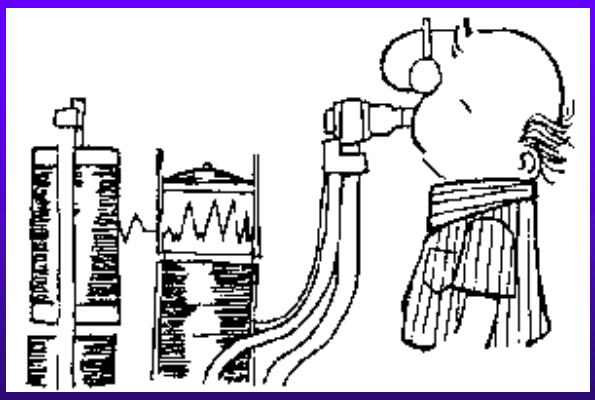
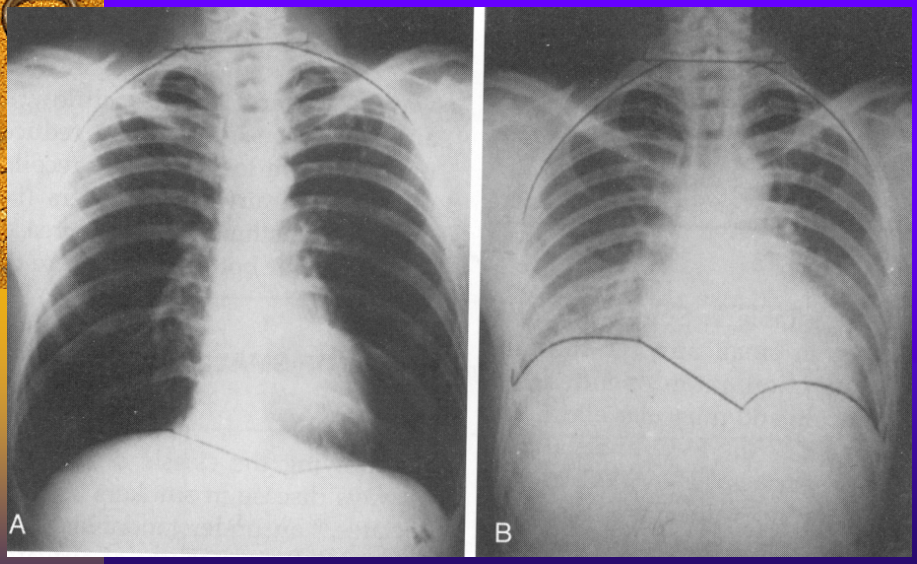
Pulmonary Function Tests

