Chronic Obstructive Pulmonary Disease

COPD is a progressive lung disease characterized by airflow limitation, often complicated by exacerbations. This handout provides a comprehensive overview for PA students, covering chronic management, exacerbations in the hospital, staging, diagnosis, PFT interpretation, GOLD scores, and outpatient treatment.

Definition and Epidemiology

- **Definition:**
  - Chronic COPD:
    - A preventable and treatable disease characterized by persistent respiratory symptoms and airflow limitation due to airway and/or alveolar abnormalities, usually caused by significant exposure to noxious particles or gases (e.g., smoking, biomass fuel).
  - COPD Exacerbation:
    - An acute worsening of respiratory symptoms (e.g., dyspnea, cough, sputum production) beyond normal day-to-day variation, often requiring a change in therapy.
  - Epidemiology:
    - Prevalence: Affects ~16 million adults in the U.S.; globally, ~300 million people (GOLD 2024).
  - Risk Factors:
    - Smoking (80-90% of cases), secondhand smoke, occupational exposures (e.g., coal dust), air pollution, biomass fuel exposure, alpha-1 antitrypsin deficiency (AATD).
  - Demographics:
    - More common in adults >40 years, male predominance (though increasing in females), higher rates in low socioeconomic groups.
  - Mortality:
    - 3rd leading cause of death worldwide; ~150,000 deaths/year in the U.S.

Pathophysiology

- **Chronic COPD:**
  - Mechanisms:
    - Airway Inflammation: Chronic exposure to irritants (e.g., cigarette smoke) → Inflammatory response (neutrophils, macrophages, CD8+ T-cells) → Release of proteases (e.g., elastase) → Destruction of alveolar walls (emphysema) and airway remodeling (chronic bronchitis).
    - Airflow Limitation: Loss of elastic recoil (emphysema), airway narrowing (chronic bronchitis), and mucus hypersecretion → Obstructive pattern on PFTs (↓ FEV1/FVC).
    - Gas Trapping: Airway collapse during expiration → Hyperinflation, increased residual volume (RV), and decreased inspiratory capacity.
    - V/Q Mismatch: Increased dead space (high V/Q regions, e.g., bullae in emphysema) → Hypercapnia; low V/Q regions → Hypoxemia.
    - Systemic Effects: Systemic inflammation → Weight loss, muscle wasting, cardiovascular disease, osteoporosis, depression.

- **COPD Exacerbation:**
  - Triggers:
    - Respiratory infections (viral 50%, bacterial 30-40%), air pollution, non-adherence to therapy, heart failure, pulmonary embolism (PE).
  - Mechanisms:
    - Acute inflammation: → Increased airway edema, mucus production, and bronchoconstriction → Worsened airflow limitation ↑ Dead space: → Hypercapnia ($PaCO_2$ >50 mmHg); hypoxemia from V/Q mismatch. Respiratory muscle fatigue: → Hypoventilation → Respiratory acidosis (pH <7.35).

Diagnosis and Staging

- **Diagnosis:**
  - Clinical History:
    - Dyspnea (progressive, worse with exertion), chronic cough, sputum production, history of smoking (>20 pack-years), occupational exposures.

- Pulmonary Function Tests (PFTs):
  - Obstructive Pattern: FEV1/FVC <0.7 post-bronchodilator confirms airflow limitation.
  - Severity: Based on FEV1 % predicted (GOLD staging, see table below).
  - Bronchodilator Response: Improvement in FEV1 >12% and >200 mL suggests reversibility (e.g., asthma overlap), but not required for COPD diagnosis.
- Imaging:
  - Chest X-Ray (CXR): Hyperinflation, flattened diaphragms, bullae (emphysema); rules out other causes (e.g., pneumonia, pneumothorax).
  - CT Chest: Emphysema (centrilobular, paraseptal), bronchiectasis, or incidental findings (e.g., lung nodules).
- Labs: Alpha-1 Antitrypsin (AAT) Level: Screen if early onset (<45 years), family history, or panlobular emphysema.
  - CBC, BMP:
  - Rule out anemia, electrolyte abnormalities.

