Respiratory system

Introduction to Pulmonary Function Test (PFT)

Definition of Pulmonary Function Tests (PFTs)

- Pulmonary Function Tests (PFTs) are a group of non-invasive diagnostic tests that measure how well the lungs are functioning.
- These tests assess lung volume, capacity, rates of flow, and gas exchange efficiency.
- The results help in diagnosing various respiratory conditions and are vital in monitoring the effectiveness of pharmacological treatments.
- In pharmacotherapeutics, understanding PFTs is essential to evaluate the baseline lung function, monitor disease progression, assess treatment response, and guide therapeutic decision-making in patients with pulmonary diseases.

Purpose and Clinical Importance of PFTs

In pharmacotherapeutics, PFTs are used for multiple purposes:

- **Diagnosis of Pulmonary Disorders**: Such as asthma, chronic obstructive pulmonary disease (COPD), interstitial lung disease, and restrictive lung disorders.
- **Evaluating Treatment Response**: After administering bronchodilators, corticosteroids, or other respiratory medications.
- **Monitoring Disease Progression**: In chronic diseases like COPD or cystic fibrosis.
- **Pre-operative Assessment**: To determine the risk of respiratory complications during and after surgery.
- **Assessing Drug-Induced Pulmonary Toxicity**: Certain drugs (e.g., amiodarone, methotrexate, bleomycin) can cause lung toxicity; PFTs help in early detection.
- **Determining Severity and Staging**: Especially in chronic diseases like COPD, to determine the stage and guide pharmacologic management.

Types of Pulmonary Function Tests

- Several tests fall under the umbrella of PFTs.

Each has specific clinical and pharmacotherapeutic implications:

Spirometry

- **Most commonly used PFT**.
- Measures **airflow** by recording the volume of air exhaled and the speed at which it is exhaled.
- Key parameters:
  - **FVC (Forced Vital Capacity)**: Maximum volume of air exhaled after full inhalation.
  - **FEV1 (Forced Expiratory Volume in 1 second)**: Volume of air exhaled in the first second of FVC.

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- **FEV1/FVC ratio**: Helps differentiate between obstructive and restrictive lung diseases.

- **Pharmacotherapeutic relevance**:
  - Used to assess the efficacy of **bronchodilators** (e.g., albuterol).
  - A **post-bronchodilator increase** in FEV1 indicates **reversible airway obstruction** (common in asthma).

Peak Expiratory Flow Rate (PEFR)

- Measures the **maximum speed of expiration**.
- Often used for **daily monitoring** in asthma patients.
- **Pharmacotherapeutic relevance**:
  - Used for **asthma self-management plans**.
  - Helps determine if a change in medication (e.g., increasing inhaled corticosteroids) is needed.

Lung Volume Tests (e.g., Plethysmography)

- Measure **total lung capacity (TLC)**, **residual volume (RV)**, and other lung volumes not measured by spirometry.
- **Pharmacotherapeutic relevance**:
  - Helpful in diagnosing **restrictive lung diseases**, which may not respond to bronchodilators.
  - Used to monitor **drug-induced pulmonary fibrosis** (e.g., due to chemotherapy).

Diffusion Capacity Test (DLCO - Diffusing Capacity for Carbon Monoxide)

- Measures how well gases (like oxygen) pass from the lungs into the blood.
- Abnormal in conditions like **interstitial lung disease**, **emphysema**, and **pulmonary hypertension**.
- **Pharmacotherapeutic relevance**:
  - Can help detect **early pulmonary toxicity** due to medications.
  - Useful in monitoring response to **anti-fibrotic therapy** or **immunosuppressants**.

Arterial Blood Gas Analysis (ABG) (though not always classified as PFT, it's often used in conjunction)

- Measures oxygen and carbon dioxide levels, as well as acid-base status.
- Important in assessing **respiratory failure** or **ventilatory function**.
- **Pharmacotherapeutic relevance**:
  - Guides oxygen therapy, ventilation support, and adjustments in **respiratory depressant drugs**.

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Interpretation of PFT Results – In Pharmacotherapy Context

Understanding PFT interpretations is crucial for selecting the appropriate medication and evaluating its effectiveness:

Pattern	PFT Findings	Common Conditions	Pharmacotherapeutic Implication
Obstructive	↓ FEV1, ↓ FEV1/FVC	Asthma, COPD	Use of bronchodilators, anti-inflammatory agents
Restrictive	↓ FVC, Normal or ↑ FEV1/FVC	Pulmonary fibrosis, obesity, neuromuscular disorders	Use of anti-fibrotic agents, immunosuppressants
Mixed	↓ FVC and ↓ FEV1/FVC	Combined diseases	Combination therapy

