Pulmonary Function Tests

Spirometry

Spirometry and Maximal Expiratory and Inspiratory Flow Volume Curves

“Dynamic function”
Obstructive Ventilation
- Decrease in expiratory airflow due to airway narrowing
- 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)
- Upper Airway
- Small Airways
- “Mixed”
- Emphysema: FVC < slow or inspiratory VC, and plethysmographic volumes greater than gas dilution volumes.

PFT Pearl #1
- FEV1/FVC=obstructive ventilatory defect
- Why is FEV1 itself NOT diagnostic of an obstructive defect?
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
- $V_{FRC} = \text{Reservoir Volume} \times \frac{\text{Initial Concentration} - \text{Final Concentration}}{\text{Final Concentration}}$
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
- \[ V_{FRC} = V_{EXP} \times \text{conc}_{EXP} \times .79 \times \text{conc}_{ALV} \text{ (final)} \]

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
- \[ P_{FC} \times V_{FC} = (P_{FC} - \Delta P)(V_{FC} + \Delta V); \Delta P \] 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

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

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

\[
\frac{\Delta \text{IC}}{\Delta \text{Dm}} = \frac{1}{\text{DL}_{\text{CO}}} = \frac{1}{\text{Dm}} = \frac{1}{\text{Vc}}
\]

(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
- Hypoventilation, Gas exchange abnormality, Shunt physiology

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