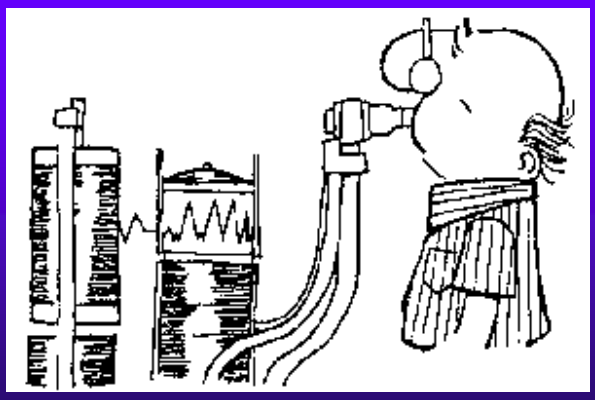
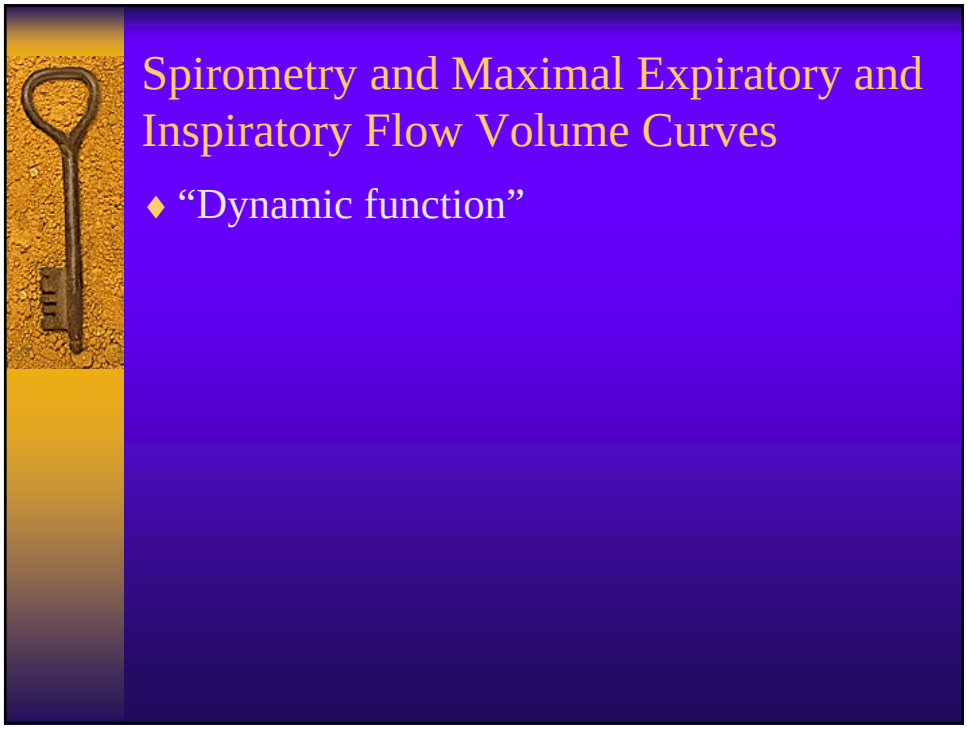
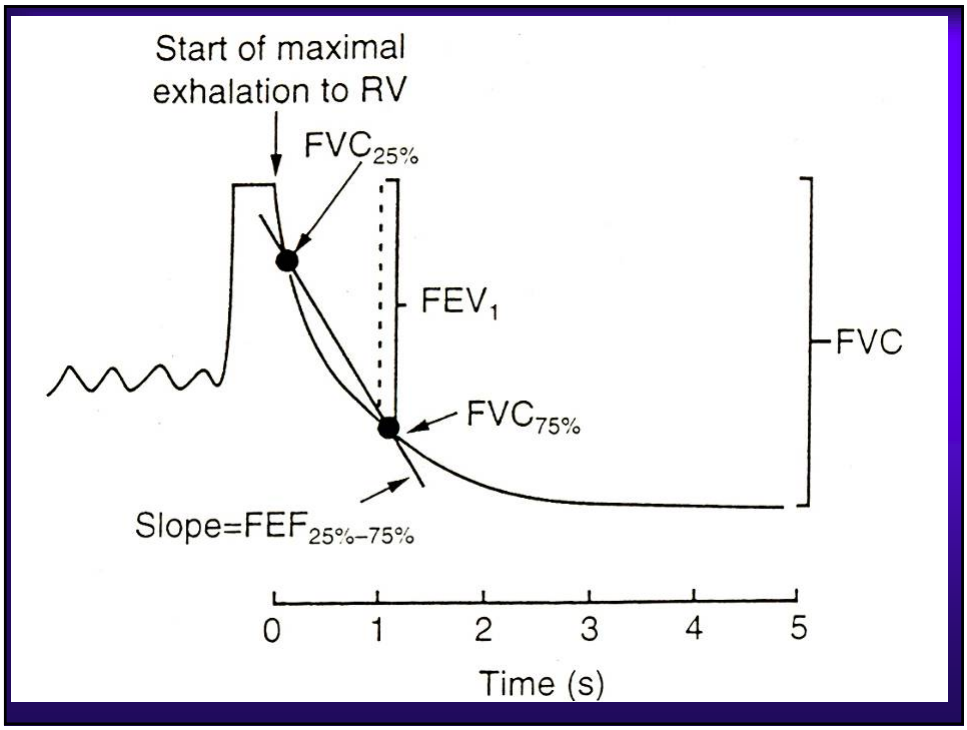
Pulmonary Function Tests