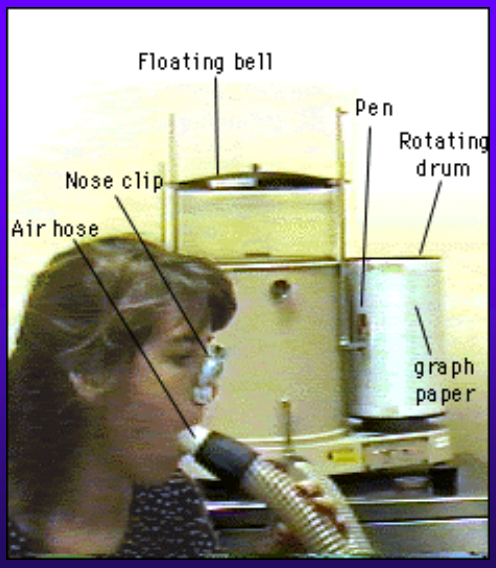


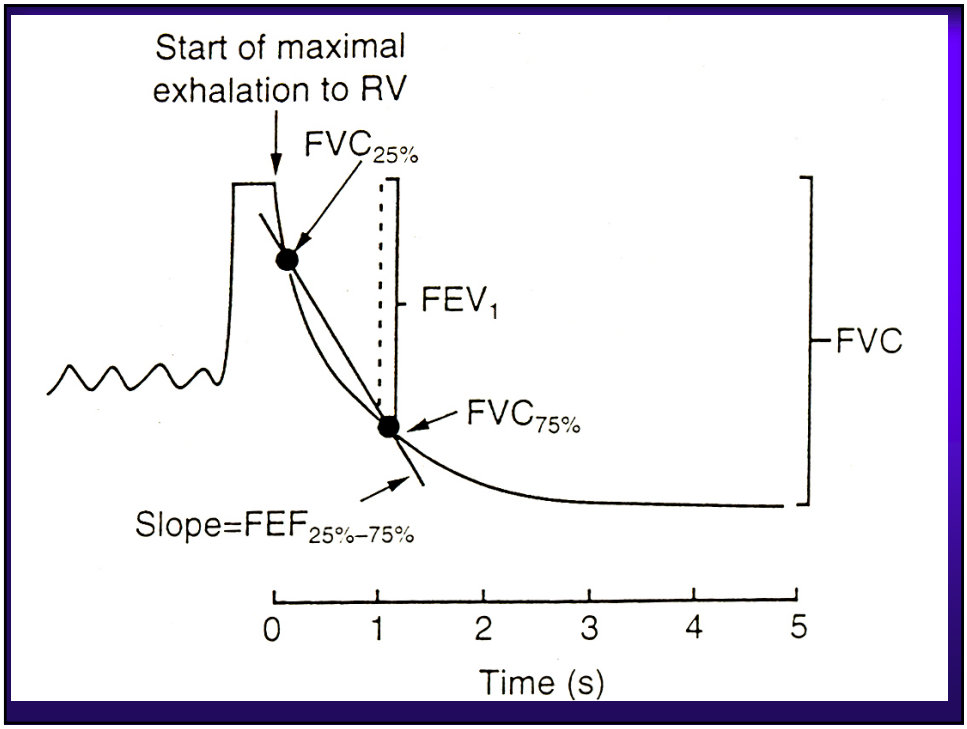


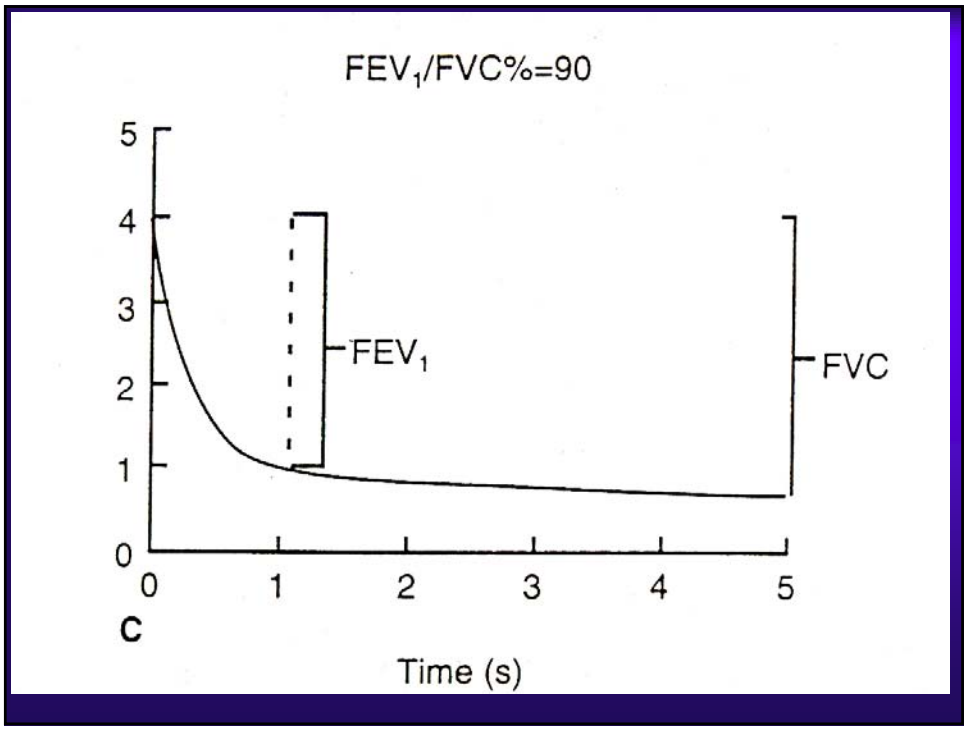
Spirometry and Maximal Expiratory and Inspiratory Flow Volume Curves

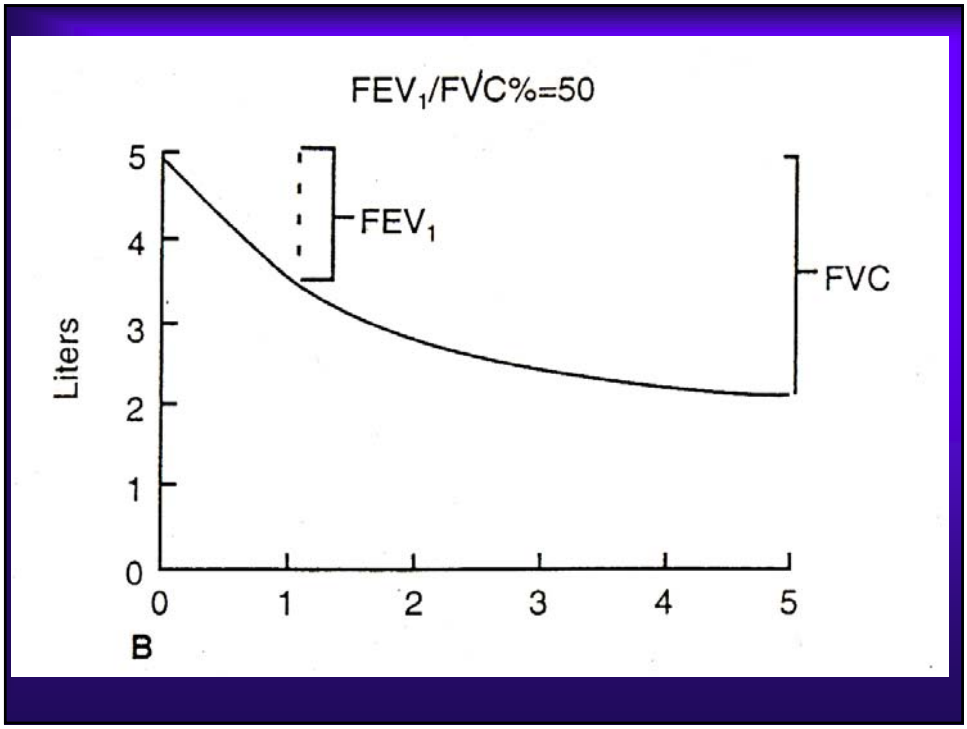
- "Dynamic function"

Spirometry




Start of maximal
exhalation to RV
FVC25%
FEV1
FVC
FVC75%
Slope=FEF25%–75%
0
1
2
3
4
5
Time (s)

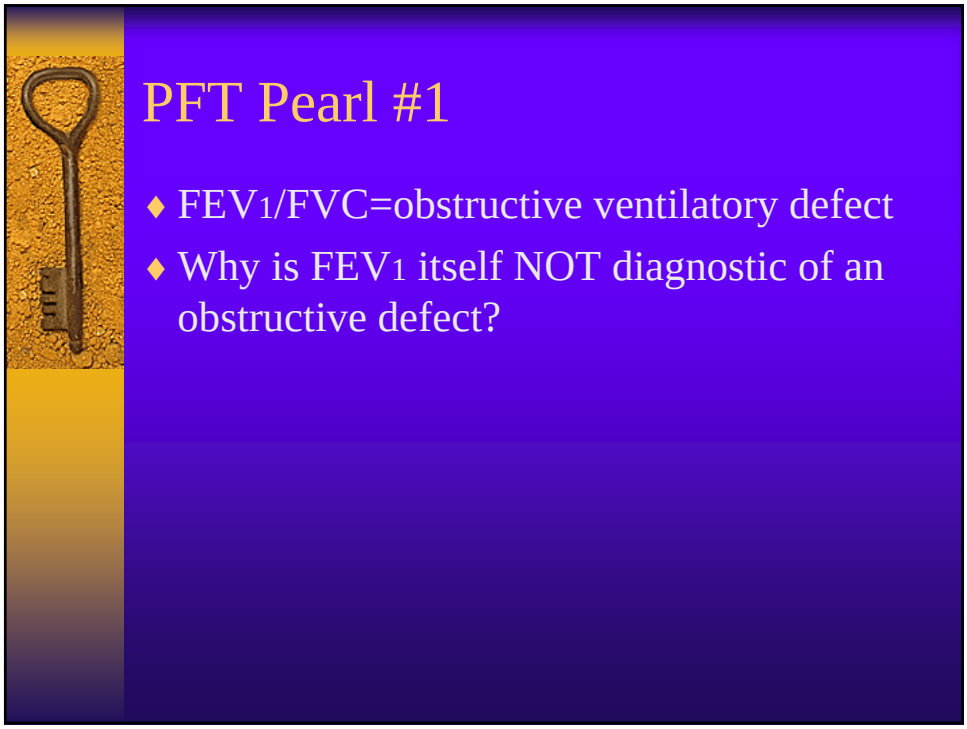

FEV1/FVC%=90
5
4
3
2
1
0
FEV1
FVC
0
1
2
3
4
5
C
Time (s)

