Using and Interpreting Carbon Monoxide Diffusing Capacity (DLCO) Correctly

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Objectives for Diffusing Capacity

- What is diffusing capacity and why do we do this test?
- Diffusing capacity physiology
- Diffusing capacity test performance
- Variability in diffusing capacity measurements
- Diffusing capacity interpretation
- Clinical utility of diffusing capacity

Animated DLCO test

Special thanks to nddmed

https://www.youtube.com/channel/UC94tvJZBjJVjqRxcpovAA-A

Why do we need this test

- To evaluate respiratory symptoms
- To determine severity of impairment in patients with known respiratory disease
- To follow the course of disease in a patient, including the response to therapy
- To screen for subclinical disease

DLCO — Indications

- Differentiate asthma from emphysema
- Anemia
- Sarcoidosis
- Alveolar hemorrhage
- Evaluation and severity of restrictive lung disease
- Pulmonary fibrosis
- Early stages of pulmonary hypertension
- Interstitial lung disease
- Disability/impairment evaluations for ILD or COPD
- Pulmonary vascular disease
- COPD

What is diffusing capacity?

Measure's ability of lungs to transport inhaled gas from alveoli to pulmonary capillaries

Carbon monoxide is carrier gas because of binding affinity to hemoglobin (0.3%)

200-250 greater affinity than oxygen

Inert gas such as 10% helium

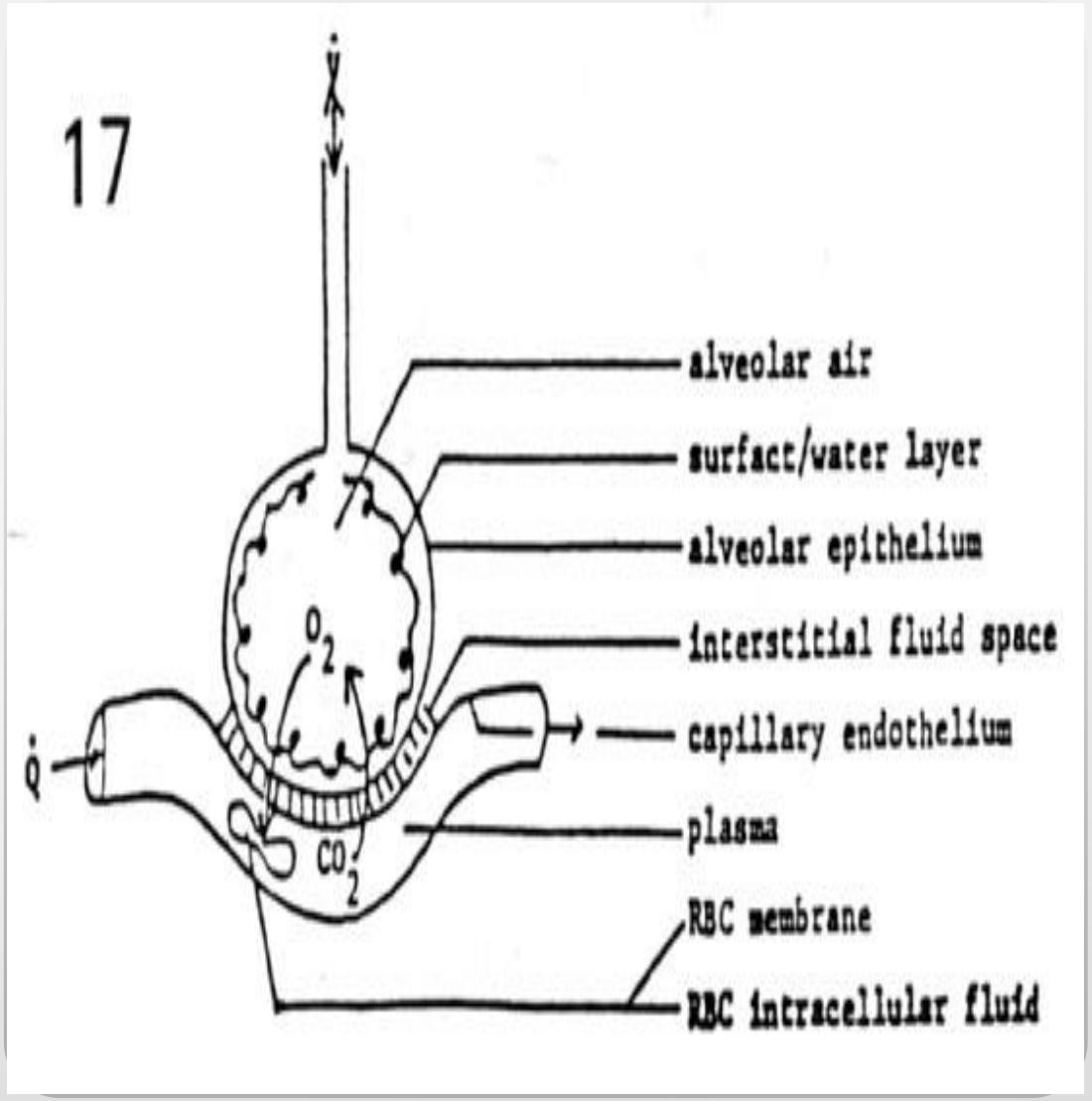
Used to diagnose various pulmonary diseases