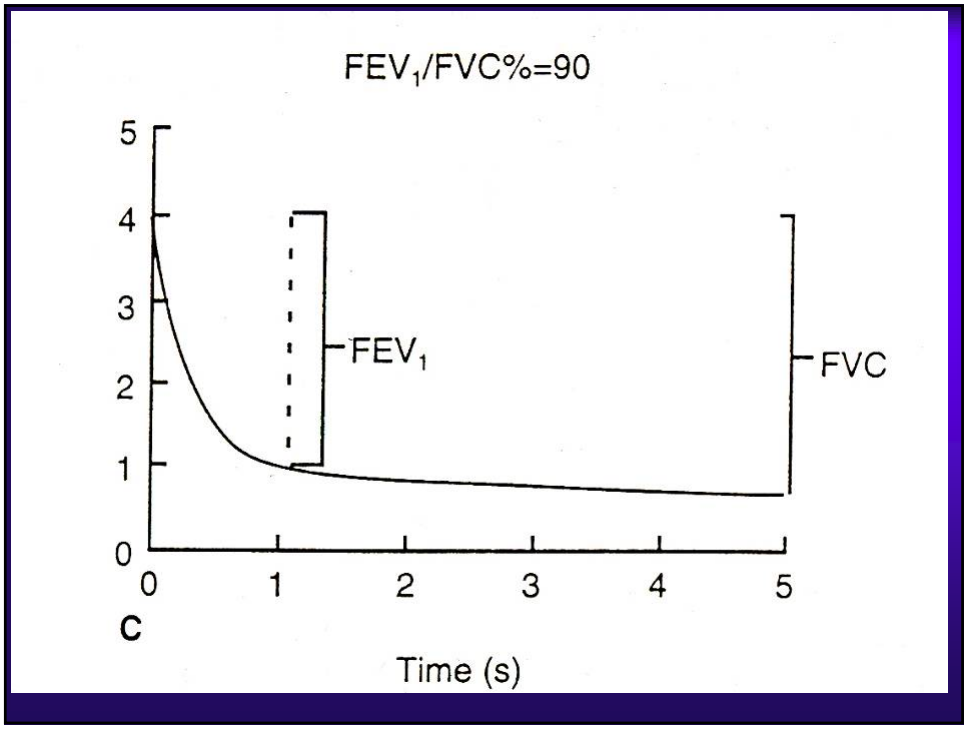


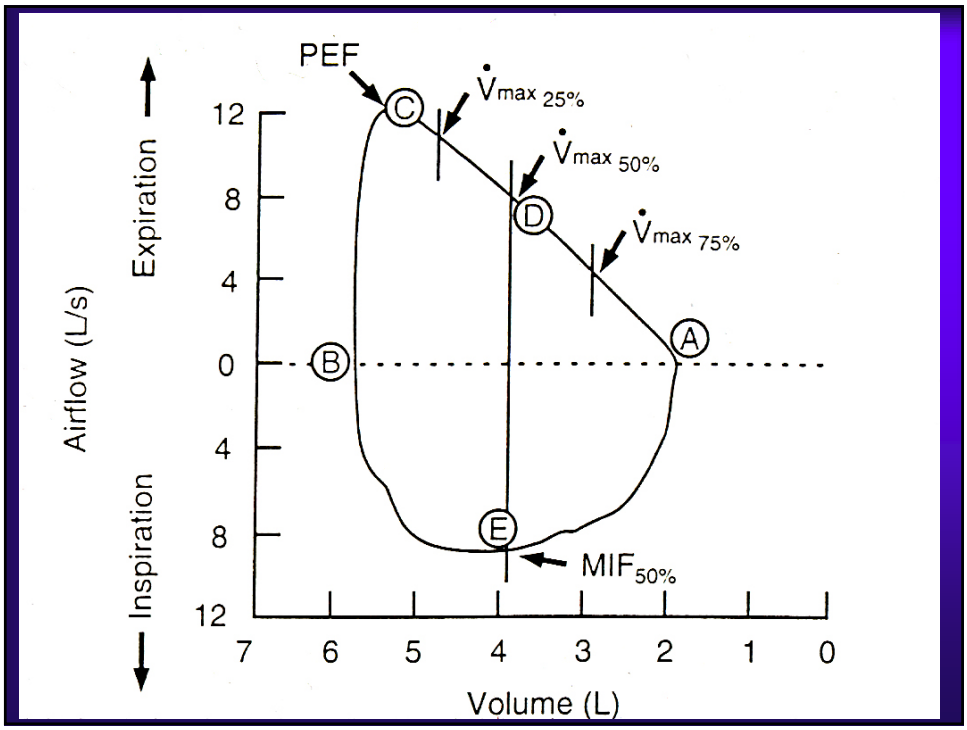
Pulmonary Function: Tests

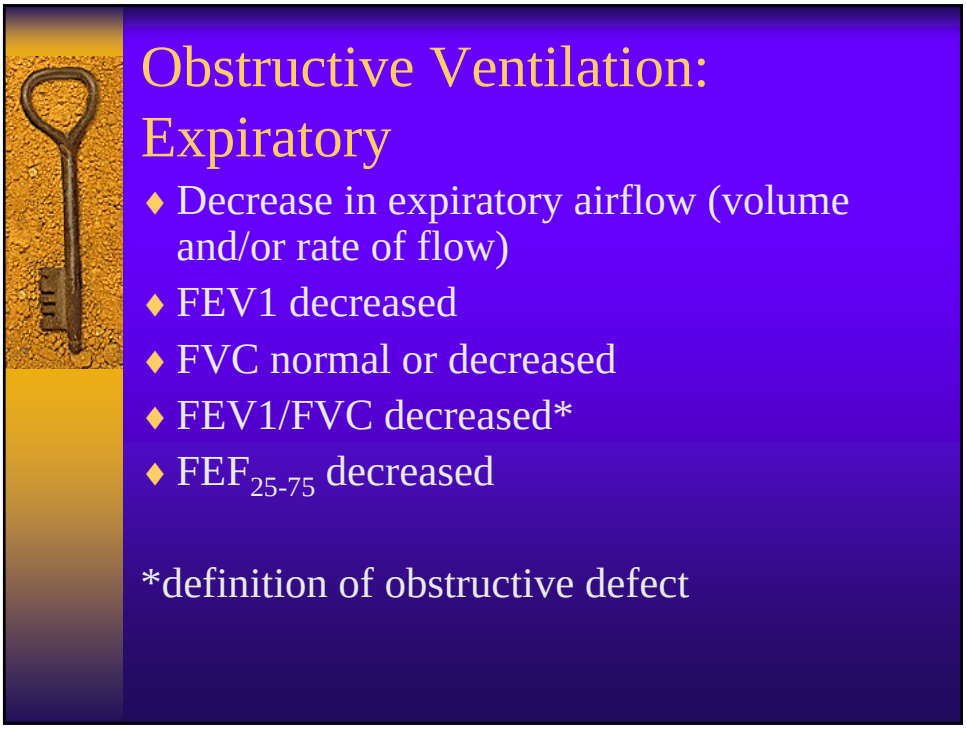
- “Dynamic function”: obstructive defects
- “Static function”: restrictive defects
- Diffusion abnormalities (gas exchange)

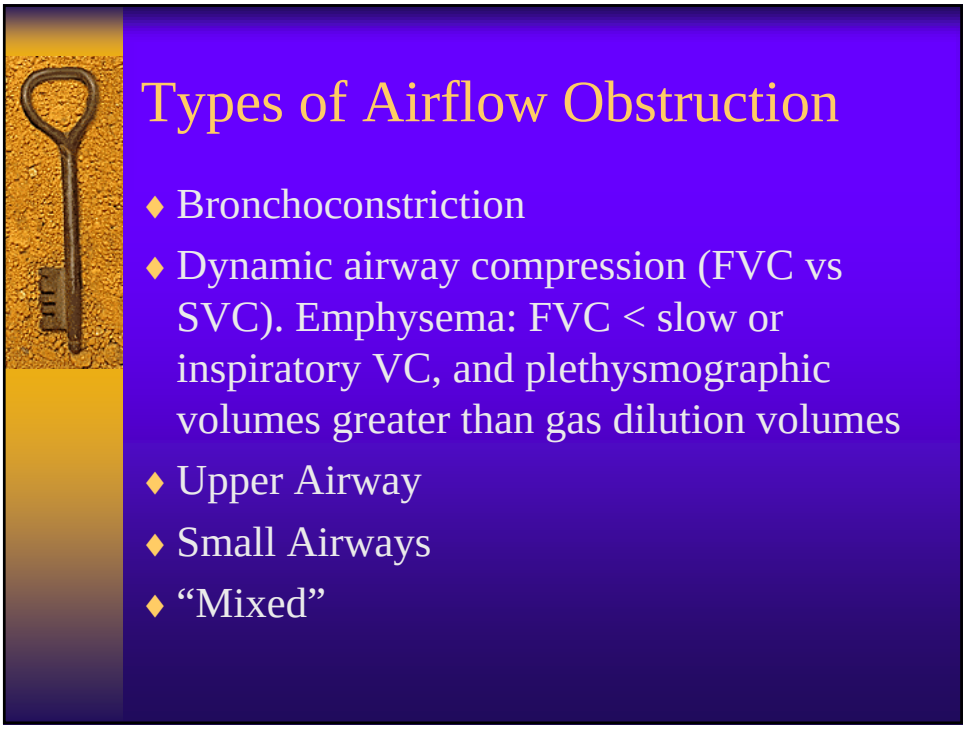

Spirometry and Maximal Expiratory and Inspiratory Flow Volume Curves
♦ "Dynamic function"