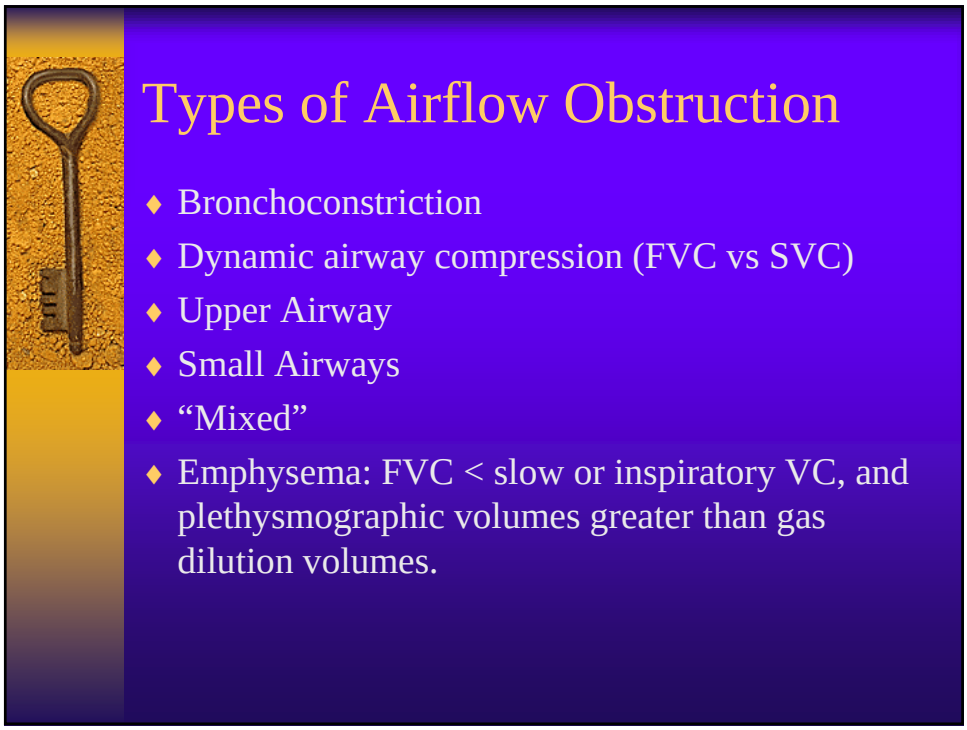


Obstructive Ventilation

- Decrease in expiratory airflow due to airway narrowing
- FEV1 decreased
- FVC normal or decreased
- FEV1/FVC decreased*
- FEF_{25-75} decreased

*definition of obstructive defect


PFT Pearl #1
♦ FEV1/FVC=obstructive ventilatory defect
♦ Why is FEV1 itself NOT diagnostic of an obstructive defect?

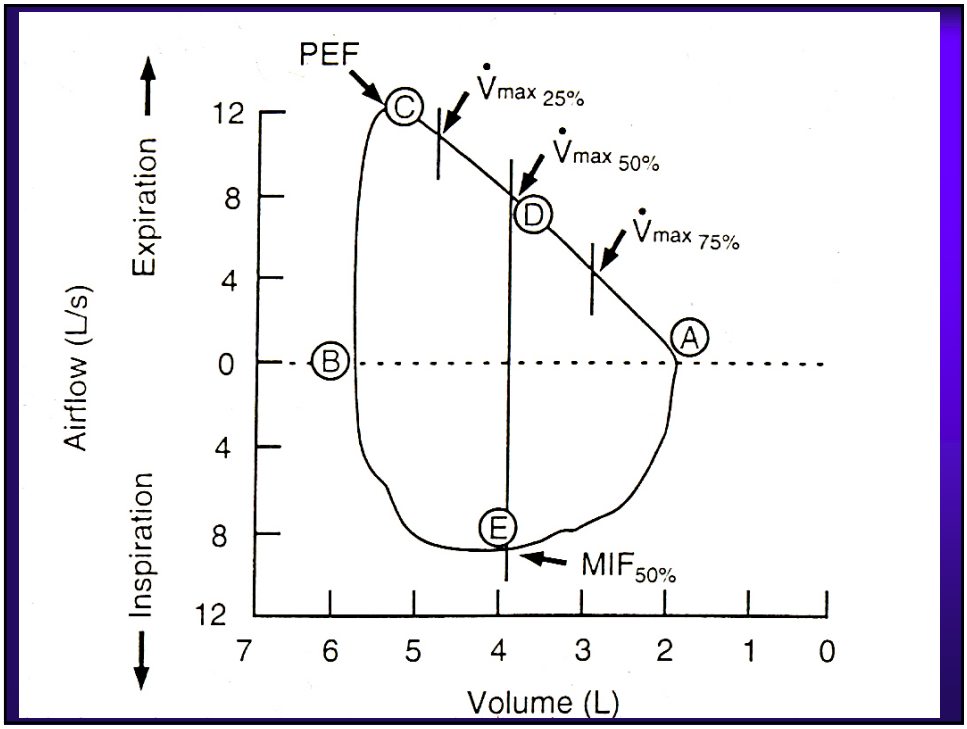

Types of Airflow Obstruction
♦ Bronchoconstriction
♦ Dynamic airway compression (FVC vs SVC)
♦ Upper Airway
♦ Small Airways
♦ "Mixed"
♦ Emphysema: FVC < slow or inspiratory VC, and plethysmographic volumes greater than gas dilution volumes.

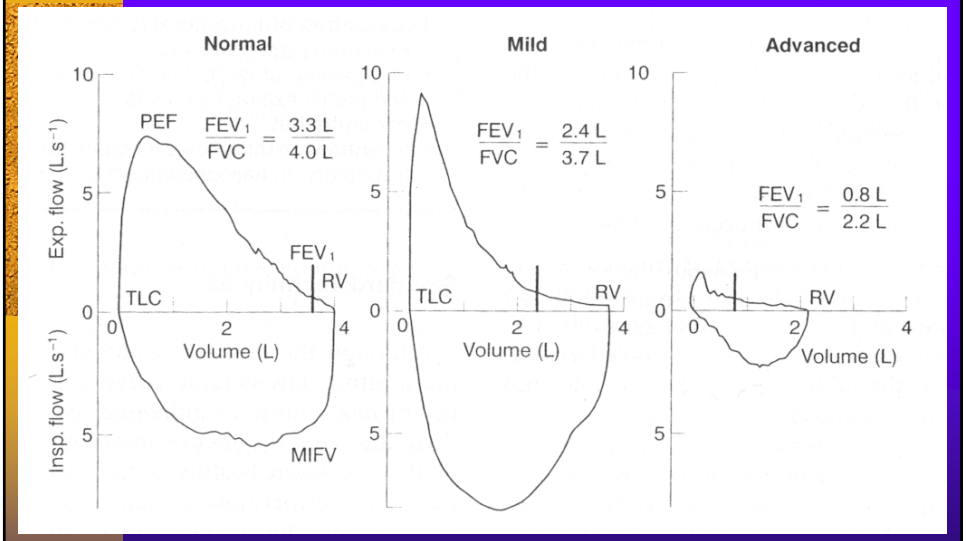
Patient: [redacted]
Age: 65 Gender: Male
Height(in): 70 (cm): 179
Weight(lb): 204 (kg): 92.5