Role of PFTs in Monitoring Pharmacotherapy

- **Asthma**: Improvement in FEV1 or PEFR indicates response to inhaled corticosteroids or bronchodilators.
- **COPD**: Stable FEV1 may indicate control; decline suggests need to escalate therapy (e.g., adding LAMA/LABA).
- **Interstitial Lung Disease**: Decrease in DLCO or FVC may require initiation or intensification of immunosuppressive therapy.
- **Drug Toxicity**: Baseline and periodic PFTs help detect lung damage caused by medications like:
    - **Amiodarone** (antiarrhythmic)
    - **Bleomycin** (chemotherapy)
    - **Methotrexate** (immunosuppressant)
    - **Nitrofurantoin** (antibiotic)

Asthma

Introduction

- Asthma is a chronic, reversible inflammatory disorder of the airways, marked by variable airflow obstruction and bronchial hyperresponsiveness.
- Episodes are usually triggered by allergens, pollutants, infections, cold air, exercise, or emotional stress, leading to bronchospasm, mucus hypersecretion, and airway inflammation.
- The disease course ranges from mild intermittent symptoms to severe persistent asthma.

Epidemiology

- Asthma affects over 300 million individuals globally. Its prevalence has increased, particularly in urban and industrialized areas.

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- In India, pediatric prevalence is around 10–15%, and adult asthma is about 2–5%, with under-diagnosis still common.
    - Age: Common in children, but may present at any age.
    - Gender: More common in boys during childhood, while adult onset is more common in females.
    - Mortality: Though rare, asthma-related deaths are typically due to severe exacerbations and poor control.

Etiopathogenesis

- Asthma involves both genetic susceptibility and environmental exposures.
- The hallmark is an exaggerated Th2 immune response to inhaled allergens.
- Pathophysiological Mechanisms:
    - Allergen exposure leads to activation of Th2 lymphocytes, producing IL-4, IL-5, and IL-13.
    - IL-4 promotes IgE synthesis, while IL-5 recruits eosinophils causing airway inflammation.
    - IL-13 increases mucus secretion and airway remodeling.
    - Mast cell degranulation releases histamine and leukotrienes, causing bronchoconstriction.
    - Chronic inflammation leads to subepithelial fibrosis, goblet cell hyperplasia, and smooth muscle hypertrophy, which contribute to persistent symptoms in chronic asthma.

Clinical Features

- Patients typically present with episodic or persistent respiratory symptoms that fluctuate in intensity and are often worse at night or early morning.
    - **Wheezing**: High-pitched whistling on exhalation.
    - **Cough**: May be dry or productive, often nocturnal.
    - **Breathlessness**: Intermittent, worsened by triggers like exertion or allergens.
    - **Chest tightness**: Sensation of constriction in the chest.
    - **Fatigue**: Particularly during or after exacerbations.
    - **Symptoms worsen with**: Exercise, cold air, smoke, stress, or respiratory infections.

Diagnosis & Investigations

- Asthma diagnosis is **clinical**, supported by **pulmonary function tests (PFTs)** and **bronchodilator reversibility testing**.
- **Key Diagnostic Tools:**

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- **Spirometry**: Reduced FEV_1/FVC ratio (<0.75–0.8), with **reversibility ≥12% and ≥200 mL** in FEV_1 post-bronchodilator.
- **Peak Expiratory Flow Rate (PEFR)**: Daily variability >10% supports diagnosis.
- **Methacholine/Bronchoprovocation Test**: For equivocal cases.
- **Eosinophil count**: Blood/sputum eosinophilia in allergic or eosinophilic asthma.
- **Chest X-ray**: Usually normal but done to rule out other causes.
- **Skin prick test / IgE levels**: If allergic asthma is suspected.

Treatment Goals

- Achieve and maintain symptom control.
- Prevent exacerbations and hospitalizations.
- Preserve normal lung function.
- Reduce reliance on rescue medication.
- Minimize treatment-related adverse effects.
- Improve quality of life and sleep.
- Ensure patient adherence and education.

Non-Pharmacological Management

- **Avoidance of triggers**: Dust, mites, smoke, mold, pollen, chemical fumes.
- **Environmental control**: Allergen-proof mattresses, remove carpets, improve ventilation.
- **Smoking cessation**: Most essential lifestyle change.
- **Physical activity**: Encouraged, but with pre-medication if exercise-induced.
- **Vaccination**: Annual **influenza** and **pneumococcal** vaccines.
- **Patient education**: Inhaler technique, symptom monitoring, written asthma action plan.

Pharmacological Therapy (Stepwise Approach)

- Asthma treatment is **step-based**, adjusting medication intensity according to disease severity.
- **Stepwise Treatment Approach (Adapted from GINA 2024):**

Step	Asthma Severity	Preferred Treatment
Step 1	Mild intermittent	Low-dose ICS-Formoterol as needed
Step 2	Mild persistent	Daily low-dose ICS or as-needed ICS-Formoterol
Step 3	Moderate persistent	Low-dose ICS + LABA (e.g., Budesonide + Formoterol)
Step 4	Severe persistent	Medium/high-dose ICS + LABA; add LAMA or LTRA if needed
Step 5	Severe, uncontrolled	Add biologics (e.g., Omalizumab, Mepolizumab); refer to specialist

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