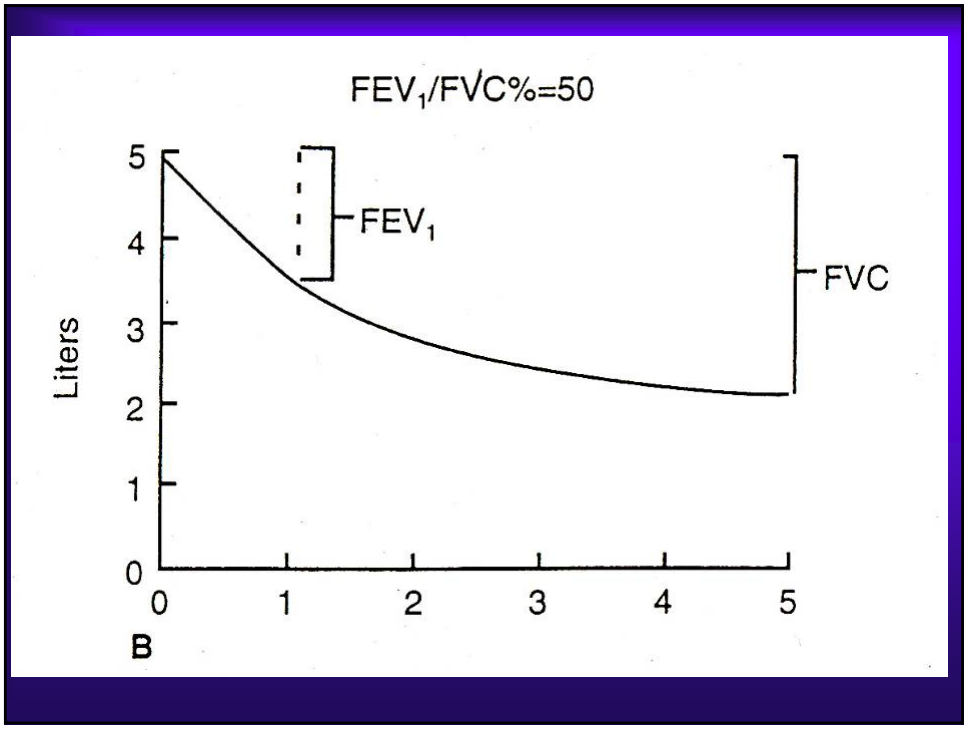

Start of maximal exhalation to RV
FVC25%
FEV1
FVC
FVC75%
Slope=FEF25%–75%
0
1
2
3
4
5
Time (s)

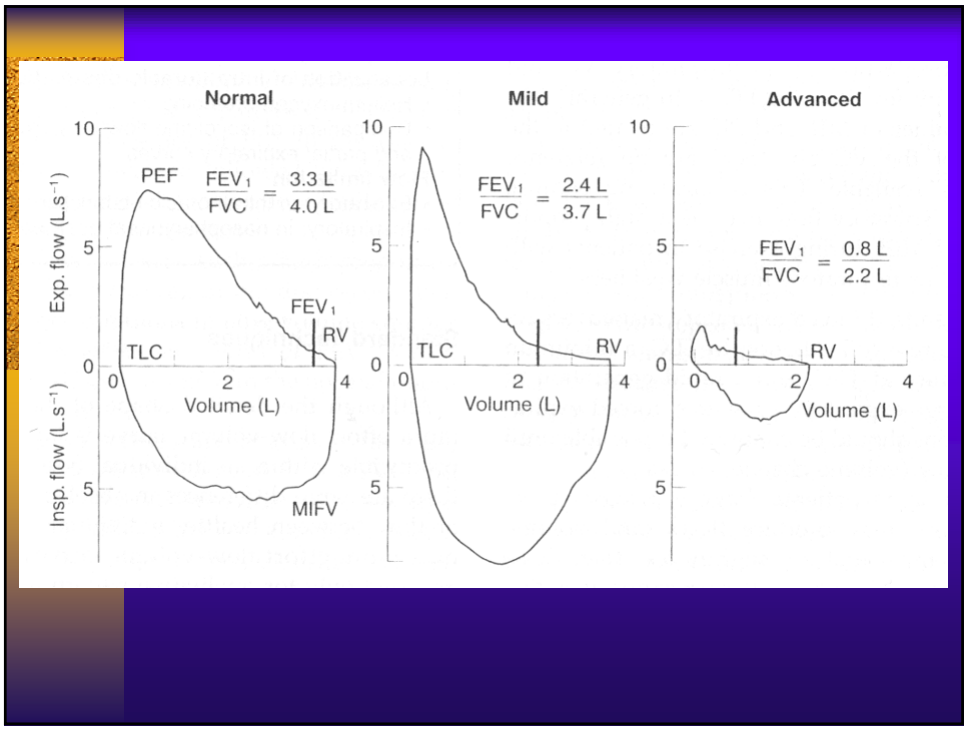

FEV1/FVC%=90
5
4
3
2
1
0
FEV1
FVC
0
1
2
3
4
5
C
Time (s)

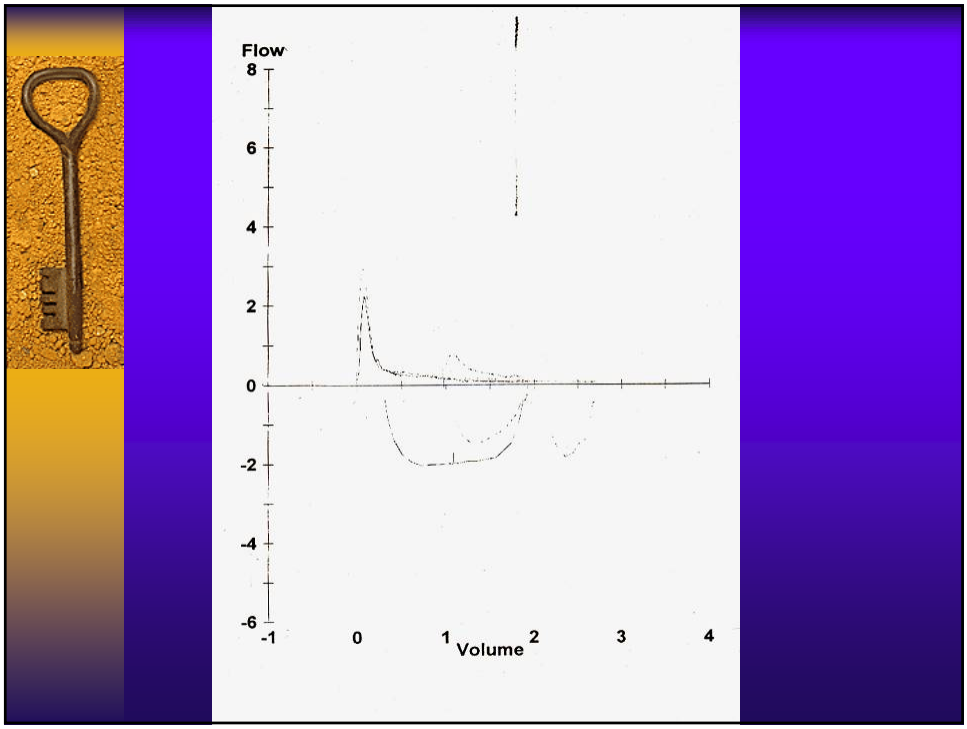

PEF
V̇max 25%
V̇max 50%
V̇max 75%
C
D
A
B
E
MIF50%
Expiration
Inspiration
Airflow (L/s)
12
8
4
0
4
8
12
7
6
5
4
3
2
1
0
Volume (L)