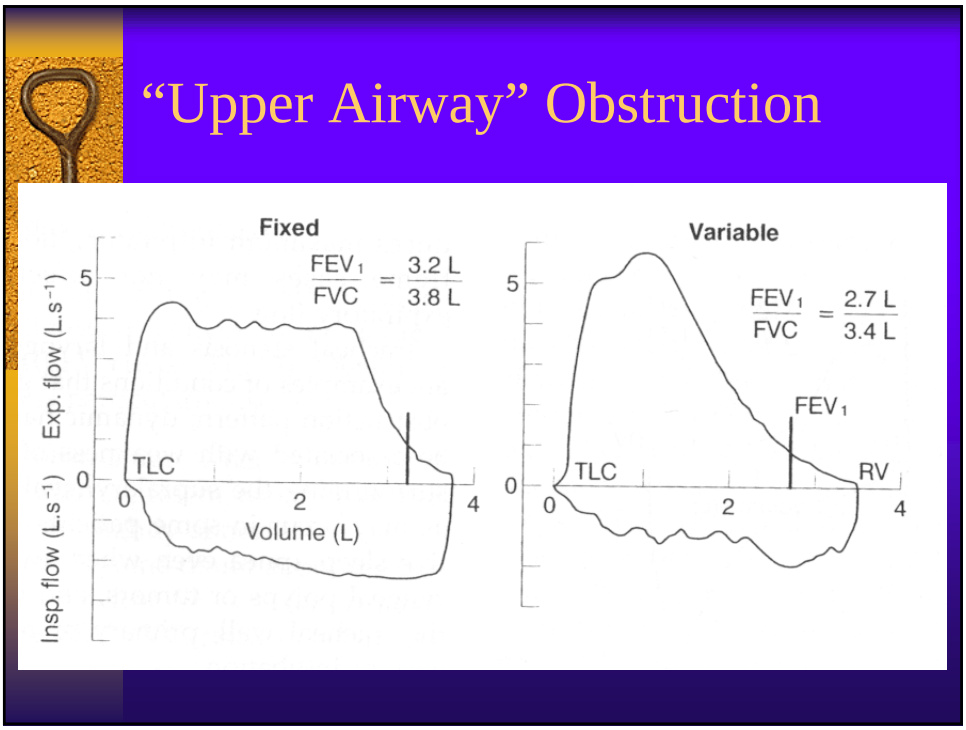
Id: [redacted]
Location: Out-Pt Date: [redacted]
Temp: 29 PBar: 763
Physician: [redacted]
Technician: GD

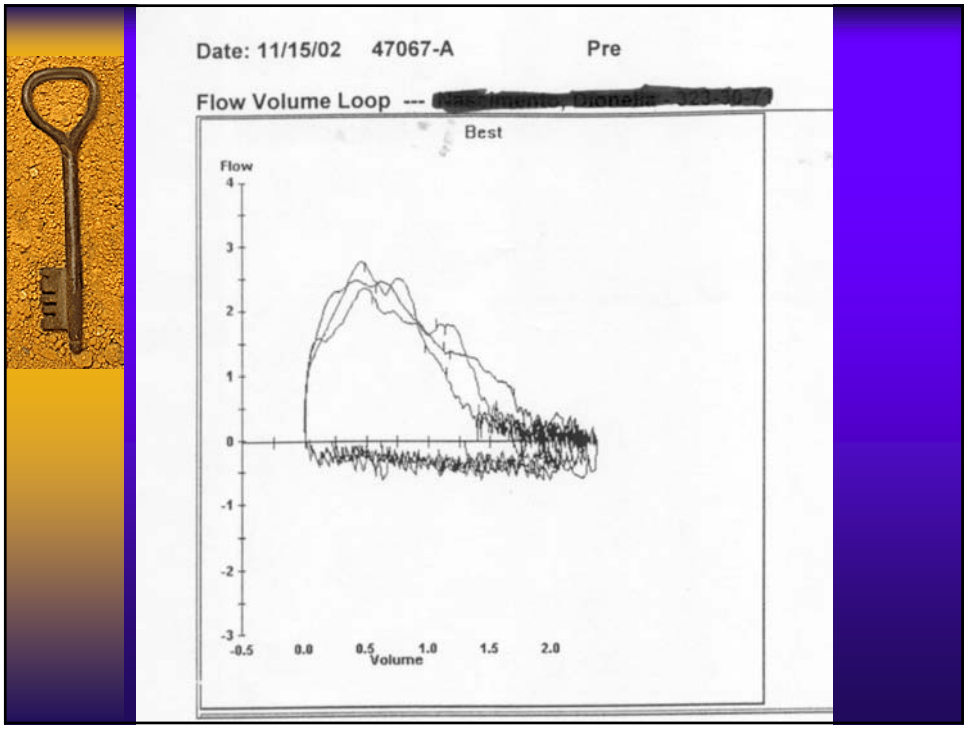
Spirometry		Ref	Pre Meas	Pre % Ref	Post Meas	Post % Ref	Po % Ch
FVC	Liters	4.70	1.93	41	2.71	58	
FEV1	Liters	3.63	0.54	15	0.60	17	
FEV1/FVC	%	77	28		22		
FEF25-75%	L/sec	2.88	0.25	9	0.24	8	
FEF25%	L/sec	7.80	0.27	3	0.29	4	
FEF50%	L/sec	4.32	0.18	4	0.19	4	
FEF75%	L/sec	1.57	0.10	6	0.09	6	
PEF	L/sec	8.44	2.27	27	2.96	35	
MVV	L/min	134			26	19	
PIF	L/sec	3.67					
FIF50%	L/sec	4.59					
FET100%	Sec		13.02		19.70		
Lung Volumes							
VC	Liters	4.49			2.85	63	
TLC	Liters	6.59			8.66	132	
RV	Liters	2.46			5.81	236	
RV/TLC	%	39			67		
FRC PL	Liters	3.52			7.02	199	
FRC He	Liters	3.52					
Vtg	Liters				6.94		

	UNITS	REFERENCE	SIT X30'@11:48
FIO2	%	21	21.00
pH		7.38-7.42	7.42
PCO2	mmHg	38-42	47.0
PO2	mmHg	76-87	55.0
HCO3	meq/L	22-26	30.0
BE		-2-+2	
%HbO2	%	>97	89.0
P(A-a)O2	mmHg		42.0