Depends on:

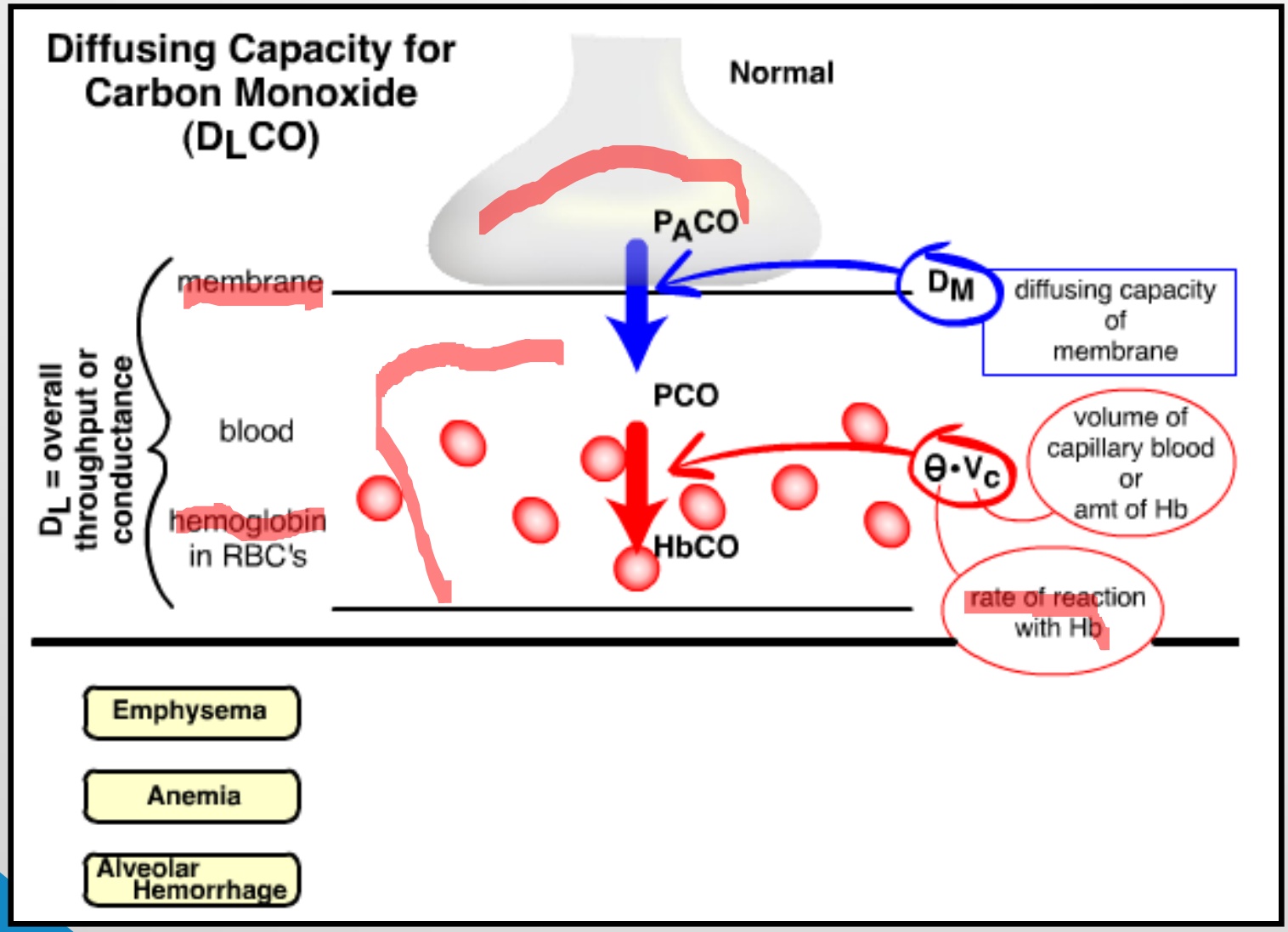
- alveolar—capillary membrane
- hemoglobin concentration
- cardiac output