Obstructive Ventilation: Expiratory
♦ Decrease in expiratory airflow (volume and/or rate of flow)
♦ FEV1 decreased
♦ FVC normal or decreased
♦ FEV1/FVC decreased*
♦ FEF_{25-75} decreased
*definition of obstructive defect


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

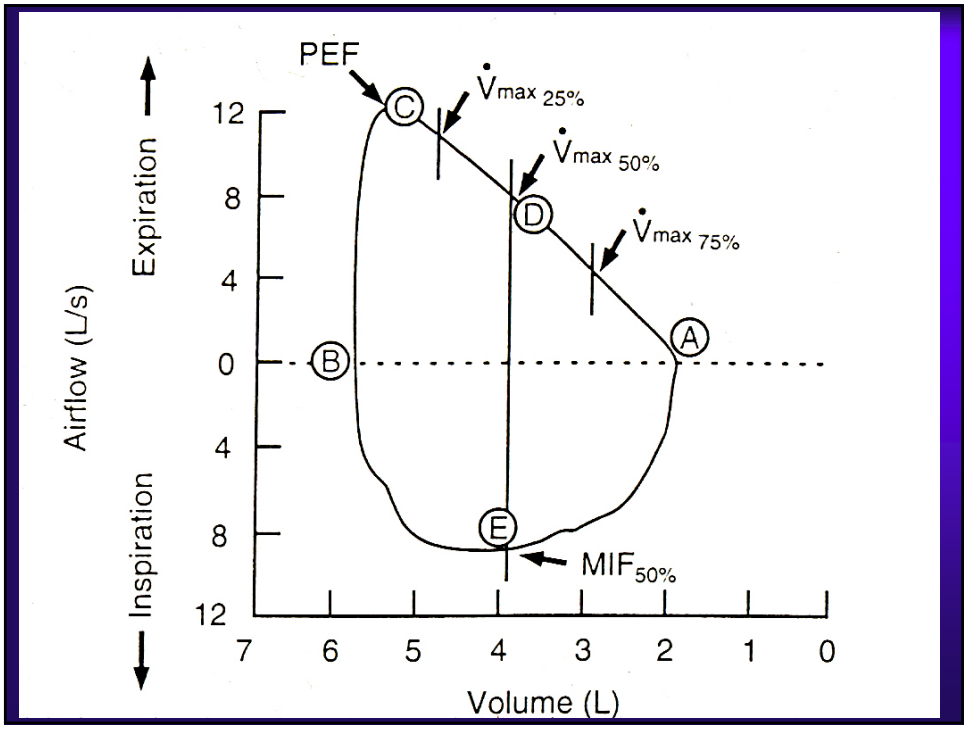

FEV1/FVC%=50
FEV1
FVC
Liters
5
4
3
2
1
0
0
1
2
3
4
5
B

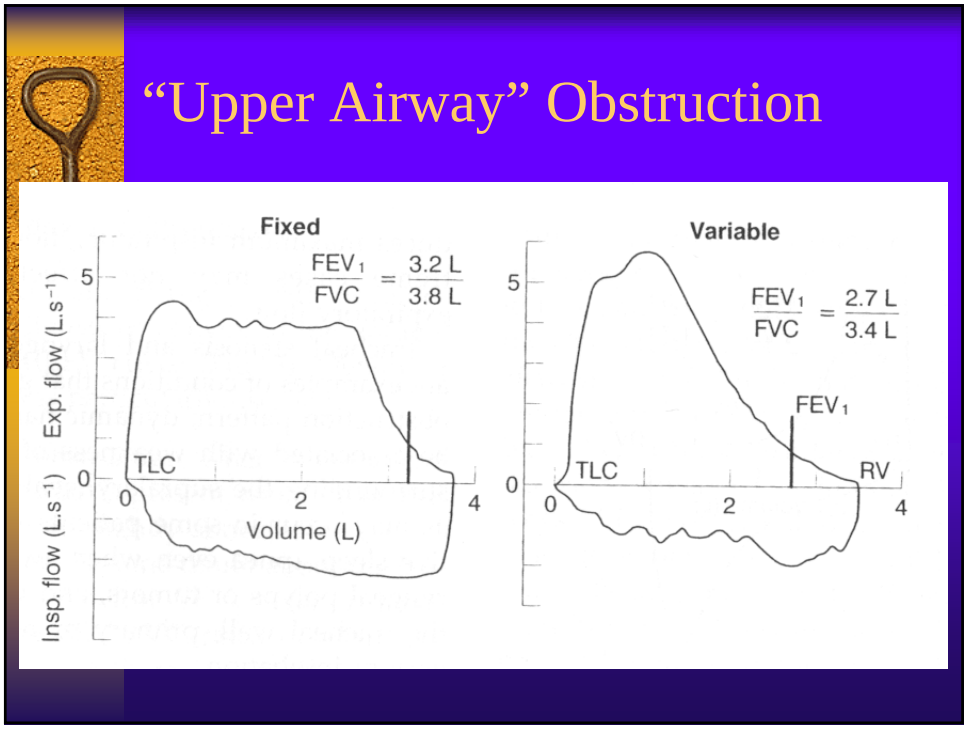

Normal
Mild
Advanced
PEF
FEV1/FVC = 3.3 L/4.0 L
FEV1/FVC = 2.4 L/3.7 L
FEV1/FVC = 0.8 L/2.2 L
FEV1
RV
TLC
MIFV
Exp. flow (L·s⁻¹)
Insp. flow (L·s⁻¹)
Volume (L)
10
5
0
2
4

