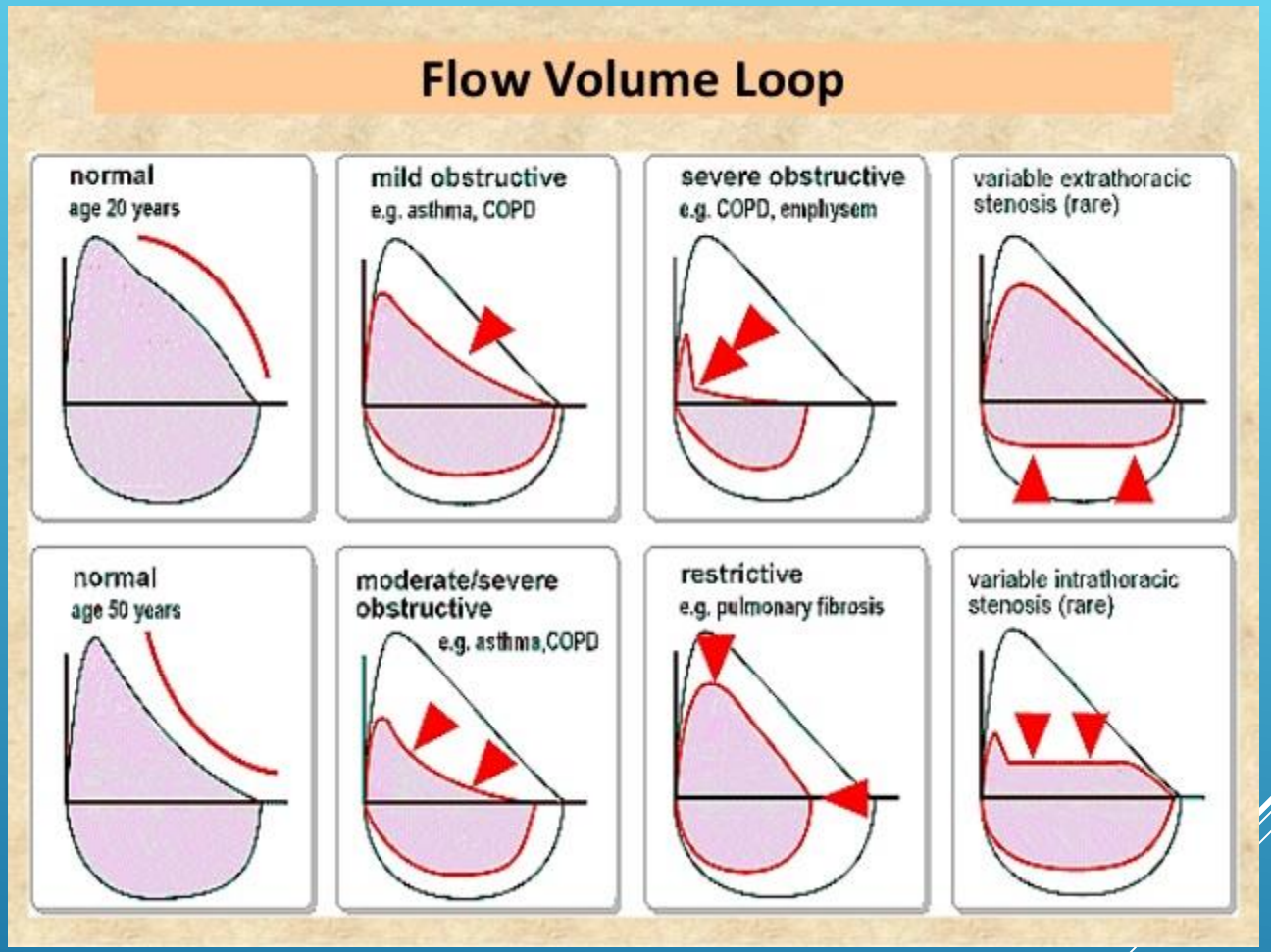







IRV
VC
VT
ERV
FRC
RV
Inspiratory Capacity (IC)
Expiratory Reserve Volume (ERV)
Residual Volume (RV)
Vital Capacity (VC)
Residual Volume (RV)
Inspiratory Reserve Volume (IRV)
Tidal Volume (TV)
Functional Residual Capacity (FRC)
Total Lung Capacity (TLC)


FEF$_{max}$
FEF$_{25\%}$
Normal flow volume loop with forced expiration and inspiration
FEF$_{25\%-75\%}$
Expiration
FEF$_{75\%}$
Flow
25%
50%
75%
Volume
FEV$_1$
Inspiration


Flow Volume Loop
normal
age 20 years
mild obstructive
e.g. asthma, COPD
severe obstructive
e.g. COPD, emphysem
variable extrathoracic stenosis (rare)
normal
age 50 years
moderate/severe obstructive
e.g. asthma,COPD
restrictive
e.g. pulmonary fibrosis
variable intrathoracic stenosis (rare)