Diffusing capacity pathway

- Pathway for diffusion of CO and O_2 involves diffusion across the
  - Alveolar capillary membrane
  - Alveolar cell basement membrane
  - Potential interstitial space
  - Capillary endothelium
  - Across a thin layer of plasma
  - Across a red blood cell membrane
  - Red blood cell until they bind with hemoglobin.



D_LCO-Nice picture!



Diffusing capacity physiology

- Gas crosses the alveolar-capillary membrane
- CO has greater affinity to binding to hemoglobin than oxygen (200-250)
  - Greater number of CO binding sites on hemoglobin molecule
  - CO so far is best gas for test

- WARNING! FOR GEEKS ONLY- Fick's law describes the diffusion of a gas through tissue
  - Amount of gas transferred across a membrane is directly proportional to
    - Tissue surface area
    - Diffusion constant
  - Difference in gas partial pressure and is inversely proportional to the tissue thickness.
  - Diffusion constant is proportional to the solubility of a gas and is inversely proportional to the square root of the molecular weight of the gas.

Grades of severity in *DLCO reduction*

- Normal DLCO: >75% of predicted, up to 140%
- Mild: 60% to LLN (lower limit of normal)
- Moderate: 40% to 60%
- Severe: <40% LLN: lower limit of normal

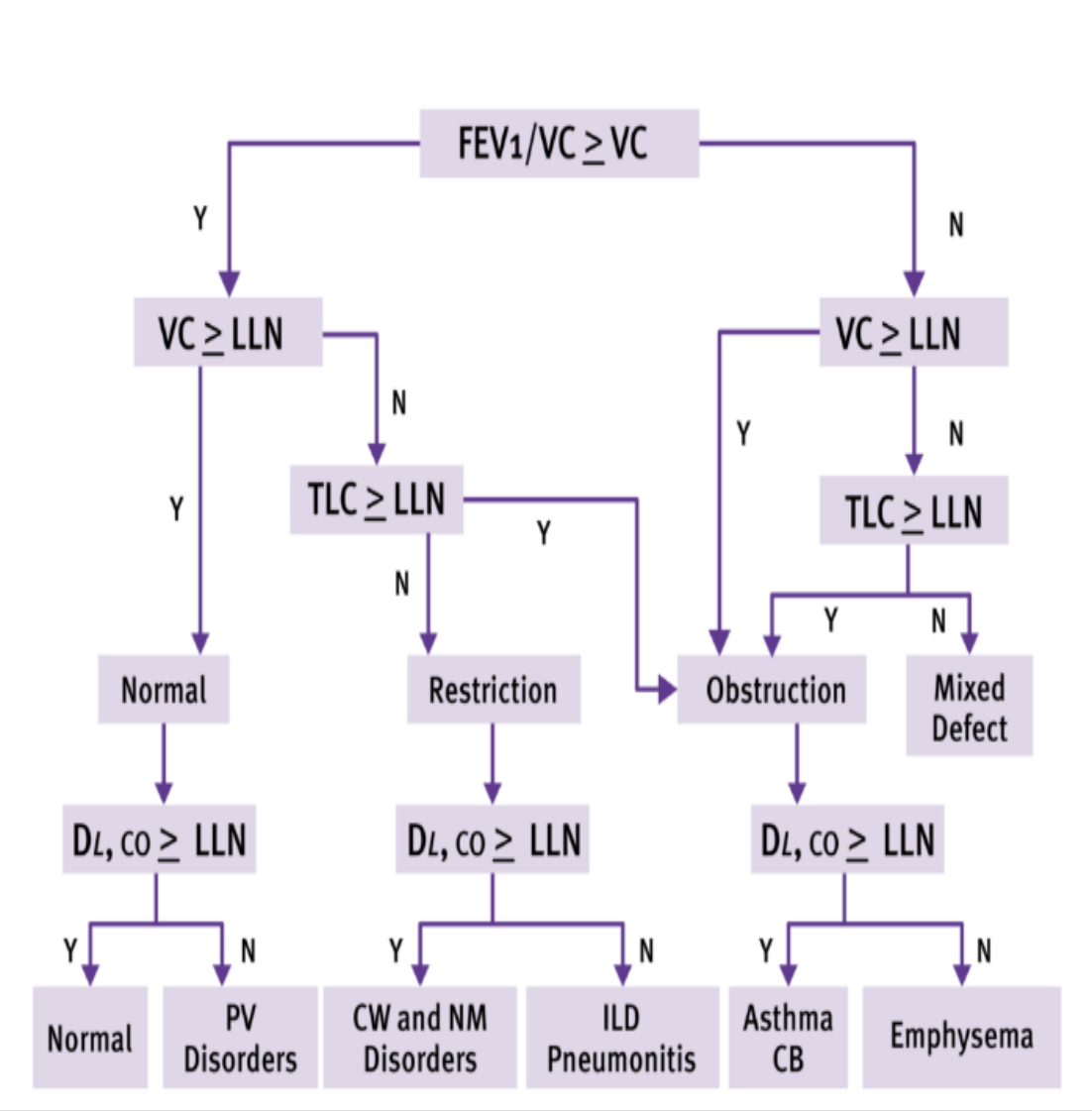
$$
\begin{aligned}
&\text{Men}: && \text{DLCO} = 0.3504\ \text{H} - 0.2156\ \text{A} - 23.168 \\
& && \text{DLCO/VA} = -0.0205\ \text{H} - 0.0283\text{A} + 9.0919 \\
&\text{Women}: && \text{DLCO} = 0.2491\ \text{H} - 0.1533\ \text{A} - 11.662 \\
& && \text{DLCO/VA} = 0.0140\ \text{H} - 0.0216\ \text{A} + 3.413
\end{aligned}
$$