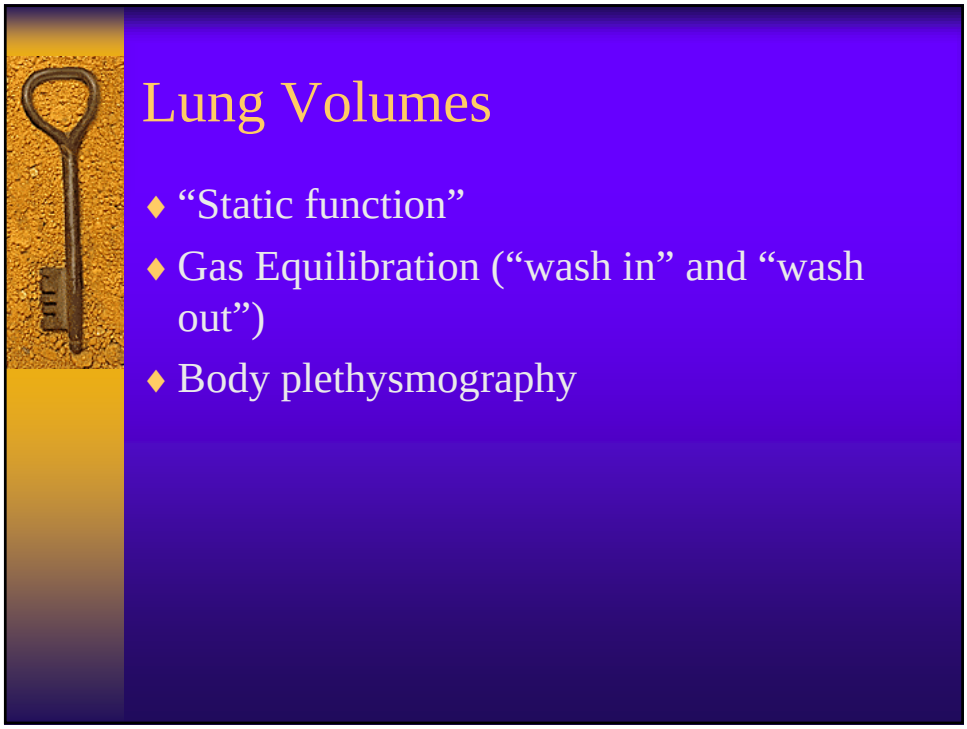


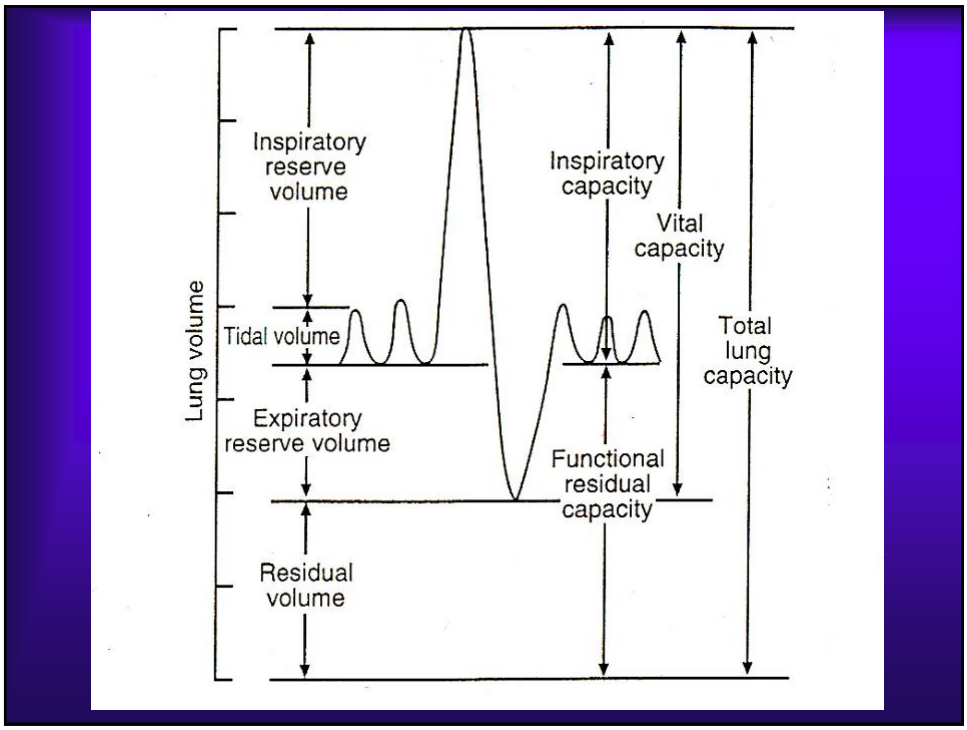
Patient: [redacted]
Id: [redacted]
Age: 65 Gender: Male
Location: Out-Pt Date: [redacted]
Height(in): 70 (cm): 179
Temp: 29 PBar: 7
Weight(lb): 204 (kg): 92.5
Physician: [redacted]
Technician: GD

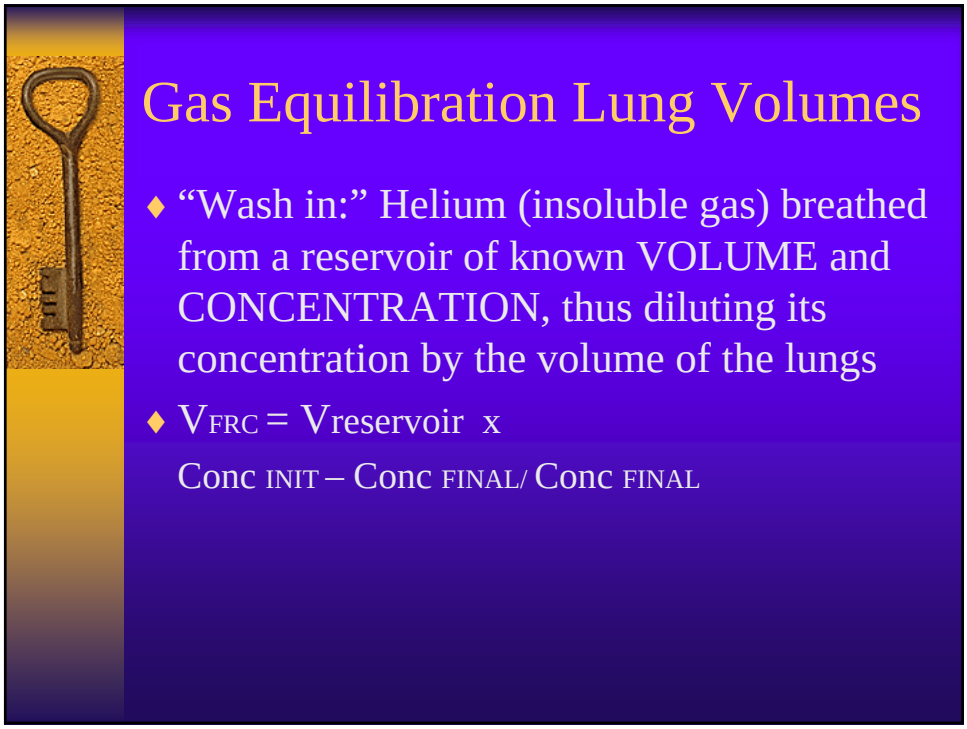
Spirometry		Ref	Pre Meas	Pre % Ref	Post Meas	Post % Ref
FVC	Liters	4.70	1.93	41	2.71	58
FEV1	Liters	3.63	0.54	15	0.60	17
FEV1/FVC	%	77	28		22	
FEF25-75%	L/sec	2.88	0.25	9	0.24	8
FEF25%	L/sec	7.80	0.27	3	0.29	4
FEF50%	L/sec	4.32	0.18	4	0.19	4
FEF75%	L/sec	1.57	0.10	6	0.09	6
PEF	L/sec	8.44	2.27	27	2.96	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	