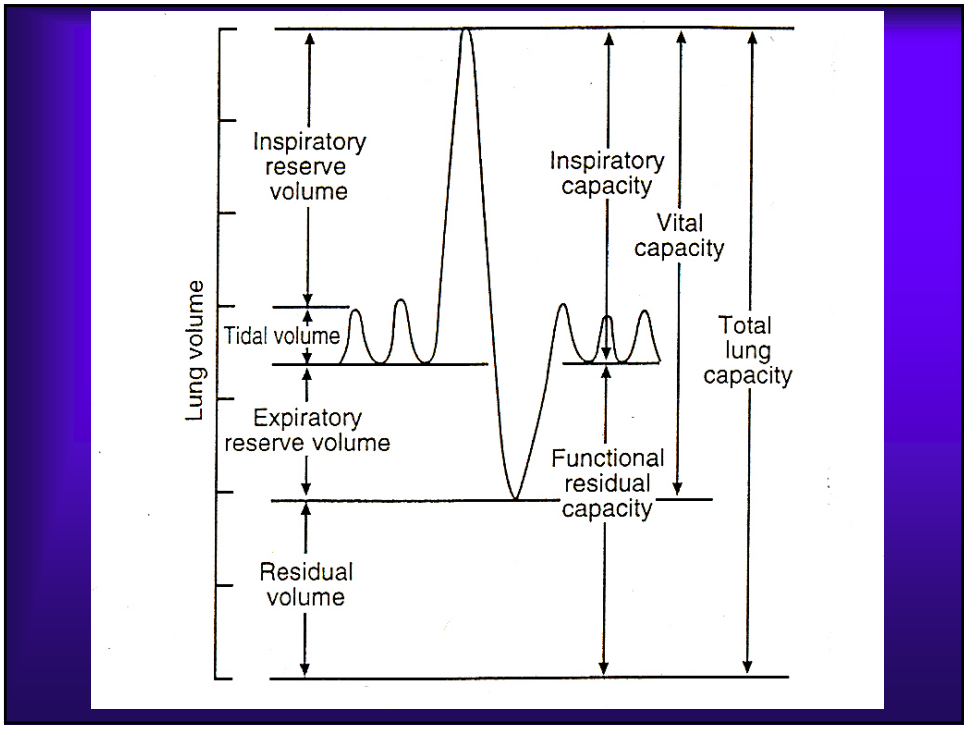

Normal
Mild
Advanced
Exp. flow (L.s⁻¹)
Insp. flow (L.s⁻¹)
10
5
0
5
PEF
FEV1/FVC = 3.3 L/4.0 L
FEV1
RV
TLC
MIFV
0
2
4
Volume (L)
FEV1/FVC = 2.4 L/3.7 L
FEV1/FVC = 0.8 L/2.2 L


“Upper Airway” Obstruction
Fixed
Variable
Exp. flow (L.s⁻¹)
Insp. flow (L.s⁻¹)
5
0
FEV1/FVC = 3.2 L/3.8 L
FEV1/FVC = 2.7 L/3.4 L
FEV1
TLC
RV
0
2
4
Volume (L)



Lung Volumes

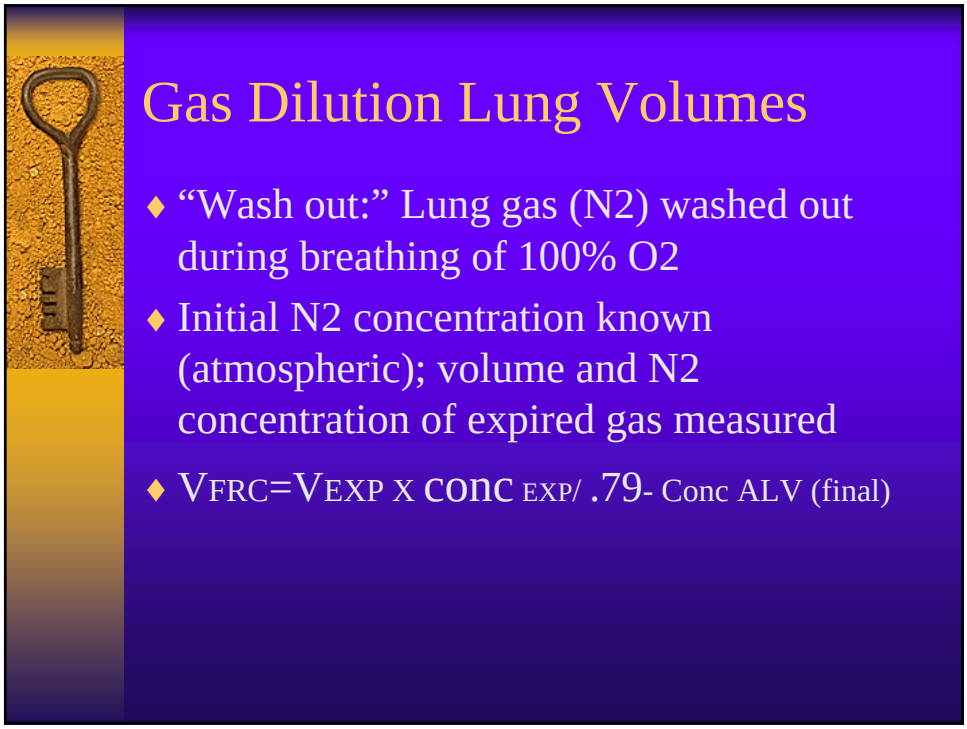
- "Static function"
- Gas Dilution ("wash in" and "wash out")
- Body plethysmography

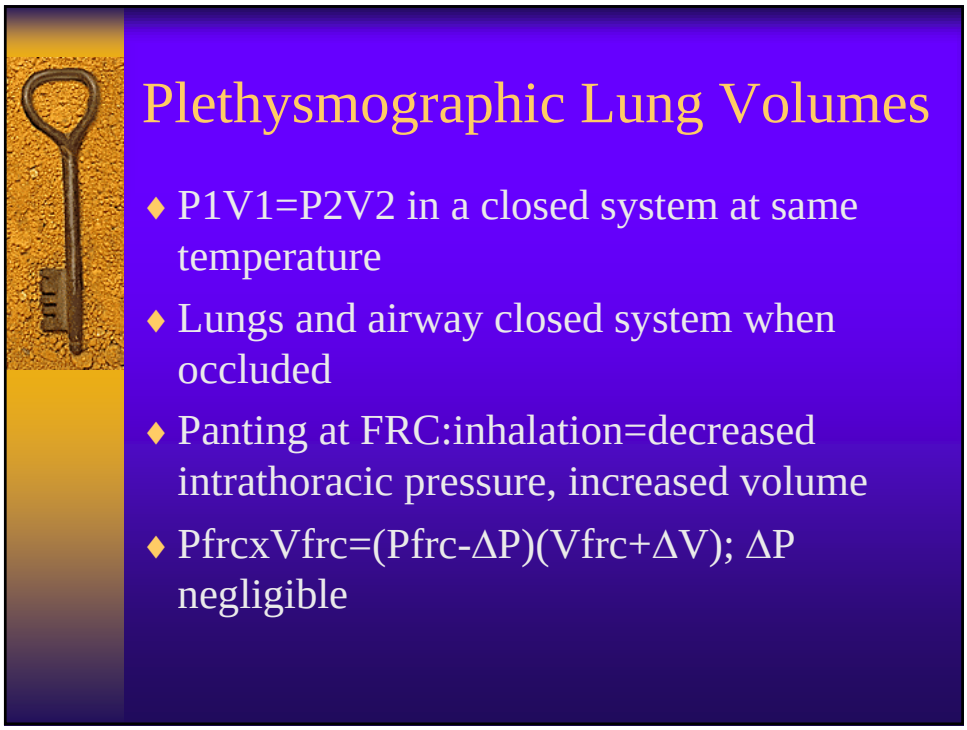


Gas Dilution Lung Volumes

- "Wash in:" Helium (insoluble) breathed from a reservoir of known VOLUME and CONCENTRATION, thus diluting its concentration by the volume of the lungs
- V_{FRC} = Vreservoir x

  Conc $_{INIT}$ – Conc $_{FINAL}$/ Conc $_{FINAL}$


Gas Dilution Lung Volumes
♦ "Wash out:" Lung gas (N2) washed out during breathing of 100% O2
♦ Initial N2 concentration known (atmospheric); volume and N2 concentration of expired gas measured
♦ VFRC=VEXP X conc EXP/ .79- Conc ALV (final)


Plethysmographic Lung Volumes
♦ P1V1=P2V2 in a closed system at same temperature
♦ Lungs and airway closed system when occluded
♦ Panting at FRC:inhalation=decreased intrathoracic pressure, increased volume
♦ PfrcxVfrc=(Pfrc-ΔP)(Vfrc+ΔV); ΔP negligible

Gas dilution vs Plethysmography

- In airways disease, if gas dilution not complete, lung volume will be UNDERESTIMATED.