Diffusing Capacity

- **Decreased DLCO**
  (<80% predicted)
  - Obstructive lung disease
  - Parenchymal disease
  - Pulmonary vascular disease
  - Anemia
- **Increased DLCO**
  (>120-140% predicted)
  - Asthma (or normal)
  - Pulmonary hemorrhage
  - Polycythemia
  - Left to right shunt

Normal Diffusing Capacity

- Average DLcosb value 25 ml CO/min/mm Hg (STPD)
- Should always be done with spirometry



Perfusion or Diffusion Limited?

- Diffusion and perfusion are the two main processes which govern the rate of alveolar-capillary gas transfer
- Perfusion limited
  - Reduced cardiac output or anemia will impede oxygen transport
  - Less uptake of oxygen by hemoglobin
- Diffusion limited
  - Oxygen transfer is impeded by physical barrier
  - Examples include
    - Atelectasis
    - Pulmonary fibrosis
    - Emphysema
    - Pneumonia
    - Interstitial edema

Diseases With Decreased DLCO

- Emphysema
  - Obstructive pattern
- Interstitial lung disease
  - Thickening of the alveolar-capillary membrane with restrictive pattern
- Idiopathic pulmonary fibrosis
  - Restrictive pattern with autoimmune diseases
- Sarcoidosis
  - Mixed pattern with anemia due to noncaseating granulomas and absent iron stores in the bone marrow
- HIV infection (PCP) – new studies emerging
  - Obstructive patten with inflammation

More Diseases With Decreased DLCO

- Pulmonary vascular disease
  - DLCO is an independent predictor of death
- Pulmonary arterial hypertension
  - DLCO was strongly associated with survival in patients with PH across different etiologies
- Pulmonary embolism
  - Reduction of DLCO provides a useful and simple screening test for PE and responsiveness of anticoagulant responsiveness
- Left-sided heart disease
  - Restrictive pattern and reduction in the alveolar–capillary membrane surface area available for gas exchange
- Anemia
  - Positive linear correlation between the hemoglobin content of the blood and DLCO

Cases of Increased DLCO

- Pulmonary hemorrhage (pulmonary vasculitis)
- Polycythemia
- Asthma
- Obesity
- Pregnancy (if not anemic)