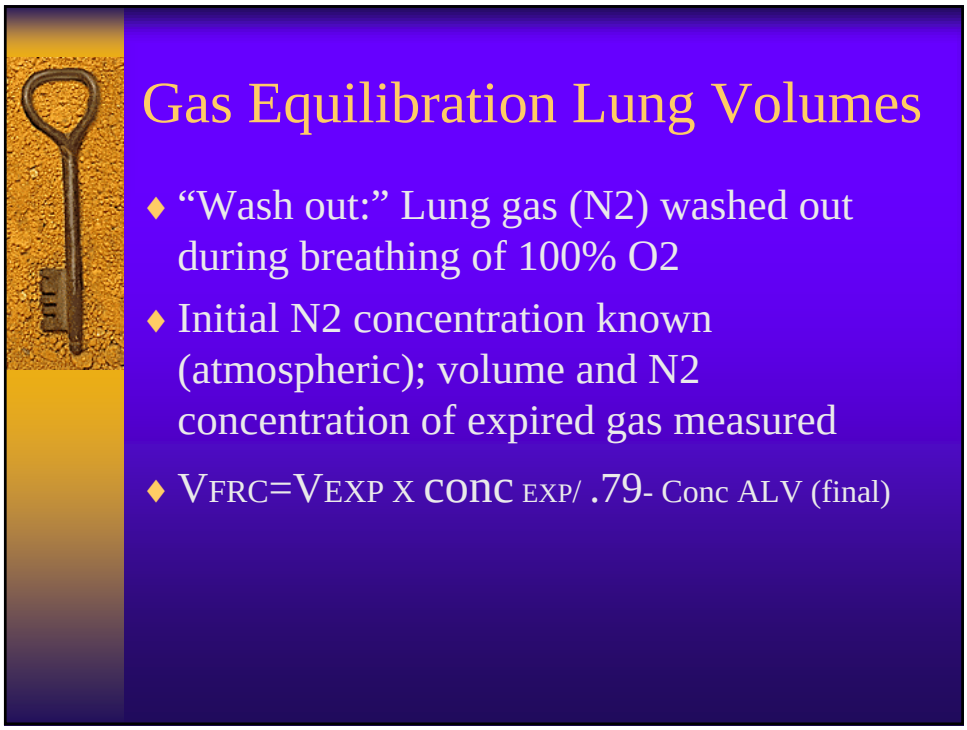

PEF
C
$\dot{V}_{max\ 25\%}$
$\dot{V}_{max\ 50\%}$
D
$\dot{V}_{max\ 75\%}$
A
B
E
$MIF_{50\%}$
Expiration
Inspiration
Airflow (L/s)
12
8
4
0
4
8
12
7
6
5
4
3
2
1
0
Volume (L)

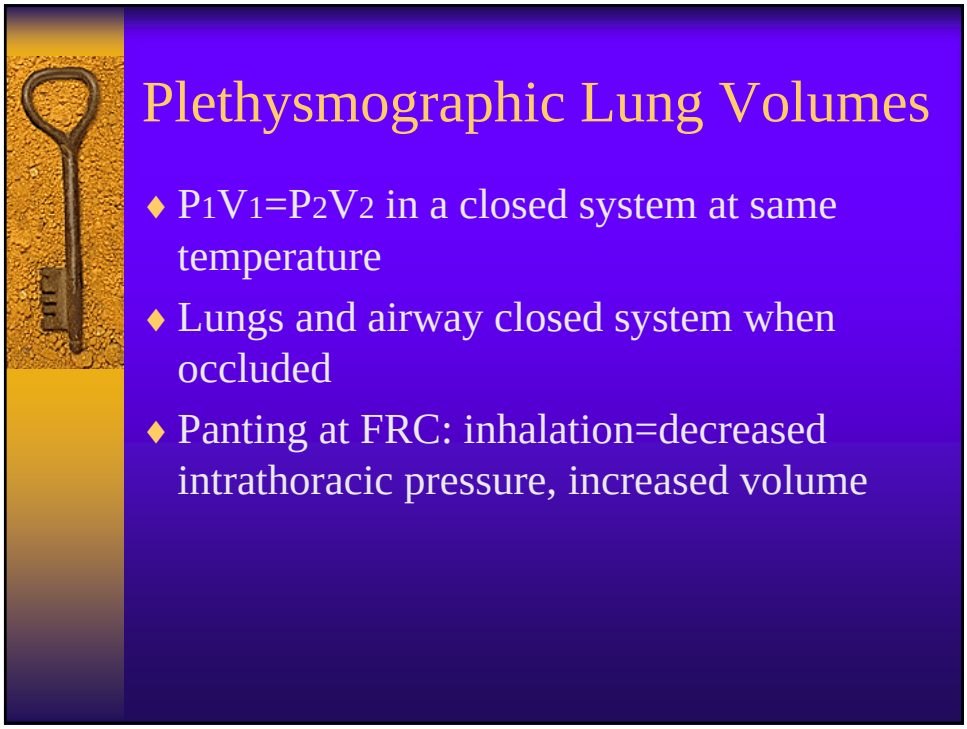

"Upper Airway" Obstruction
Fixed
$\frac{FEV_1}{FVC} = \frac{3.2\ L}{3.8\ L}$
Exp. flow (L.s⁻¹)
Insp. flow (L.s⁻¹)
5
0
TLC
0
2
4
Volume (L)
Variable
$\frac{FEV_1}{FVC} = \frac{2.7\ L}{3.4\ L}$
FEV_1
TLC
RV
5
0
0
2
4

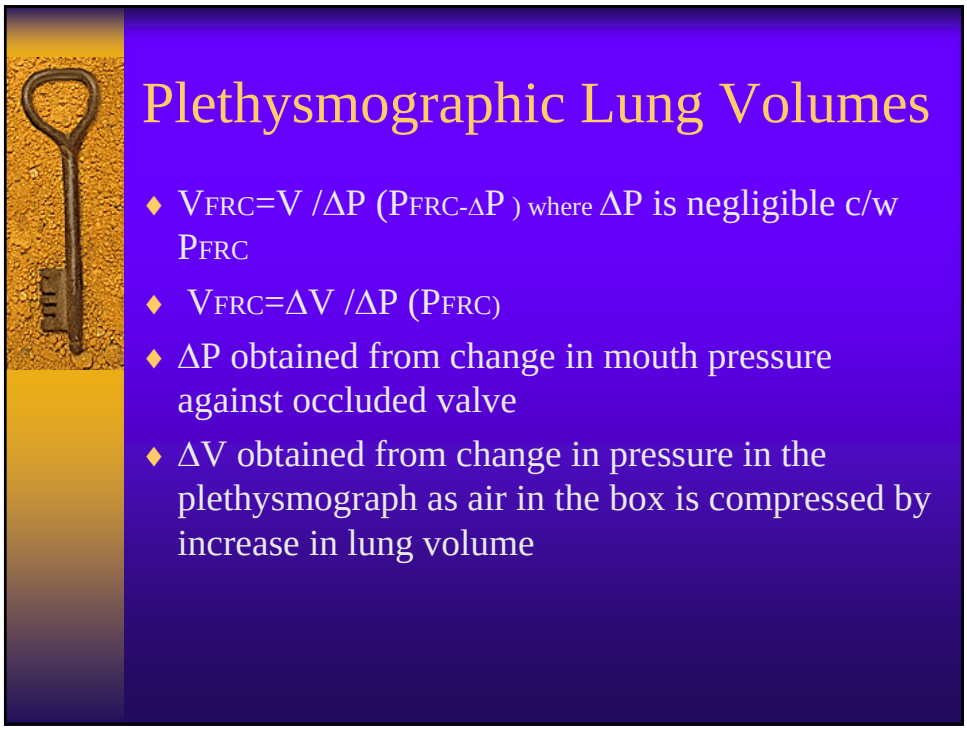

Lung Volumes
♦ "Static function"
♦ Gas Equilibration ("wash in" and "wash out")
♦ Body plethysmography


