Pulmonary Function Tests

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Pulmonary Function Tests

- Spirometry
- Peak-Flowmetry
- Bronchoprovocation Tests
- Body Box Plethysmography
- Nitrogen Washout Test
- DLco
SPIROMETRY

Physiology

- Tidal Volume
- Inspiratory Reserve Volume
- Expiratory Reserve Volume
- Residual Volume
- Vital Capacity
- Total Lung Capacity
SPIROMETRY

Volume measuring Spirometers

Flow measuring Spirometers
  - Hot wire cooling
  - IR scattering
SPIROMETRY
The FVC Maneuver

- Maximal inspiration and then rapidly, forcefully and completely exhale.
- Sitting or Standing.
- Nose clip.
- No hesitation in start of test.
- Patient Instruction is necessary.
SPIROMETRY
Spirometric Parameters

- Forced Vital Capacity (FVC)
- Forced expiratory Volume in 1st second (FEV₁)
- FEV₁/ FVC
- Peak expiratory flow rate (PEFR)
- Mean expiratory flow during the middle half of FVC (FEF25-75)
SPIROMETRY
Acceptability of Spirogram

- At least 3 forced expiratory curves that are free from:
  - Interruptions due to coughing, glottis closure or...
  - Hesitant or false start.
  - Inconsistent effort.
  - Early termination.
  - Excessive variability (Two largest FVC or FEV1 should not vary by more than 5%).
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Acceptability Criteria

- Maximal inspiration at start
- Maximal expiratory effort with no hesitation or false start (VEXT or Back Extrapolated volume < 5% of FVC if FVC is more than 3 liters or < 150 ml if FVC less than 3 liters)
- No cough or discontinuity of effort in the first second
- No obstruction of airflow by mouthpiece, tongue, teeth or glottis
- Satisfactory end of effort (Plateau on volume-time curve with < 40 ml exhaled over the last 2 seconds or usually at least 6 seconds)
- No leak (e.g., from nose, lips, mouthpiece, ... )
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Reproducibility Criteria

- Largest and second largest FVC within 5% or 100 ml
- Largest and second largest FEV1 within 5% or 100 ml
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Spirometric Tests Interpretation

- **Selecting Predicted Values:**
  Age, Gender, Race, Height,

- **Setting Lower Limit of Normal (LLN):**
  - 80% of predicted values.
  - 95th percentile method.
  - 95% confidence interval \( [\text{Predicted value} - (1.645 \times \text{SEE})] \)
Almost 100 published paper about “Reference Value” in the world

Two published papers in international journals from Iran:
  - Boskabadi (2002)

3-4 published paper about reference value in Iranian Journal:
  - Kashan
  - Kordestan
  - Yazd
  - sari
SPIROMETRY
Selecting Predicted Values:

- ERS/ ECCS predicted values for men:
  - FVC = 5.76 H -0.026A - 4.34 (SEE = 0.61)
  - FEV1 = 4.30H -0.029A - 2.49 (SEE = 0.51)

- ERS/ ECCS predicted values for women:
  - FVC = 4.43 H -0.026A - 2.89 (SEE = 0.43)
  - FEV1 = 3.95H -0.025A - 2.60 (SEE = 0.38)
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Spirometric Tests Interpretation

Severity of Obstruction:

Mild: FEV1 >= 70%
Moderate: 60% <= FEV1 < 70%
Moderately Severe: 50% <= FEV1 < 60%
Severe: 34% <= FEV1 < 50%
Very Severe: FEV1 < 34%
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Spirometric Tests Interpretation

Severity of Restriction*

- **Mild:** $70\% = \text{FVC} < \text{LLN}$
- **Moderate:** $60\% = \text{FVC} < 70\%$
- **Moderately Severe:** $50\% = \text{FVC} < 60\%$
- **Severe:** $34\% = \text{FVC} < 50\%$
- **Very Severe:** $\text{FVC} < 34\%$

*When TLC is not available.

LLN = Lower Limit of Normal.
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Reporting

- A testing session may consist of three to eight acceptable efforts.
- Failure to meet acceptability and reproducibility criteria should be noted. The largest FEV1 and the Largest FVC from all acceptable maneuvers should be reported.
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Common Mistakes

- Erroneous measurement of patient’s height
- Errors arising from selected reference value
- Early Termination
- Poor Effort (Weak Push) (Inadequate Force)
- Small inspiration
- Poor Start
- Poor reproducibility
Measurement of Real Height

Use of arm span

Indication:
- Kyphoscoliosis
- Paralytic individuals
- Lower extremities amputation

Method:

Correct measurement of arm span
- Men: real length = arm span/1.03
- Women: real length = arm span/1.01
SPIROMETRY

Analysis of trends: cross sectional vs. longitudinal

- When PFT is measured at regular intervals, the resulting data must be looked as trend of changes besides.
- After age 35 to 40 the annual decline of FEV1 & FVC in adults is about 25 to 30 ml.
- There is an acceleration in the rate of decline with age.
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Analysis of trends: Confounding factors

- PFTs done by different instruments
- PFTs done by different technicians
- PFTs interpreted using different predicted values
- PFTs done at different times of day (up to 5% variation)
- PFTs done when the subject was not healthy enough
- Learning effect
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Analysis of trends

- ATS: A greater than 15% change from year to year has to be considered significant.