PFT Example

- FVC: 1.39 L (37%)
- FEV1:0.54 L (19%)
- FEV1/FVC: (39%)
- VC: 1.82 L (49%)
- TLC (PL): 7.42 L (122%)
- VA (He): 2.34 L
- Interpretation?

Restrictive Ventilation

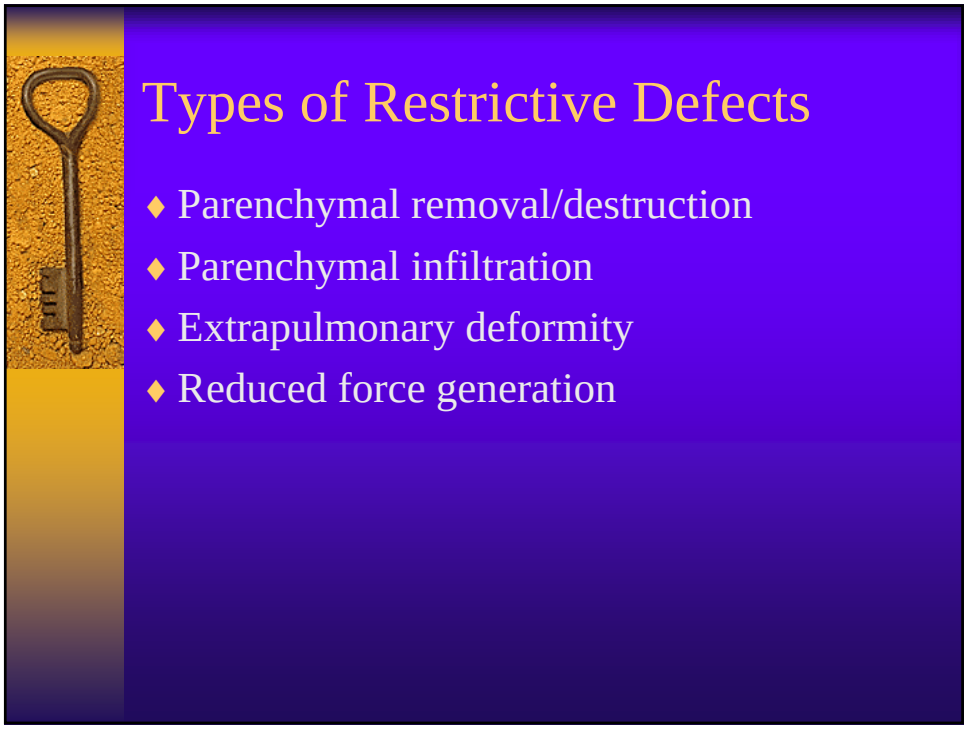
- A decrease in lung expansion
- FEV1 decreased
- FVC decreased
- FEV1/FVC normal or increased
- Total Lung Capacity (TLC) decreased*

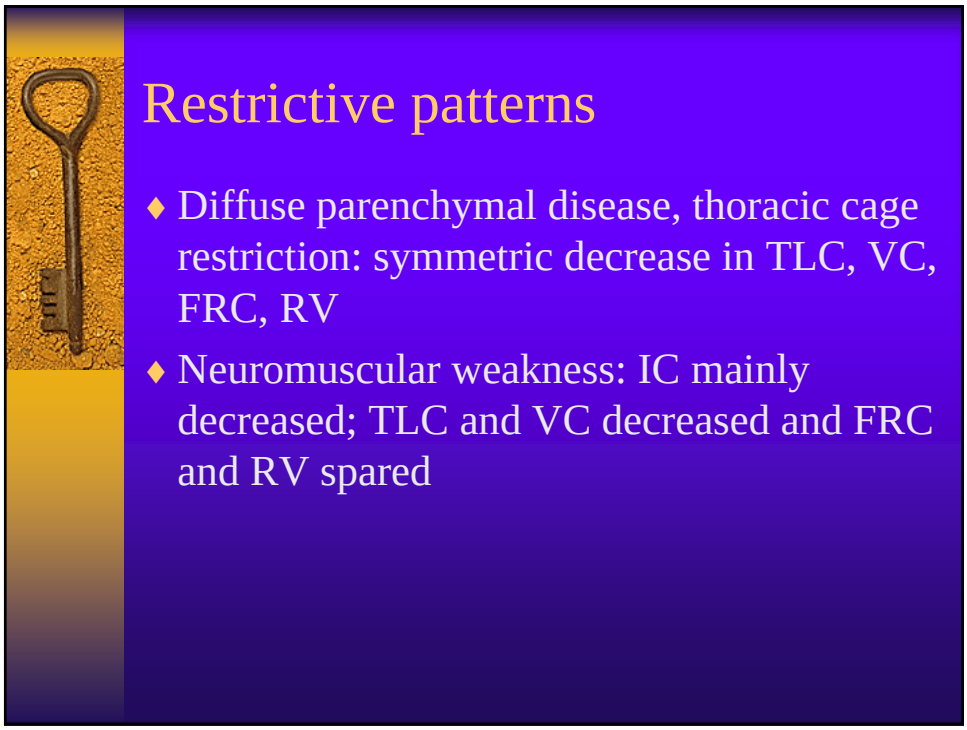
* Definition of restrictive ventilatory defect

PFT Pearl #2 and #3

Why is FVC itself NOT diagnostic of a restrictive ventilatory defect?

Why is VC itself not diagnostic of a restrictive ventilatory defect?