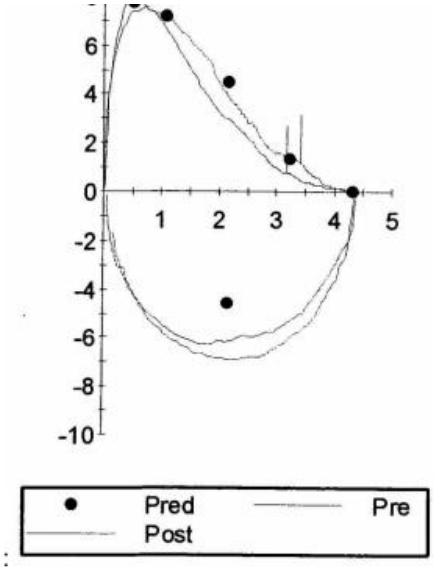
Case Study 1

- A 65-year-old man undergoes pulmonary function testing as part of a routine health-screening test. He had no pulmonary complaints. He is a lifelong nonsmoker and had a prior history of asbestos exposure while serving in the Navy. His pulmonary function test results are as follows:

Spirometry

	Pre-Bronchodilator (BD)			Post- BD
Test	Actual	Predicted	% Predicted	% Change
FVC (L)	4.39	4.32	102	-1
FEV_1 (L)	3.20	3.37	95	7
FEV_1/FVC (%)	73	78		8
FRC (L)	3.17	3.25	98	
ERV (L)	0.63	0.93	68	
RV (L)	2.54	2.32	109	
TLC (L)	6.86	6.09	113	
DLCO uncorr	25.69	31.28	82	
DLCO corr	26.14	31.28	84	

DLCO is measured in ml/min/mmHg



Flow Volume Loop

Case 1 Interpretation

- Is this a normal or abnormal PFT test?
  - The FVC and the FEV1 are 102% and 95% of predicted, respectively, values well above the lower limit of normal and the FEV1/FVC ratio is greater than the predicted value minus 8.
- What are your observations about the flow volume loop?
  - The flow-volume loop also corresponds quite nicely to the predicted values for this patient (darkened circles). Based on this normal spirometry pattern, you would conclude that there is no evidence of air-flow obstruction. The patient also has normal total lung capacity, indicating that there is no evidence of restriction, and a normal diffusing capacity for carbon monoxide, indicating that the alveolar-capillary surface area for gas exchange is normal.
- Was there a significant change in the bronchodilator response?
  - There is no bronchodilator response.
- Was her DLCO normal or abnormal?
  - Normal

Case study 2

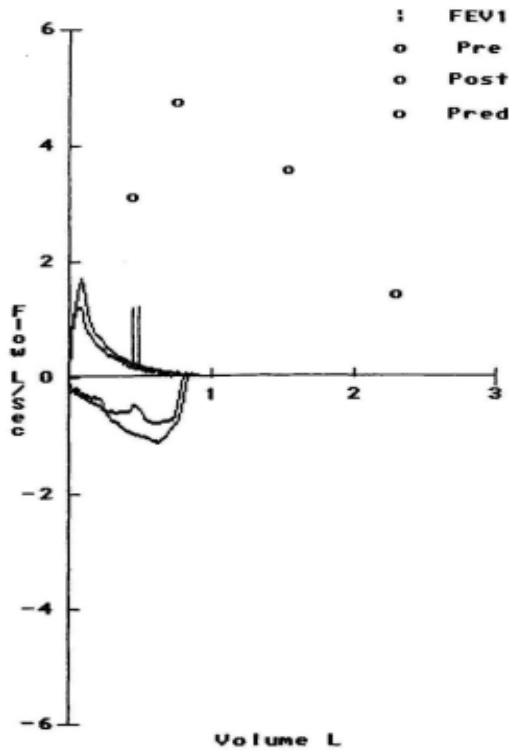
- A 41-year-old woman presents to the General Internal Medicine Clinic at Harborview Medical Center complaining of dyspnea with mild exertion.
- She has a 10 pack-year history of smoking and a history of using intravenous drugs including heroin and ritalin.
- Her pulmonary function tests are as follows:

Spirometry

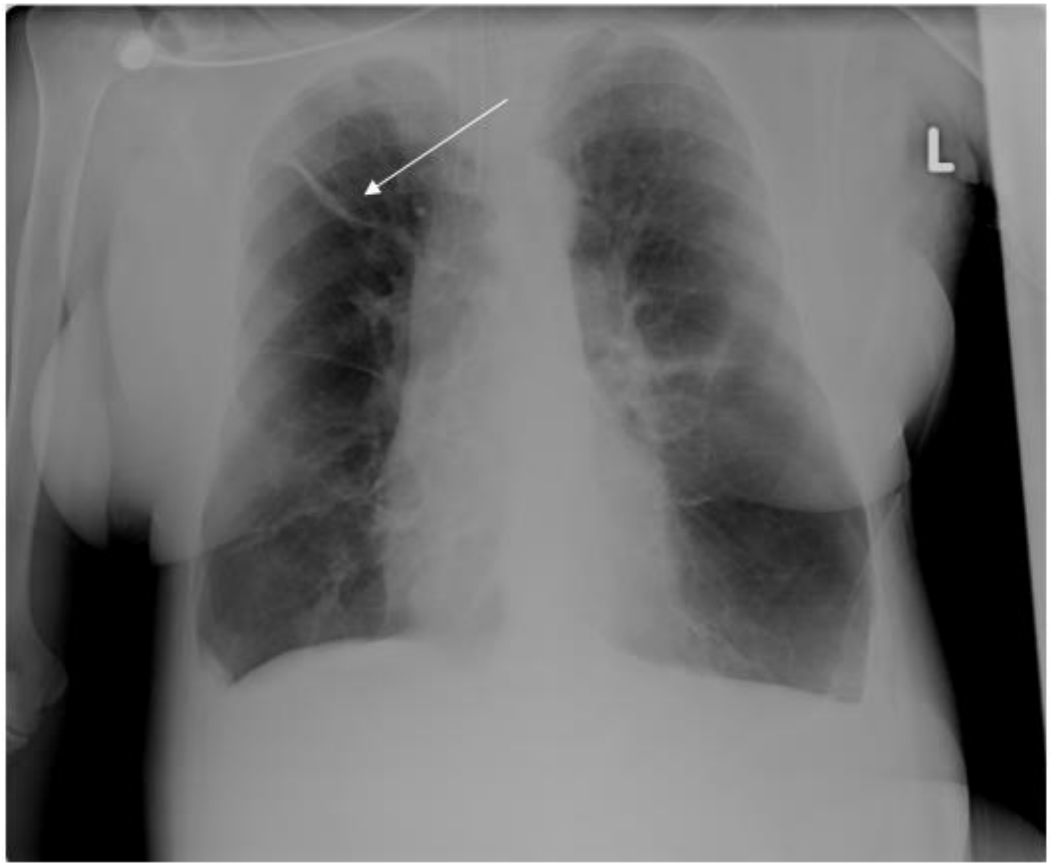
	Pre-Bronchodilator (BD)			Post- BD	
Test	Actual	Predicted	% Predicted	Actual	% Change
FVC (L)	0.90	3.09	29	0.74	- 17
FEV_1 (L)	0.49	2.57	19	0.44	-10
FEV_1/FVC (%)	54	83		59	8
RV (L)	3.83	1.49	257		
TLC (L)	4.78	4.44	108		
RV/TLC (%)	80	33			
DLCO corr	0.75	24.85	3		

Flow Volume Loops

Her flow volume loop is as follows:



X-Ray



Case 2 Interpretation

- Is this patient demonstrating air-flow obstruction?
  - Yes- her FEV1, FVC and her FEV1/FVC are all decreased
- Does her flow volume loop demonstrate the characteristic scooped-out appearance seen in obstructive lung disease?
  - Yes- and also demonstrates markedly reduced peak expiratory flows.
- Based on her FEV1 of 19% predicted would this would be classified as "very severe" obstructive lung disease?
  - The patient also has evidence of air-trapping, as her RV is 257% predicted. She would not be classified as being hyper-inflated because her TLC is only 108% predicted.
- Was there evidence of a bronchodilator response?
  - There is no evidence of a bronchodilator response as her FVC and FEV1 both values decline following bronchodilator administration.

Case 2 Interpretation

- Was her DLCO decreased ?
  - Her DLCO is decreased, indicating a loss of alveolar-capillary surface area for gas exchange.
- Is it likely that she has asthma?
  - Asthma is an unlikely diagnosis given the absence of reversibility with bronchodilator administration.
- Her chest x-ray provides some clues to the diagnosis- do you know what it is?
  - There is marked hyperlucency at the bases, suggesting that this is a basilar-predominant form of emphysema. The lower lobes are over-inflated.