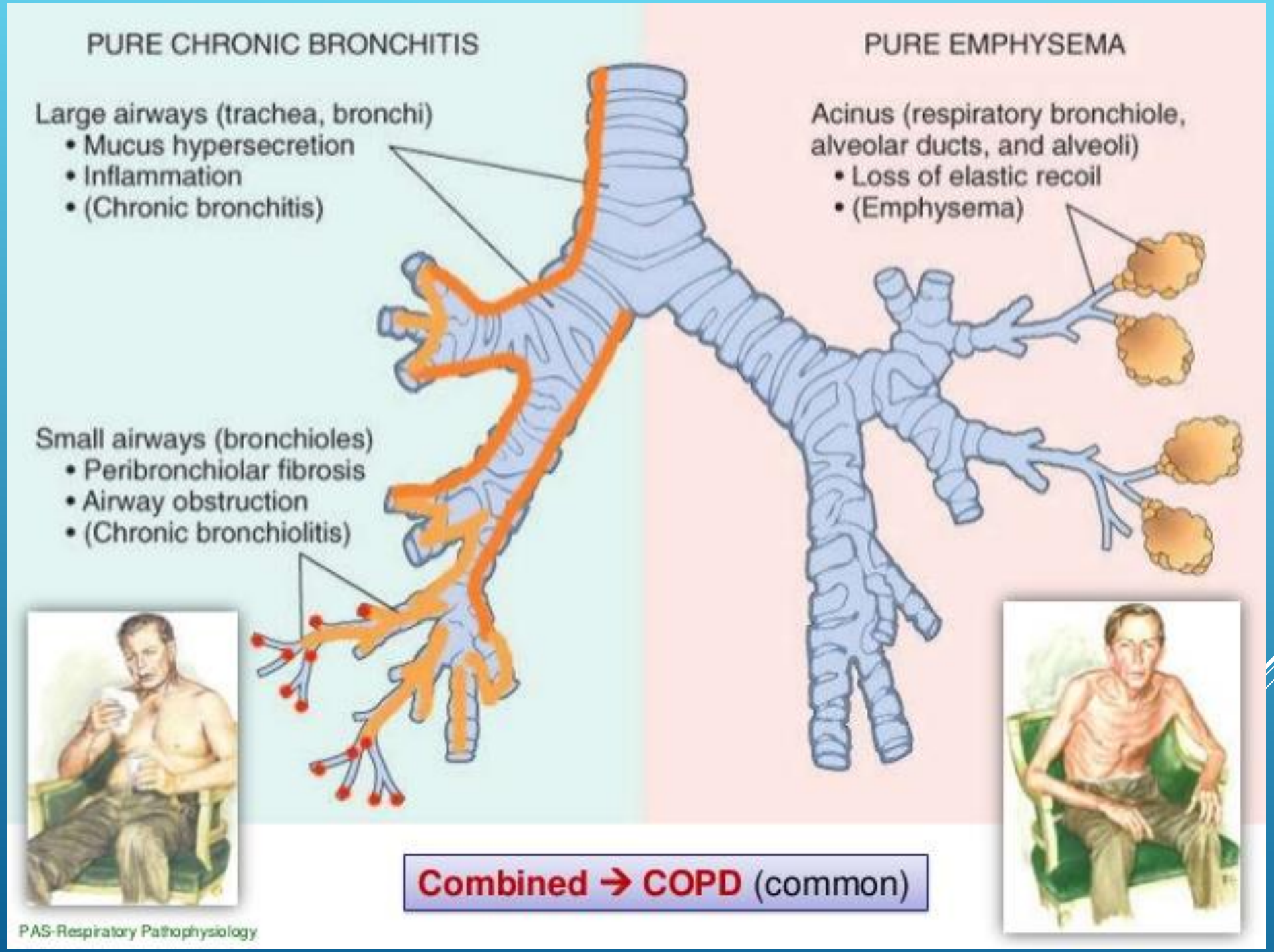
Category	Examples
Obstructive lung disease	Asthma
	Chronic obstructive pulmonary disease (COPD)
	Bronchiectasis
	Bronchiolitis
Restrictive pathophysiology—parenchymal disease	Idiopathic pulmonary fibrosis (IPF)
	Asbestosis
	Desquamative interstitial pneumonitis (DIP)
	Sarcoidosis
Restrictive pathophysiology—neuromuscular weakness	Amyotrophic lateral sclerosis (ALS)
	Guillain-Barré syndrome
Restrictive pathophysiology—chest wall/pleural disease	Kyphoscoliosis
	Ankylosing spondylitis
	Chronic pleural effusions
Pulmonary vascular disease	Pulmonary embolism
	Pulmonary arterial hypertension (PAH)
Malignancy	Bronchogenic carcinoma (non-small-cell and small-cell)
	Metastatic disease
Infectious diseases	Pneumonia
	Bronchitis
	Tracheitis

Obstructive Airway Disease:

- Localized: Foreign body, aspiration, tumor..
- Diffuse – Distal airway diseases
  - Transient reversible spasm - Asthma
  - Chronic irreversible permanent – COPD.