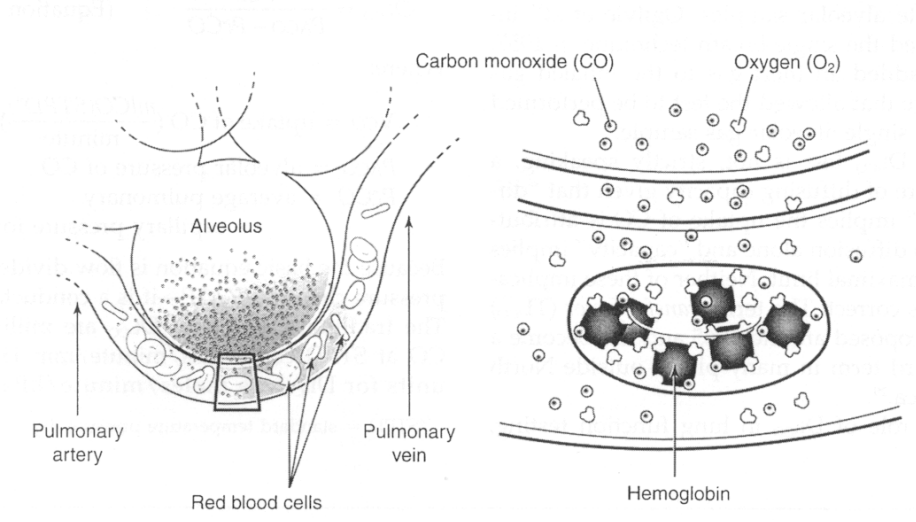

Types of Restrictive Defects
♦ Parenchymal removal/destruction
♦ Parenchymal infiltration
♦ Extrapulmonary deformity
♦ Reduced force generation


Restrictive patterns
♦ Diffuse parenchymal disease, thoracic cage restriction: symmetric decrease in TLC, VC, FRC, RV
♦ Neuromuscular weakness: IC mainly decreased; TLC and VC decreased and FRC and RV spared

Height: 69 in (176 cm) Weight: 203 lb (92.3 kg)
Body Mass Index: 29.80

Location: Out-Pt
Physician: [redacted]
Technician: AE

Spirometry		Ref	Pre Meas	Pre % Ref	Post Meas	Post % Ref
FVC	Liters	4.43	1.88	42		
FEV1	Liters	3.41	0.88	26		
FEV1/FVC	%	77	47			
FEF25-75%	L/sec	3.10	0.23	7		
FEF25%	L/sec	7.62	1.02	13		
FEF50%	L/sec	3.97	0.26	7		
FEF75%	L/sec	1.39	0.08	6		
PEF	L/sec	8.06	2.81	35		
MVV	L/min	126	41	33		
PIF	L/sec	3.55	3.26	92		
FIF50%	L/sec	4.49	3.19	71		
FET100%	Sec		13.80			
Lung Volumes						
VC	Liters	4.43	1.73	39		
TLC	Liters	6.88	4.39	64		
RV	Liters	2.39	2.66	111		
RV/TLC	%	35	61			
FRC PL	Liters	3.64	3.45	95		
FRC He	Liters	3.64				
Vtg	Liters		3.78			
Diffusion						
DLCO	mL/mmHg/min	31.8	15.2	48		
DL Adj	mL/mmHg/min	31.8	15.2	48		
VA	Liters		4.13			
DLCO/VA	mL/mHg/min/L	4.73	3.68	78		
Respiratory Muscle Pressures						
PI max	cmH2O	105	75	71		
PE max	cmH2O	197	150	76		



Diffusing Capacity for CO (DL_{CO})

- Rate of gas flow across lungs (ml/min)/pressure gradient for flow across alveolar capillary membrane (mmHg)

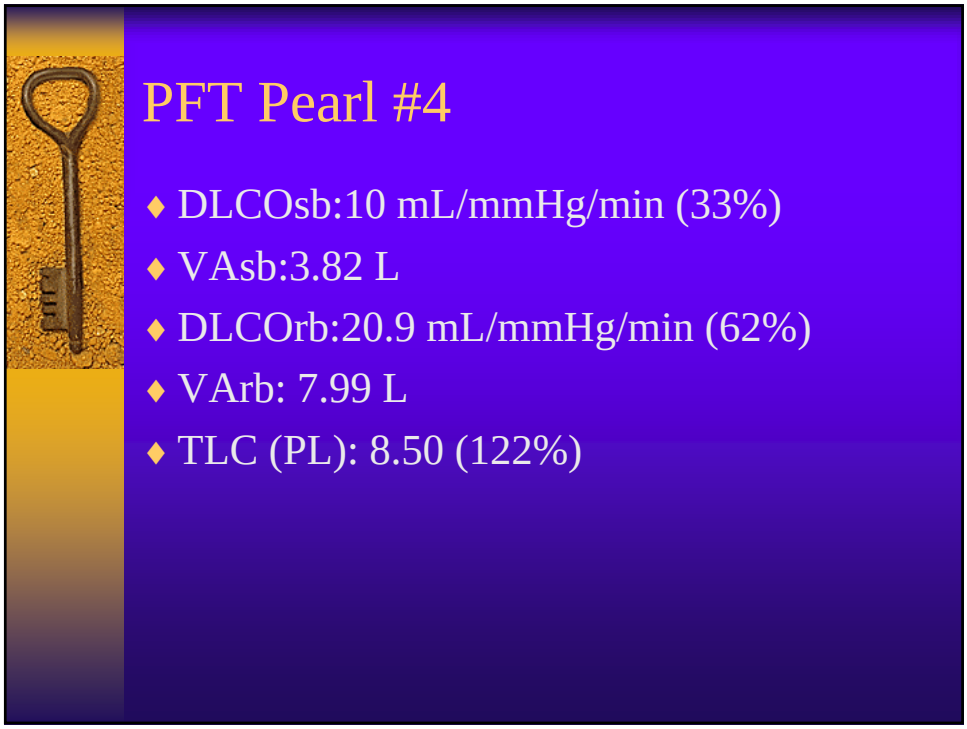
$$\frac{1}{DL_{CO}} = \frac{1}{Dm} + \frac{1}{\theta Vc}$$

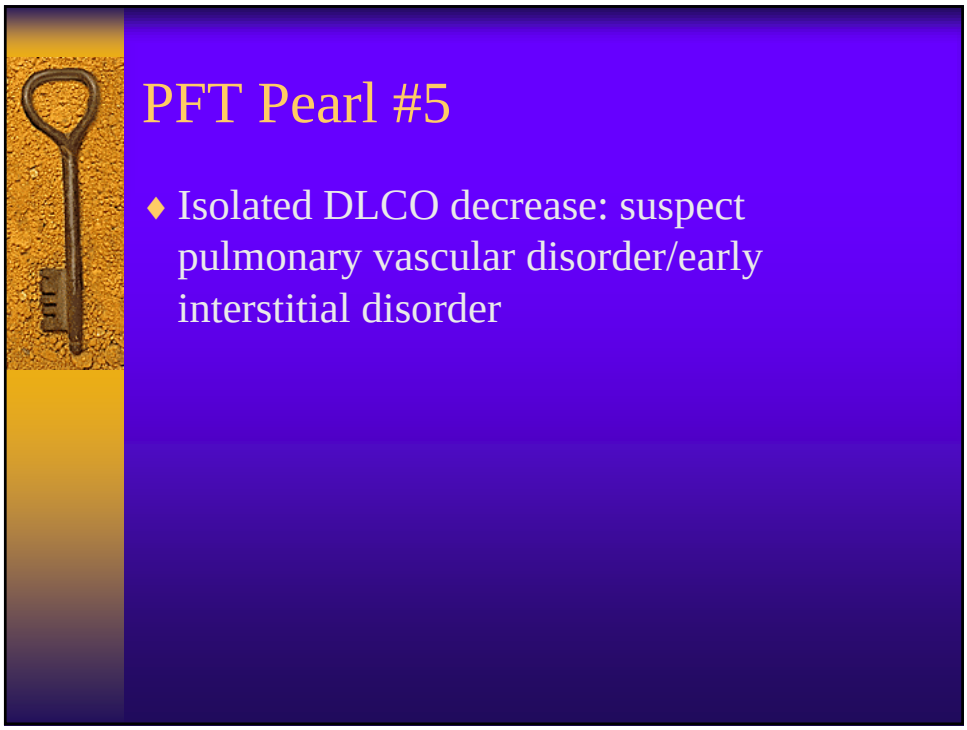
(Roughton and Forster, J. Appl. Physiol 1957)