Decreased Diffusing Capacity with Emphysema

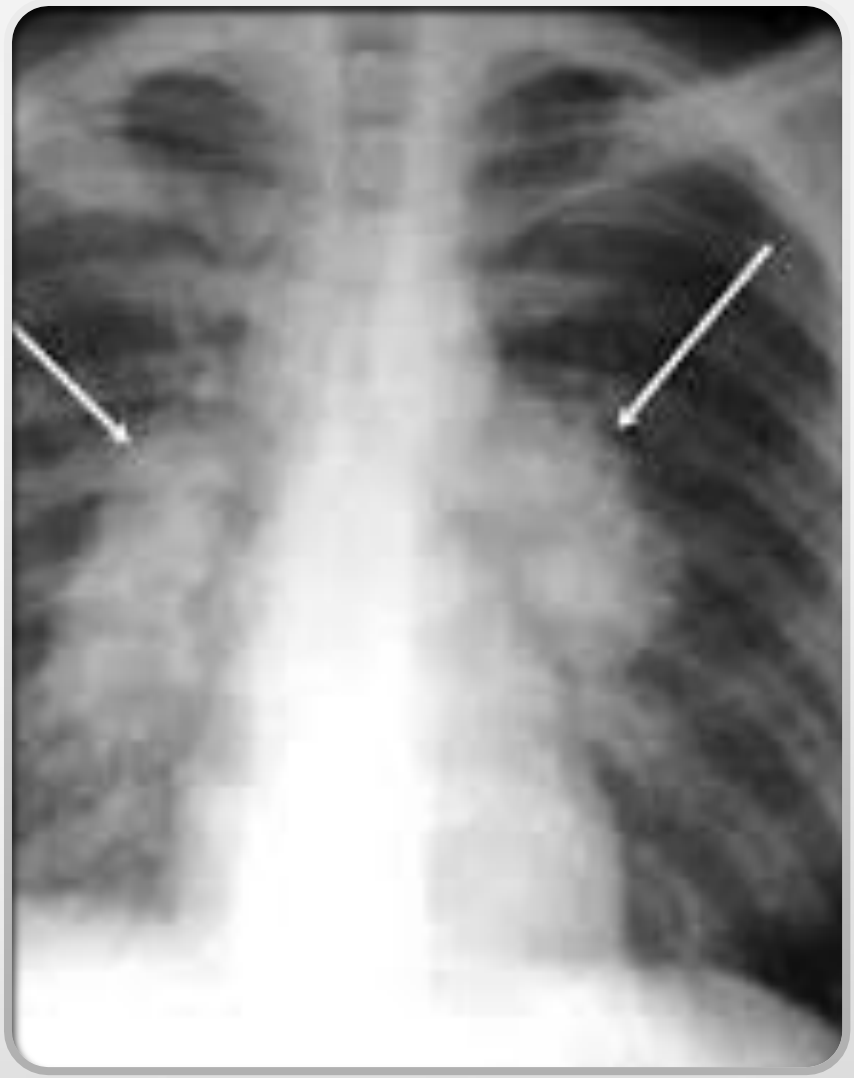
- Decreased *DLCO is associated with* airflow obstruction
  - Diagnosis of emphysema is to be considered
- Emphysema with a restrictive process such as idiopathic pulmonary fibrosis
  - Reduced DLCO
  - Normal spirometry and lung volumes

Diffusing Capacity and Interstitial lung disease

- Decreased *DLCO with restrictive process*
- *Elements of fibrosis with biopsies*
- Reduced lung volumes
- Patchy distribution of ground glass, reticular, nodular, or cystic opacities on radiographic images
- Monitored over time to determine severity of disease process

Diffusing Capacity and Sarcoidosis

- Airway obstruction and lower DLCO
- Symptoms related to the lung, skin, eyes, peripheral nerves, liver, kidney, heart, and other tissues.
- North American blacks and European white people
- More common in women
- Noncaseating granulomas in a biopsy specimen
- Bilateral hilar adenopathy
- Diffuse reticular infiltrates



Diffusing Capacity and COPD

- Obstructive pattern with spirometry
- Normal DLCO unless complicated by emphysema
- In patients with COPD, DLCO less than 50% of predicted is accompanied by O2 desaturation during exercise
- Low resting DLCO (<50% - 60% of predicted) may indicate the need for assessment of oxygenation during exercise

Summary

- DLCO is a valuable test when done with conjunction of PFT
- Obstructive and restrictive disorder can be identified
- Monitor the progress of lung disorders

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