- Zenz: A greater than 10% change from year to year has to be considered significant, 15% change is clinically significant.

- When comparing PFT's in longer intervals, be sure to adjust aging effect (30 ml/yr)
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Bronchodilator studies

- It is used to assess reversibility of airway obstruction
- Test to test & day to day variability
- An acute response to B.D correlates with clinical response to B.D or corticosteroid therapy in asthma & COPD
Most laboratories use $\beta$-agonists

The use of a large volume spacer device is recommended

Commercially available preparations of $\beta$-agonists use an alcohol carrier, which may irritate the airways (Paradoxical bronchospasm)
SPIROMETRY
Bronchodilator studies

- The lack of an acute B.D response does not rule out the presence of airway hyperresponsiveness.
- The lack of an acute B.D response does not preclude a beneficial clinical response to B.D therapy.
- Significant response may be determined on the basis of change in F-V curve shape, Subjective judgment, the magnitude of change in FEV1 (12% with an absolute value > 200ml).
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Preshift & Postshift testing

- It can demonstrate a significant physiologic change that may be related to workplace.
- Quality control is of paramount importance in performing comparative measurements.
- PFT indices are Max in early morning and Min in early afternoon with an 5% variation.
- A 10% decline in PFT indices during working shift is regarded significant.
- Delayed response to workplace exposures may not be detected by this method.
SPIROMETRY
Peak Flow measurement

- Follow daily trends in patients.
- Results are expressed as a percentage of the mean value for the 15-day period.
- A greater than 20% change in peak flow is usually considered significant.
- It is useful in detecting a relationship to occupational exposures when coupled with symptoms, use of medications and daily activities.
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Peak Flow measurement

- It is effort dependent.
- The patient should be well trained to be consistent.
- The patient is not blinded to results.
- Peak flow has greater within-person variability than FEV1 and may underestimate the degree of impairment in severe obstructive patients.
- Some patients with severe airway obstruction can have normal peak flows.
- Peak flow can be reduced for reasons other than airway obstruction.
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Peak Flow measurement

- The devices are not indestructible!
- The devices` accuracy may be impaired because of wetness or accumulated dust.
- There is no inexpensive calibration method available.
- Routine periodic replacement of Peakflowmeters is recommended.
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Measurement of absolute lung volumes

- Gas dilution techniques:
  - Helium dilution
  - Nitrogen washout
- Body box plethysmography
- Radiographic techniques
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Gas transfer studies

- Diffusing capacity measurement evaluates the absorption and excretion gas between the alveoli and the pulmonary capillaries.

- DLCO is a function of Surface area of alveolar membrane, efficiency of alveolar membrane and pulmonary capillary bed.
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Gas transfer studies

- Confounding factors are:
  - Variations in hemoglobin
  - Variations in carboxyhemoglobin
  - Altitude
  - Body position
SPIROMETRY

Gas transfer studies

- No consensus regarding indications for measurement of DLCO.
- Valuable screening test and a sensitive indicator of occupational-related interstitial disease.
- Possible indications are: restrictive disorders, obstructive disorders, cardiovascular disorders, other causes of gas exchange impairment and disability evaluation.
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Gas transfer studies

- DLCO is abnormal in restrictive disorders. (useful for diagnosis & long term follow up)
- DLCO is reduced in emphysema & cystic fibrosis.
- DLCO is reduced in thromboembolism, fat embolism, pulmonary hypertension & pulmonary edema.
- DLCO is increased in obesity, asthma, polycythemia, pulmonary hemorrhage, exercise & increased pulmonary capillary bed (e.g. left to right intracardiac shunt).
Tiffeneau was the first to suspect that nonallergic airway responsiveness contributes to the way in which human airways react when exposed to common allergens.

There is a relationship between airway inflammation and airway responsiveness.
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Bronchoprovocation Tests

- Bronchial Challenge:
  - Histamine
  - Metacholine
  - Cold Air
  - Exercise

- PC20: The concentration of metacholine causing a 20% drop in FEV1

- Normal subjects have a PC20>=8
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Bronchoprovocation Tests

Screening Occupational Asthma:
- In Preplacement Exams for places with known occupational sensitizers.
- The presence of hyperresponsiveness should not be used to exclude worker, repeating test serially may lead to Asthma Dx.
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Bronchoprovocation Tests

- Diagnosing Occupational Asthma:
  - In subjects with symptoms & FEV1/FVC > LLN