• Differential Diagnosis:

- Asthma: Younger age, reversible obstruction, atopy history.
- Bro nchiectasis:Recurrent infections, large-volume sputum, CT findings.
- Heart Failure:Orthopnea, edema, elevated BNP, CXR with pulmonary edema.
- Interstitial Lung Disease (ILD): Restrictive pattern on PFTs, CT with fibrosis.

PFT Interpretation

Parameter	COPD Finding	Interpretation	Notes
FEV1/FVC	<0.7 (post-bronchodilator)	Obstructive pattern	Confirms COPD diagnosis; <0.7 after albuterol.
FEV1	↓ (<80% predicted)	Severity of obstruction	GOLD staging: 1 (≥80%), 2 (50-79%), 3 (30-49%), 4 (<30%).
FVC	Normal or ↓	May be reduced in severe COPD	Due to air trapping, hyperinflation.
TLC	↑ (>120% predicted)	Hyperinflation	Emphysema; increased residual volume (RV).
DLCO	↓ (<80% predicted)	Emphysema severity	Reduced in emphysema (alveolar destruction); normal in chronic bronchitis.

GOLD Classification and Staging

• GOLD Staging (Based on FEV1):

Used to assess airflow limitation severity (post-bronchodilator FEV1/FVC <0.7).

• GOLD ABCD Assessment Tool:

Combines symptom burden and exacerbation risk:

- Symptom Burden: Assessed by mMRC dyspnea scale (0-4) or CAT score (0-40).
  - mMRC ≥2 or CAT ≥10 → High symptoms.
- Exacerbation Risk:
  - Based on history of exacerbations or hospitalizations.
  - Group A: Low symptoms, low risk (0-1 exacerbation/year, no hospitalizations).
  - Group B: High symptoms, low risk.
  - Group C: Low symptoms, high risk (≥2 exacerbations or ≥1 hospitalization).
- Group D: High symptoms, high risk.
- Guides outpatient treatment (see below).

GOLD Classification Table

Stage	FEV1 % Predicted	Description
GOLD 1 (Mild)	≥80%	Mild airflow limitation, often asymptomatic.
GOLD 2 (Moderate)	50-79%	Symptomatic (dyspnea, cough), exacerbations possible.
GOLD 3 (Severe)	30-49%	Severe symptoms, frequent exacerbations, reduced quality of life.
GOLD 4 (Very Severe)	<30%	End-stage, chronic respiratory failure, cor pulmonale risk.

Clinical Presentation

• Chronic COPD:

- Symptoms: Dyspnea on exertion, chronic cough (often productive), wheezing, fatigue, weight loss (late-stage).

- Exam:
  - Barrel chest,
  - hyperresonance on percussion, decreased breath sounds, prolonged expiration, accessory muscle use.
  - Late-Stage:
    - Cyanosis, digital clubbing (if bronchiectasis), signs of cor pulmonale (JVD, edema, RV heave).
- Comorbidities:
  - Cardiovascular disease (e.g., CAD, HTN), osteoporosis, depression, lung cancer.

- **COPD Exacerbation:**

- Symptoms: Increased dyspnea, cough, sputum production (purulent if bacterial), wheezing, chest tightness.
- Exam:
  - Tachypnea (RR >20), hypoxemia (SpO2 <90%), accessory muscle use, wheezing, crackles (if infection or heart failure).
  - Severe: Altered mental status, cyanosis, respiratory fatigue.
- Red Flags: SpO2 <88% despite O2, PaCO2 >60 mmHg with pH <7.30 → Consider BiPAP, Hemodynamic instability, respiratory arrest → Intubate.

Diagnostic Workup

- **Chronic COPD:**

- PFTs: Confirm diagnosis (FEV1/FVC <0.7), assess severity (FEV1 % predicted).
- CXR/CT Chest: Emphysema, rule out other causes (e.g., lung mass).
- ABG: If hypoxemia (SpO2 <90%) or hypercapnia suspected (late-stage).
  - 6-Minute Walk Test (6MWT):
- Assess functional capacity, desaturation.
- Screen for AATD:If early onset or family history.

