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”
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”
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
  \[ V_{FRC} = V_{reservoir} \times \frac{\text{Conc init} - \text{Conc final}}{\text{Conc final}} \]

- “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
  \[ V_{FRC} = V_{exp} \times \text{conc exp}^{0.79} \times \text{conc ALV} \text{ (final)} \]
Plethysmographic Lung Volumes
- $P_{V1}=P_{V2}$ in a closed system at same temperature
- Lungs and airway closed system when occluded
- Panting at FRC: inhalation=decreased intrathoracic pressure, increased volume

$V_{FRC}=V / \Delta P (P_{FRC}-\Delta P)$ where $\Delta P$ is negligible c/w $P_{FRC}$

$V_{FRC}=\Delta V / \Delta P (P_{FRC})$

$\Delta P$ obtained from change in mouth pressure against occluded valve

$\Delta V$ 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

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
Diffusing Capacity for CO (DL\textsubscript{CO})

- $DL_{CO} = \frac{CO \text{ rate of uptake (ml/min)}}{\Delta PCO (mmHg)}$
- O\textsubscript{2} 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\textsubscript{CO})

- Inspirate 0.25% CO, 10% inert gas, 21%O\textsubscript{2}, balance N\textsubscript{2}
- 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/rebreath 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, orthopedic and lower abdominal with lung disease, or smoking
- Age>60 years

Pre-operative Pulmonary Assessment: PFTs

- Spirometry: FEV\textsubscript{1} or FVC <70%, FEV\textsubscript{1}/FVC<65%
- PaCO\textsubscript{2}>45 mmHg in COPD
- None contraindicate
- Lung resection: FEV\textsubscript{1} best for pulmonary reserve and post op complications; post op FEV\textsubscript{1} <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)

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