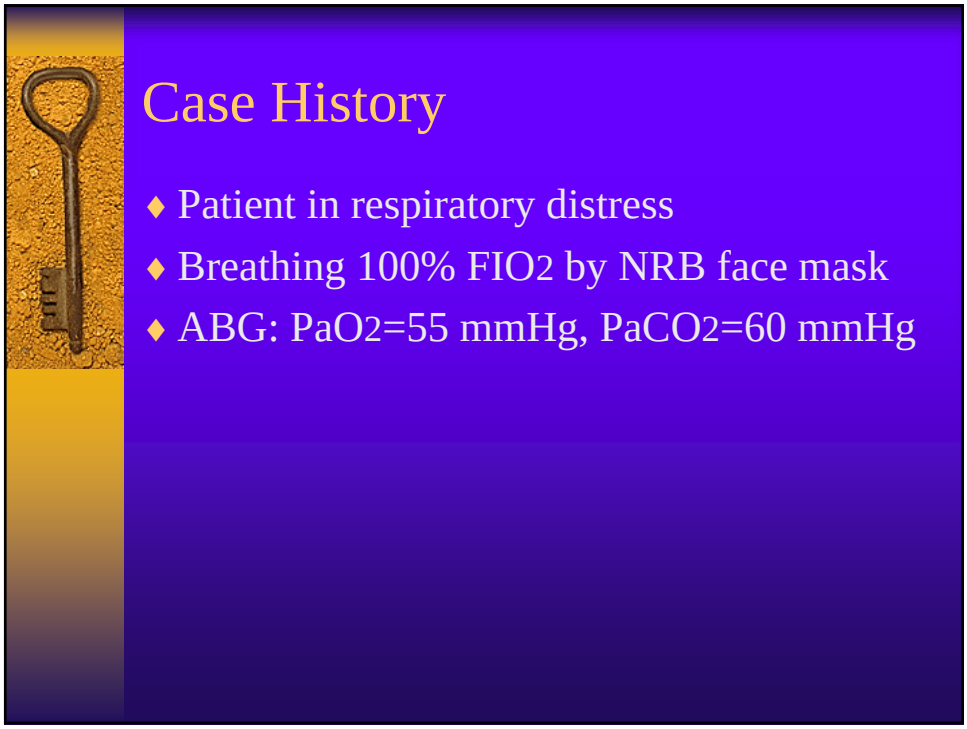
Diffusion through liquid: Gas gradient, solubility, hemoglobin, membrane thickness, surface area

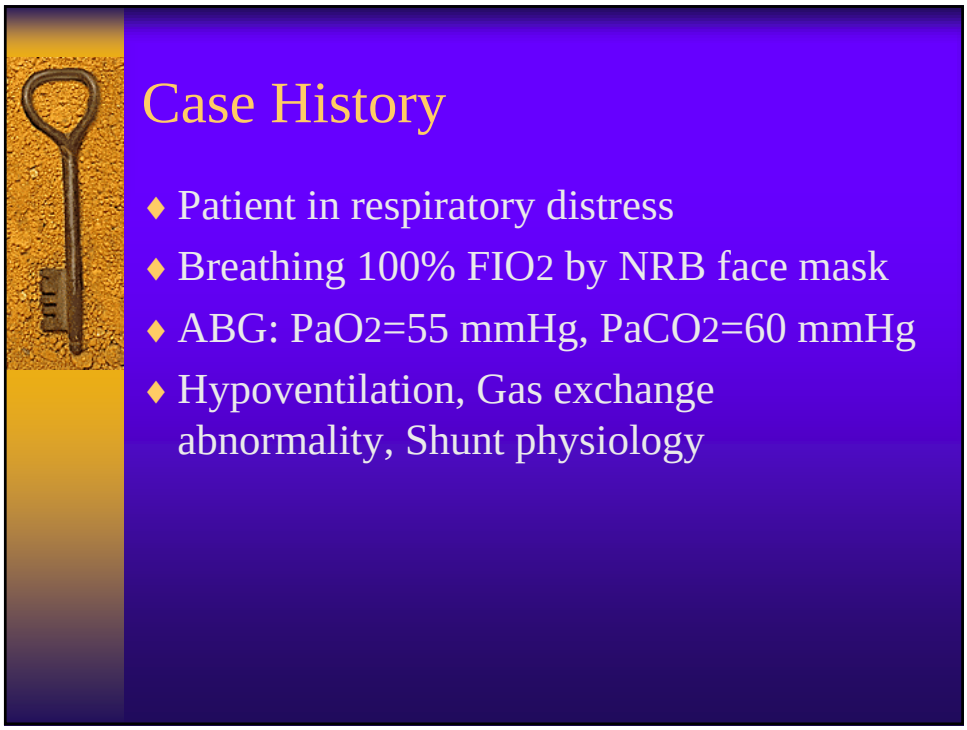
Diffusing Capacity

- Increased in alveolar hemorrhage, obesity, asthma, exercise, supine, L-R shunt' erythrocytosis, high altitude
- Decreased in emphysema (destruction and non-equilibration), restrictive disorders, pulmonary vascular disorders, anemia, abnormal Hgb
- Single breath vs rebreathe techniques


PFT Pearl #4
♦ DLCOsb:10 mL/mmHg/min (33%)
♦ VAsb:3.82 L
♦ DLCOrb:20.9 mL/mmHg/min (62%)
♦ VArb: 7.99 L
♦ TLC (PL): 8.50 (122%)


PFT Pearl #5
♦ Isolated DLCO decrease: suspect pulmonary vascular disorder/early interstitial disorder


Case History
♦ Patient in respiratory distress
♦ Breathing 100% FIO2 by NRB face mask
♦ ABG: PaO2=55 mmHg, PaCO2=60 mmHg


Case History
♦ Patient in respiratory distress
♦ Breathing 100% FIO2 by NRB face mask
♦ ABG: PaO2=55 mmHg, PaCO2=60 mmHg
♦ Hypoventilation, Gas exchange abnormality, Shunt physiology