Lung volume
Inspiratory reserve volume
Tidal volume
Expiratory reserve volume
Residual volume
Inspiratory capacity
Vital capacity
Total lung capacity
Functional residual capacity


Gas Equilibration Lung Volumes
♦ "Wash in:" Helium (insoluble gas) breathed from a reservoir of known VOLUME and CONCENTRATION, thus diluting its concentration by the volume of the lungs
♦ VFRC = Vreservoir x
Conc INIT – Conc FINAL/ Conc FINAL


Gas Equilibration 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
♦ $P_1V_1=P_2V_2$ in a closed system at same temperature
♦ Lungs and airway closed system when occluded
♦ Panting at FRC: inhalation=decreased intrathoracic pressure, increased volume


Plethysmographic Lung Volumes
♦ $V_{FRC}=V/\Delta P (P_{FRC}-\Delta P)$ where ΔP is negligible c/w P_{FRC}
♦ $V_{FRC}=\Delta V/\Delta P (P_{FRC})$
♦ ΔP obtained from change in mouth pressure against occluded valve
♦ ΔV obtained from change in pressure in the plethysmograph as air in the box is compressed by increase in lung volume

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

Types of Restrictive Defects

- Parenchymal removal/destruction
- Parenchymal infiltration
- Extrapulmonary deformity
- Reduced force generation

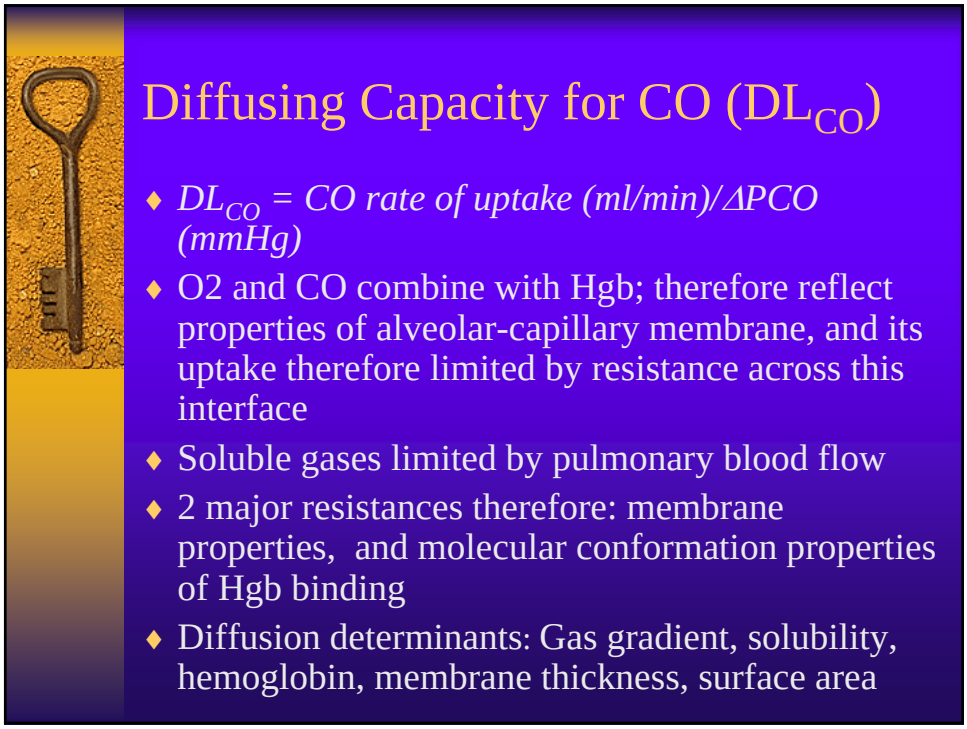
Restrictive patterns

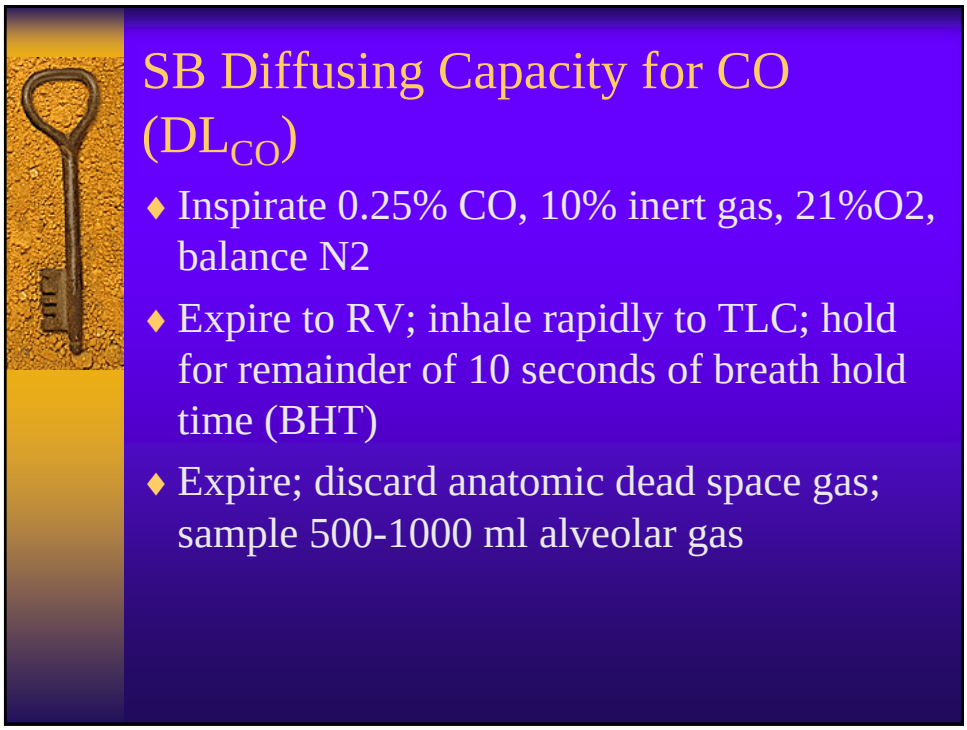
- Diffuse parenchymal disease, thoracic cage restriction: symmetric decrease in TLC, VC, FRC, RV
- Neuromuscular weakness: IC mainly decreased; TLC and VC decreased and FRC and RV spared