- **COPD Exacerbation:**

- Arterial Blood Gas (ABG): Hypoxemia, PaO2 <60 mmHg. Hypercapnia: PaCO2 >50 mmHg, pH <7.35 (respiratory acidosis).
- CXR: Rule out pneumonia, pneumothorax, heart failure.
- Labs:
  - CBC: Leukocytosis (infection), anemia.
  - BMP: Electrolytes, renal function.
  - BNP: If heart failure suspected.

    - Sputum Culture: If purulent sputum (e.g., Pseudomonas in severe COPD).
- Other Tests:
    - EKG: Rule out arrhythmia, RV strain (if PE suspected).
    - D-dimer/CTPA: If PE suspected (e.g., sudden onset, clear CXR).
    - Influenza/RSV PCR: If viral trigger suspected (seasonal).

Management Flowsheet: COPD Exacerbation in the Hospital

Management Flowsheet

- **Step 1:** Assess Severity ABG: PaO2 <60 mmHg, PaCO2 >50 mmHg, pH <7.35, SpO2 <88%, respiratory distress?
- **Step 2:** Oxygen/BiPAP,
    - O2: Target SpO2 88-92% (nasal cannula, Venturi).
    - BiPAP: If PaCO2 >50 mmHg, pH 7.25-7.35 (IPAP 10-20 cmH2O, EPAP 4-8 cmH2O).
    - Intubate: If pH <7.25, respiratory arrest.
- **Step 3**: Bronchodilators/Steroids
    - Albuterol 2.5 mg + ipratropium 0.5 mg nebs q4h.
    - Prednisone 40 mg PO daily x 5 days.
- **Step 4:** Antibiotics (If Indicated)
    - Purulent sputum: Azithromycin 500 mg day 1, then 250 mg x 4 days.
    - Severe: Levofloxacin 750 mg IV daily.
- **Step 5**: Monitor/Discharge
    - ABG q2-4h, SpO2, respiratory rate.
    - Discharge: SpO2 >88%, no BiPAP, outpatient regimen (LABA/LAMA).

Treatment

Chronic COPD (Outpatient Management)

- Non-Pharmacologic:
    - Smoking Cessation: Counseling, nicotine replacement (e.g., patches), varenicline 1 mg BID x 12 weeks.
    - Vaccinations: Influenza (annually), pneumococcal (PCV20), COVID-19.
    - Pulmonary Rehabilitation: Exercise training, education, nutrition counseling (improves quality of life, reduces exacerbations).
    - Oxygen Therapy: If PaO2 ≤55 mmHg or SpO2 ≤88% at rest; titrate to SpO2 88-92%.

- Pharmacologic (GOLD ABCD Groups):
  - Group A (Low Symptoms, Low Risk):
    - SABA: Albuterol 90 mcg/inhalation PRN.
  - Group B (High Symptoms, Low Risk):
    - LABA or LAMA: E.g., salmeterol 50 mcg BID or tiotropium 1.25 mcg daily (Spiriva Respimat).
    - SABA PRN: Albuterol.
  - Group C (Low Symptoms, High Risk):
    - LAMA: Tiotropium or umeclidinium 62.5 mcg daily.
    - SABA PRN.
  - Group D (High Symptoms, High Risk):
    - LABA + LAMA: E.g., indacaterol/glycopyrrolate (Utibron Neohaler).
    - Add ICS if eosinophil count ≥300/μL or asthma overlap: E.g., budesonide/formoterol 160/4.5 mcg, 2 puffs BID.
    - SABA PRN.
    - Add Roflumilast 500 mcg daily (if FEV1 <50%, chronic bronchitis).
    - Azithromycin 250 mg 3x/week (if frequent exacerbations, non-smoker).
- Advanced Therapies:
  - Lung Volume Reduction Surgery (LVRS): For severe emphysema, upper lobe predominant, FEV1 20-35%.
- Lung Transplant: For end-stage COPD (FEV1 <20%, BODE index ≥7).
- Key Tips:
- LAMA/LABA preferred over ICS (ICS only if eosinophil ≥300/μL or asthma history; risk of pneumonia with ICS).
- Monitor adherence: Incorrect inhaler technique common cause of poor control.

