

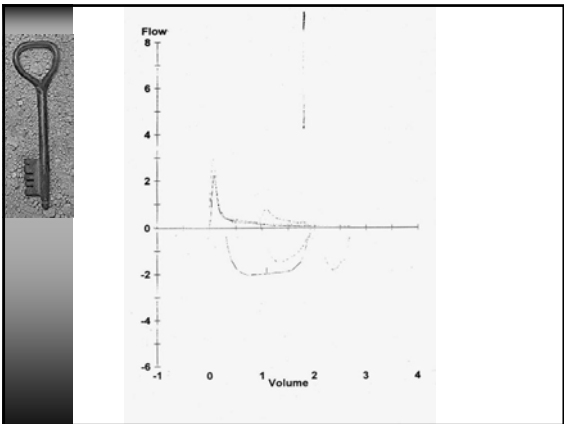
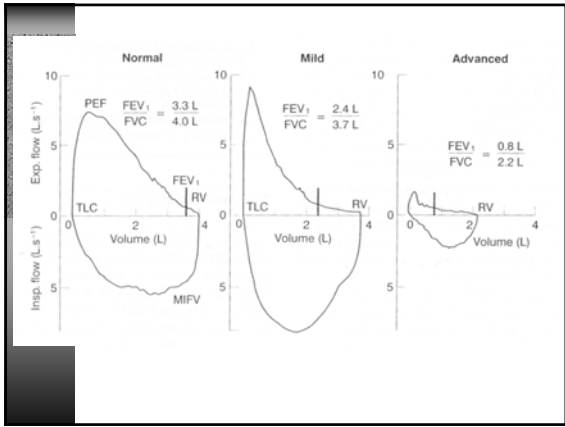
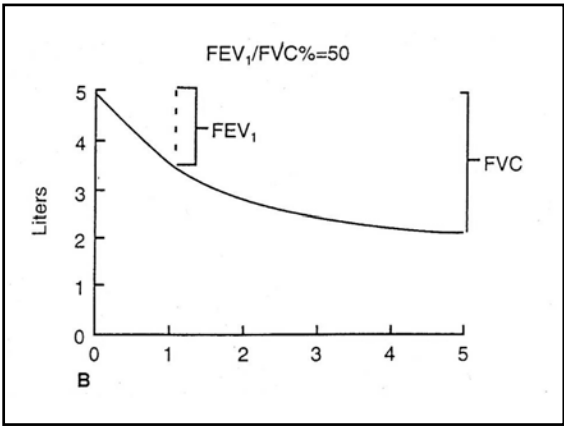
Obstructive Ventilation: Expiratory

- ◆ Decrease in expiratory airflow (volume and/or rate of flow)
- ◆ FEV₁ decreased
- ◆ FVC normal or decreased
- ◆ FEV₁/FVC decreased*
- ◆ FEF₂₅₋₇₅ decreased

*definition of obstructive defect

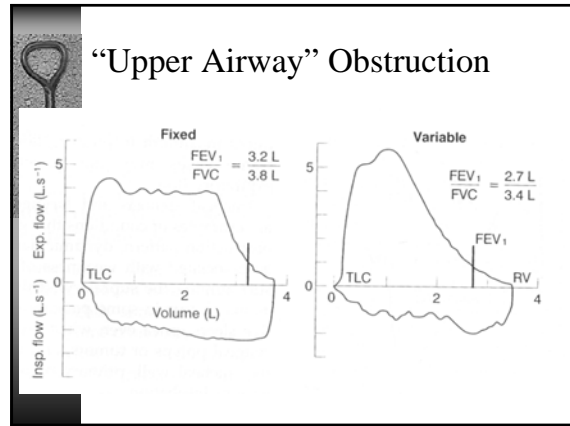
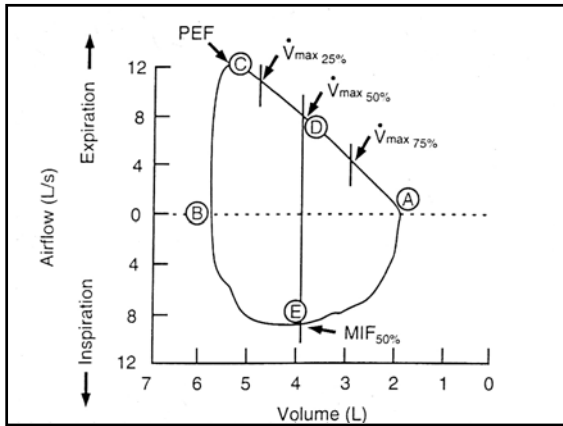
Types of Airflow Obstruction

- ◆ 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"



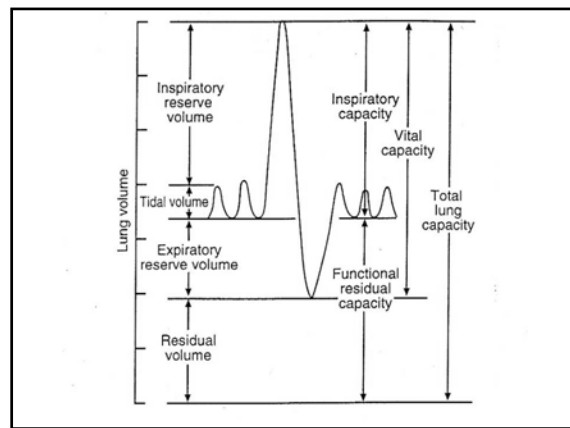
Patient: [REDACTED] Gender: Male Location: Out-Pt Date: [REDACTED]
 Age: 65 Height(in): 70 (cm): 179 Temp: 29 PBar: 7
 Weight(lb): 204 (kg): 92.5 Physician: [REDACTED] Technician: GD

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	
FEF _{25-75%}	L/sec	2.88	0.25	9	0.24	8
FEF _{25%}	L/sec	7.80	0.27	3	0.29	4
FEF _{50%}	L/sec	4.32	0.18	4	0.19	4
FEF _{75%}	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				
FIF _{50%}	L/sec	4.59				
FET _{100%}	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	



Lung Volumes

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




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
- ◆ $V_{FRC} = V_{reservoir} \times \frac{Conc\ INIT - Conc\ FINAL}{Conc\ FINAL}$


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
- ◆ $V_{FRC} = V_{EXP} \times \frac{Conc\ EXP}{.79 - Conc\ ALV\ (final)}$



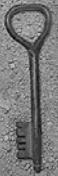
Plethysmographic Lung Volumes

- ◆ $P_1 V_1 = P_2 V_2$ 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

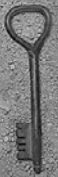
- ◆ A decrease in lung expansion
- ◆ FEV1 decreased
- ◆ FVC decreased
- ◆ FEV1/FVC normal or increased
- ◆ Total Lung Capacity (TLC) decreased*

* 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) Location: 5000
 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		
PIF50%	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})

- ◆ $DL_{CO} = CO \text{ rate of uptake (ml/min)} / \Delta PCO \text{ (mmHg)}$
- ◆ 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, orthopaedic 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