COPD

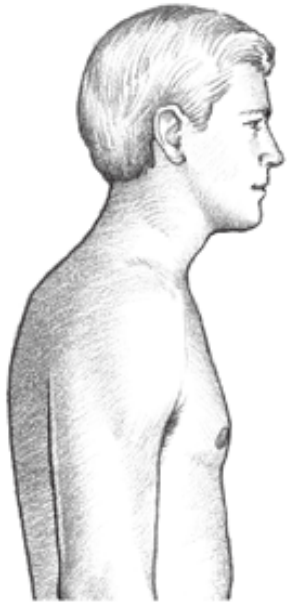
- **persistent respiratory symptoms and airflow limitation that is not fully reversible**
- ***COPD includes:***
  - **emphysema, an anatomically defined condition characterized by destruction of the lung alveoli with air space enlargement**
  - **Chronic bronchitis, a clinically defined condition with chronic cough and phlegm;**
  - **small airway disease, a condition in which small bronchioles are narrowed and reduced in number.**


PURE CHRONIC BRONCHITIS
PURE EMPHYSEMA
Large airways (trachea, bronchi)
• Mucus hypersecretion
• Inflammation
• (Chronic bronchitis)
Acinus (respiratory bronchiole, alveolar ducts, and alveoli)
• Loss of elastic recoil
• (Emphysema)
Small airways (bronchioles)
• Peribronchiolar fibrosis
• Airway obstruction
• (Chronic bronchiolitis)
Combined → COPD (common)
PAS-Respiratory Pathophysiology

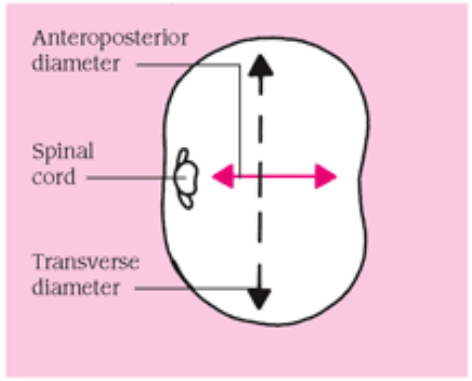
Recognizing barrel chest

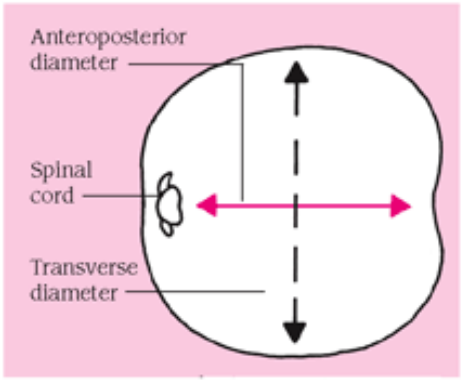
In a normal adult chest, the ratio of anteroposterior to transverse (or lateral) diameter is 1:2. In patients with barrel chest, this ratio approaches 1:1 as the anteroposterior diameter enlarges.

NORMAL CHEST



BARREL CHEST





WHAT HAPPENS IN COPD?

- Lung disease in which the lungs are damaged
- Typically occurs in smokers, but may happen with other environmental exposures and hereditary conditions
- Breathing tubes that carry air in and out of the lungs are obstructed
- In COPD air sacs lose their elasticity and so they collapse or don't inflate properly
- In COPD the breathing tubes are blocked with mucous and become swollen so air cannot move in and out

SIGNS AND SYMPTOMS

- Wheezing
- Coughing
- Sputum production
- Shortness of breath
- Chest tightness

DIAGNOSIS

- Clinical symptoms
- Chest x-ray
- Lung function tests

Laboratory findings:

- Hallmark of COPD → airflow Obstruction
- PFT → ↓ FEV_1 , FEV_1 / FVC.
- Lung volume ↑ →

I. total lung capacity

II. Functional residual capacity

III. Residual volume.

GOLD stage	Severity	Symptom	PTF
0	At Risk	Chronic cough+ sputum	Normal
I	Mild	± Chronic cough+ sputum	$FEV_1/FVC<70\%$, $FEV_1>=80\%$
II	Moderate	± Chronic cough+ sputum	$FEV_1/FVC<70\%$, $50\%<=FEV_1<80\%$
III	Severe	± Chronic cough+ sputum	$FEV_1/FVC<70\%$, $30\%<=FEV_1<50\%$
IV	Very Severe	± Chronic cough+ sputum	$FEV_1/FVC<70\%$, $FEV_1<30\%$ Or $FEV_1<50\%$ with respiratory failure or right heart failure

ABG

- Hypoxemia
  I. Resting
  II. Exertional
- PH
- PCO2→ Pco2>45 → ventilatory failure
- **Chronic hypoxemia**
  I. Elevated HCT
  II. Right ventricular hypertrophy

Treatment:

Stable phase:

I. Smoking cessation

II. Oxygen therapy

III. Lung volume reduction surgery