COPD Exacerbation (Hospital Management)

- General Principles:
  - Reverse bronchoconstriction, improve oxygenation/ventilation, treat infection, and prevent recurrence.
  - Supportive Care:
    - Oxygen Therapy: Target SpO2 88-92% (avoid over-oxygenation → Risk of CO2 retention). Nasal cannula, Venturi mask, or high-flow nasal cannula (HFNC) if severe hypoxemia.

- Non-Invasive Ventilation (NIV):
  - BiPAP: First-line for hypercapnic failure ($PaCO_2$ >50 mmHg, pH 7.25-7.35).
    - Settings: IPAP 10-20 cmH_2O, EPAP 4-8 cmH_2O; titrate to improve pH, $PaCO_2$.
    - Contraindications: Altered mental status, pneumothorax, inability to protect airway.
  - Intubation/Mechanical Ventilation:
    - Indications: Failure of BiPAP (pH <7.25, rising $PaCO_2$), respiratory arrest, severe hypoxemia (PaO_2/FiO_2 <150).
    - Settings: Avoid overventilation (target pH >7.25, not $PaCO_2$ normalization); low tidal volume (6-8 mL/kg IBW), PEEP 5 cmH_2O.
- Pharmacologic:
- Bronchodilators:
  - SABA: Albuterol 2.5 mg nebulized q20min x 3, then q1-4h.
  - SAMA: Ipratropium 0.5 mg nebulized q20min x 3, then q4-6h.
  - Corticosteroids: Prednisone 40 mg PO daily x 5 days (or methylprednisolone 60 mg IV if unable to tolerate PO). Short course reduces exacerbation duration, hospital stay (GOLD 2024).
- Antibiotics (If Infection Suspected):
  - Indications: increased sputum purulence + increased dyspnea or sputum volume.
    - Mild-Moderate: Azithromycin 500 mg PO day 1, then 250 mg daily x 4 days or doxycycline 100 mg PO BID x 5 days.
  - Severe (e.g., ICU, Pseudomonas risk): Levofloxacin 750 mg IV daily or piperacillin-tazobactam 4.5 g IV q6h x 5-7 days.
- Magnesium Sulfate: 2 g IV over 20 min (if severe bronchospasm, not routine).

- Treat Precipitants:
  - Heart Failure: Diuretics (furosemide 40 mg IV), nitroglycerin if hypertensive.
  - PE: Anticoagulation (heparin 80 units/kg IV bolus, then 18 units/kg/h).
- Pneumonia: Antibiotics (e.g., ceftriaxone + azithromycin), oxygen.
- Monitor:
  - ABG q2-4h (if BiPAP/intubated), continuous SpO_2, respiratory rate, mental status.
  - Daily CXR if intubated (rule out pneumothorax, VAP).
- Key Tips:
  - BiPAP first for hypercapnic failure; intubate if pH <7.25 or respiratory arrest.

- Antibiotics only if purulent sputum or severe exacerbation (e.g., ICU).
- Transition to outpatient regimen once stable (SpO2 >88%, no BiPAP requirement).

Examples

1. Case 1: Chronic COPD (GOLD B)

- Presentation: 60 y/o M, 40 pack-year smoker, dyspnea on exertion (mMRC 2), FEV1 65% predicted, 1 exacerbation last year.
- Interpretation: GOLD Stage 2 (FEV1 50-79%), Group B (high symptoms, low risk).
- Management: Start tiotropium 1.25 mcg daily, albuterol PRN, smoking cessation counseling, pulmonary rehab, influenza vaccine.

2. Case 2: COPD Exacerbation (Moderate)

- Presentation: 65 y/o F, known COPD, increased dyspnea, purulent sputum, SpO2 86% on room air, ABG: PaO2 55 mmHg, PaCO2 48 mmHg, pH 7.38.
- Interpretation: Moderate exacerbation, hypoxemia, no respiratory acidosis.
- Management: O2 via nasal cannula (SpO2 88-92%), albuterol 2.5 mg + ipratropium 0.5 mg nebulized q4h, prednisone 40 mg PO daily x 5 days, azithromycin 500 mg PO day 1 then 250 mg x 4 days, monitor ABG.