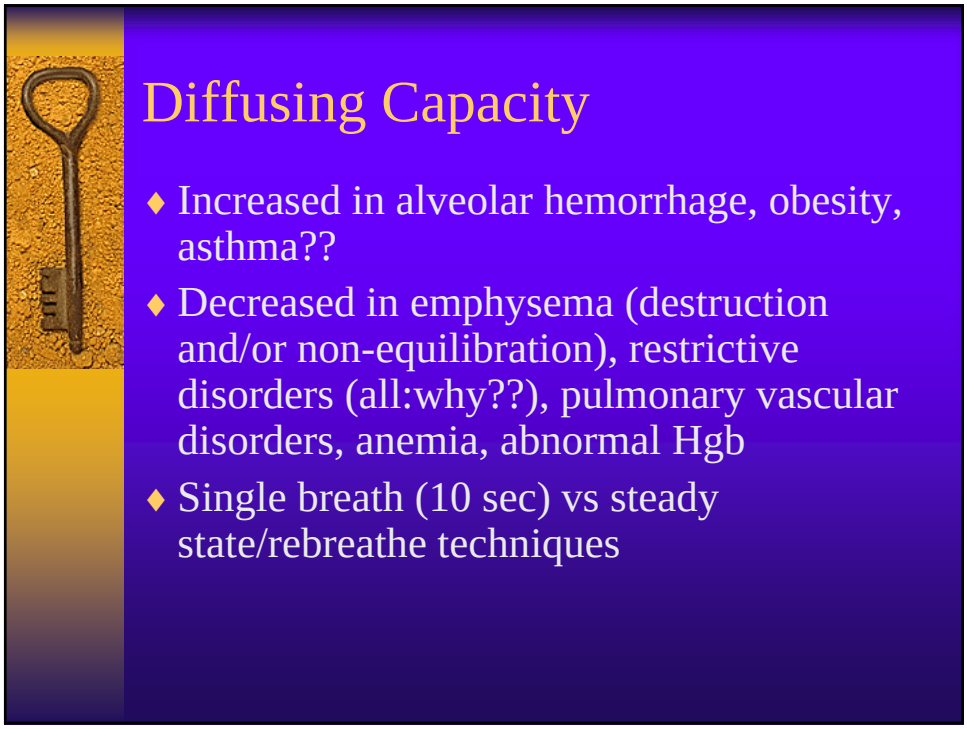
Height: 69 in (176 cm) Weight: 203 lb (92.3 kg)
Body Mass Index: 29.80

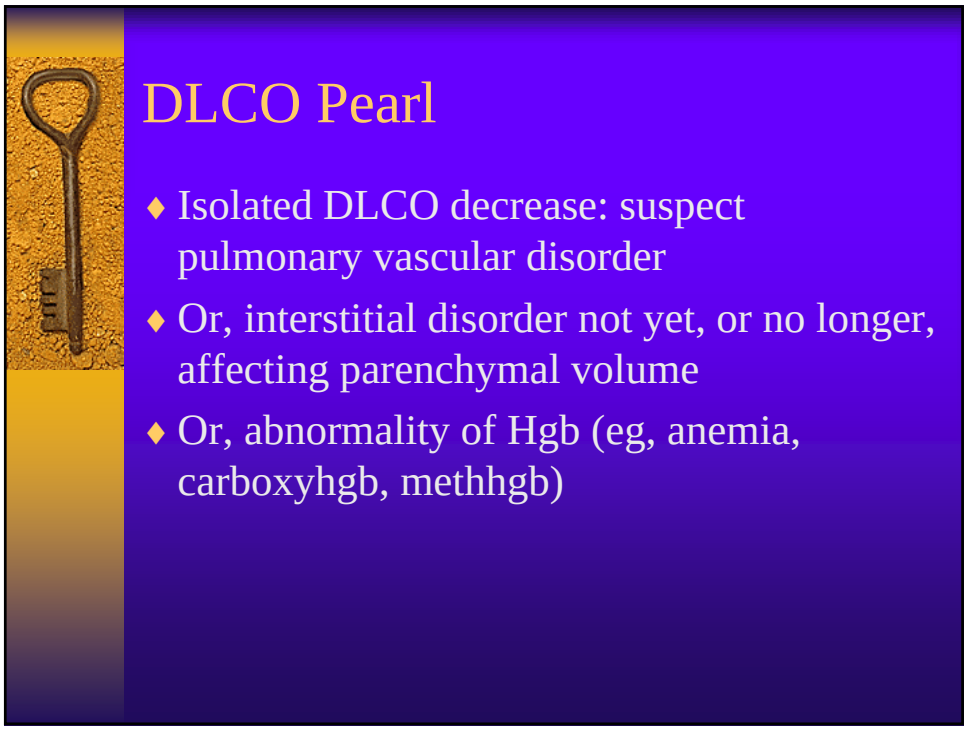
Physician: [redacted]
Technician: AE

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})
♦ *DL_{CO} = CO rate of uptake (ml/min)/ΔPCO (mmHg)*
♦ O2 and CO combine with Hgb; therefore reflect properties of alveolar-capillary membrane, and its uptake therefore limited by resistance across this interface
♦ Soluble gases limited by pulmonary blood flow
♦ 2 major resistances therefore: membrane properties, and molecular conformation properties of Hgb binding
♦ Diffusion determinants: Gas gradient, solubility, hemoglobin, membrane thickness, surface area


SB Diffusing Capacity for CO (DL_{CO})
♦ Inspirate 0.25% CO, 10% inert gas, 21%O2, balance N2
♦ Expire to RV; inhale rapidly to TLC; hold for remainder of 10 seconds of breath hold time (BHT)
♦ Expire; discard anatomic dead space gas; sample 500-1000 ml alveolar gas


Diffusing Capacity
♦ Increased in alveolar hemorrhage, obesity, asthma??
♦ Decreased in emphysema (destruction and/or non-equilibration), restrictive disorders (all:why??), pulmonary vascular disorders, anemia, abnormal Hgb
♦ Single breath (10 sec) vs steady state/rebreathe techniques


DLCO Pearl
♦ Isolated DLCO decrease: suspect pulmonary vascular disorder
♦ Or, interstitial disorder not yet, or no longer, affecting parenchymal volume
♦ Or, abnormality of Hgb (eg, anemia, carboxyhgb, methhgb)

Pre-operative Pulmonary Assessment: PFTs

- Complications: highest for thoracic and upper abdominal (ie, near the diaphragm)
- All having lung resection, orthopoedic and lower abdominal with lung disease, or smoking
- Age>60 years

Pre-operative Pulmonary Assessment: PFTs

- Spirometry: FEV1 or FVC <70%, FEV1/FVC<65%
- PaCO2>45 mmHg in COPD
- None contraindicate
- Lung resection: FEV1 best for pulmonary reserve and post op complications; post op FEV1 <30% predicted=increased long term mortality and immediate post op problems

Pre-operative Pulmonary Assessment: PFTs

- DLCO <40%, PaCO2>45 mmHg specific risk factors
- VO2 max <20 mL/kg/min excessive mortality
- Does not apply to LVRS: should have TLC>/=110%, RV>220%, FEV1</=45%, DLCO</=70%

PFT Summary

- Obstructive ventilatory defect: decreased FEV1/FVC
- Restrictive ventilatory defect: decreased TLC
- Low DLCO: abnormal uptake of gas by Hgb across alveolar capillary membrane: Diffusion determinants= Gas gradient, solubility, hemoglobin, membrane thickness, surface area
- Disorders with airway dysequilibration (emphysema): gas dilution will underestimate lung volumes (and ? DLCO)

Series ‘‘ATS/ERS TASK FORCE: STANDARDISATION OF LUNG FUNCTION TESTING’’ Edited by V. Brusasco, R. Crapo and G. Viegi. General considerations for lung function testing

Eur Respir J 2005; 26: 153–161