3. Case 3: COPD Exacerbation (Severe, Hypercapnic)

- Presentation: 70 y/o M, severe COPD, dyspnea, lethargy, SpO2 80%, ABG: PaO2 50 mmHg, PaCO2 70 mmHg, pH 7.28.
- Interpretation: Severe exacerbation, hypercapnic respiratory failure (Type 2).
- Management: BiPAP (IPAP 15 cmH2O, EPAP 5 cmH2O), albuterol + ipratropium nebs, methylprednisolone 60 mg IV daily, levofloxacin 750 mg IV daily, repeat ABG in 1h, consider ICU if no improvement.

4. Case 4: Chronic COPD (GOLD D)

- Presentation: 68 y/o F, FEV1 40% predicted, 3 exacerbations last year (1 hospitalization), CAT score 15.
- Interpretation: GOLD Stage 3 (FEV1 30-49%), Group D (high symptoms, high risk).
- Management: Indacaterol/glycopyrrolate BID, budesonide/formoterol 160/4.5 mcg BID (eosinophils 350/µL), albuterol PRN, azithromycin 250 mg 3x/week, oxygen (SpO2 ≤88%), pulmonary rehab.

5. Case 5: COPD with AATD

- Presentation: 42 y/o M, 10 pack-year smoker, dyspnea, FEV1 45% predicted, CT: panlobular emphysema, AAT level 20 mg/dL.
- Interpretation: GOLD Stage 3, AAT deficiency (genotype ZZ).
- Management: Augmentation therapy (IV AAT 60 mg/kg weekly), tiotropium daily, albuterol PRN, smoking cessation, genetic counseling for family.

Complications

• Chronic COPD:

- Pulmonary Hypertension: From chronic hypoxemia → Cor pulmonale (RV failure).
- Respiratory Failure: Chronic hypercapnia, hypoxemia (FEV1 <30%).
- Lung Cancer: 4-6x increased risk in smokers with COPD.
- Osteoporosis: Chronic inflammation, steroids → Fractures.

• Exacerbation:

- Respiratory Failure: Hypercapnic (Type 2) → BiPAP or intubation.
- Pneumothorax: From air trapping, bullae rupture.
- Ventilator-Associated Pneumonia (VAP): If intubated >48h.
- Arrhythmias: Hypoxemia, acidosis → Atrial fibrillation, VTach.

Prognosis

• Chronic COPD:

- Mortality: 5-year survival ~50% for FEV1 <50%; worse with frequent exacerbations.
- BODE Index: Predicts mortality (Body mass index, Obstruction [FEV1], Dyspnea [mMRC], Exercise [6MWT]); score ≥7 → High risk.

• Exacerbation:

- Mortality: 10-20% in-hospital if requiring NIV; 20-40% if intubated.
- Recovery: 70-80% recover to baseline within 4-6 weeks; worse outcomes if frequent exacerbations.

• Key Factors:

- Smoking cessation improves survival (up to 10 years gained).

- Pulmonary rehab, LAMA/LABA, and oxygen (if indicated) reduce exacerbations.
- Comorbidities (e.g., heart failure, lung cancer) worsen prognosis.

Key Pearls

- COPD Diagnosis:
  - FEV1/FVC <0.7 post-bronchodilator; stage with FEV1 % predicted.
- GOLD ABCD:
  - Guides outpatient therapy (LAMA/LABA for most; ICS if eosinophils ≥300/μL).
- Exacerbation:
  - O2 (SpO2 88-92%), BiPAP for hypercapnia (pH 7.25-7.35), intubate if pH <7.25.
- Antibiotics:
  - Only if purulent sputum or severe exacerbation (e.g., ICU).
- Chronic Management:
  - Smoking cessation, pulmonary rehab, vaccinations critical.
- AATD:
  - Screen if early onset, panlobular emphysema; augmentation therapy if deficient.

References

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"COPD Management" (2025).

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- CHEST:

"Non-Invasive Ventilation in COPD Exacerbations" (2022).