Role of Remote Patient Monitoring in Chronic Obstructive Pulmonary Disease

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Disclosures

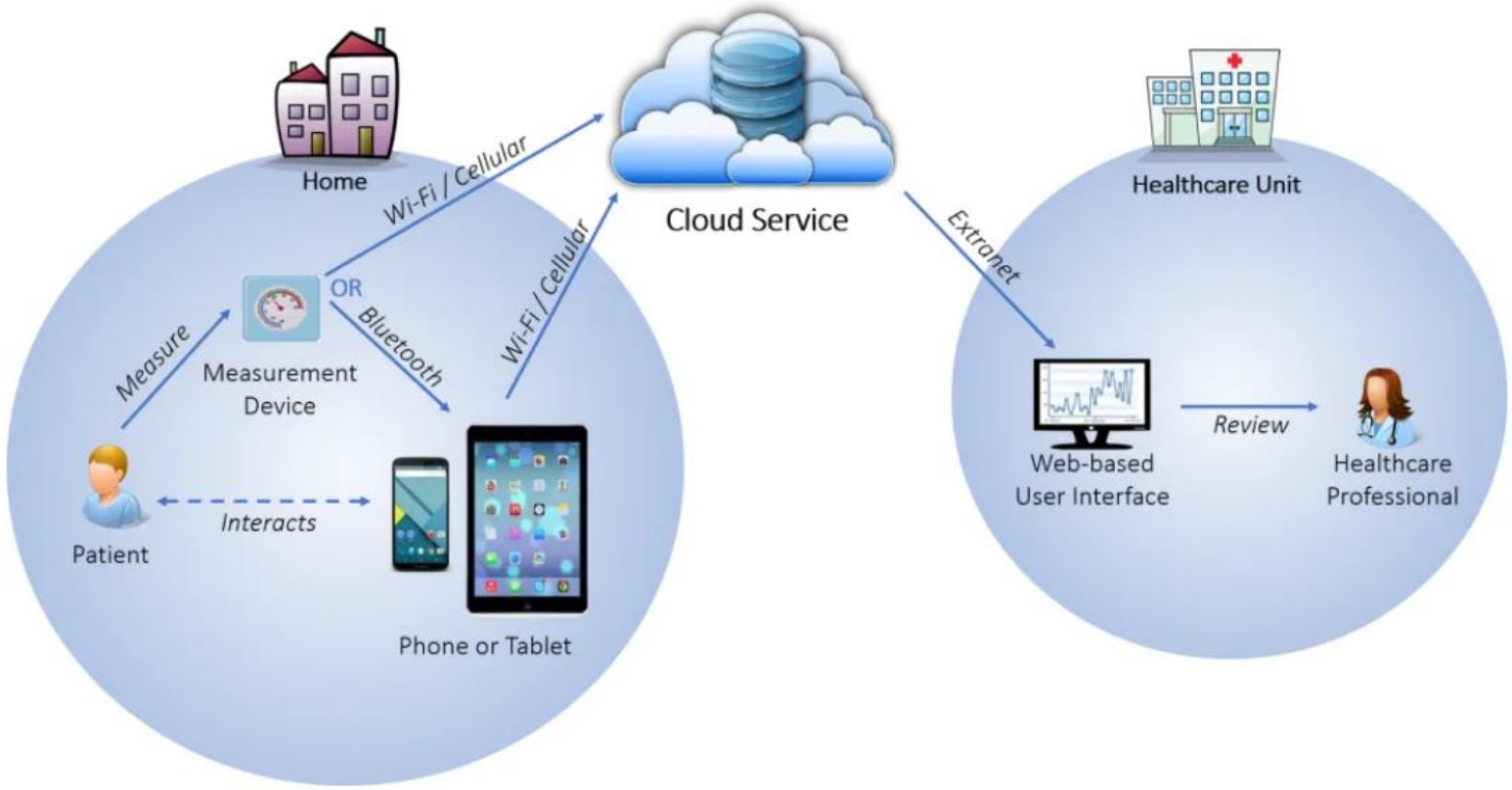
- I have no relevant conflicts of interest to disclose in relation to this presentation.

Objectives

- Describe remote patient monitoring (RPM) and its role in chronic obstructive pulmonary disease (COPD)
- Review COPD burden, pathophysiology, assessment, and management of stable COPD and exacerbations
- Discuss available technologies and monitoring parameters for COPD RPM
- Assess the overall impact of RPM on healthcare costs, healthcare utilization, patient outcomes, patient satisfaction, and quality of life
- Apply what we learned to a patient case

Remote Patient Monitoring Overview

Remote Patient Monitoring



- Remote collection and analysis of patient physiological data to manage an acute or chronic health condition
- Data must be electronically submitted, may be integrated to electronic medical record or portal
- Can contain programmable alerts for out-of-range values

Koskimies, O. *Med Devops*. 2019.

RPM Use Cases & Benefits

- Hypertension
- Diabetes
- COPD
- Heart Failure
- Sleep Apnea
- Obesity
- Asthma

Use Cases

- Decreased healthcare utilization
- Reduced healthcare costs
- Improved health outcomes, including chronic conditions

Benefits

Telethealth. HHS. 2022.

COPD Overview

COPD Burden

Increased morbidity and mortality

> 3 million deaths each year

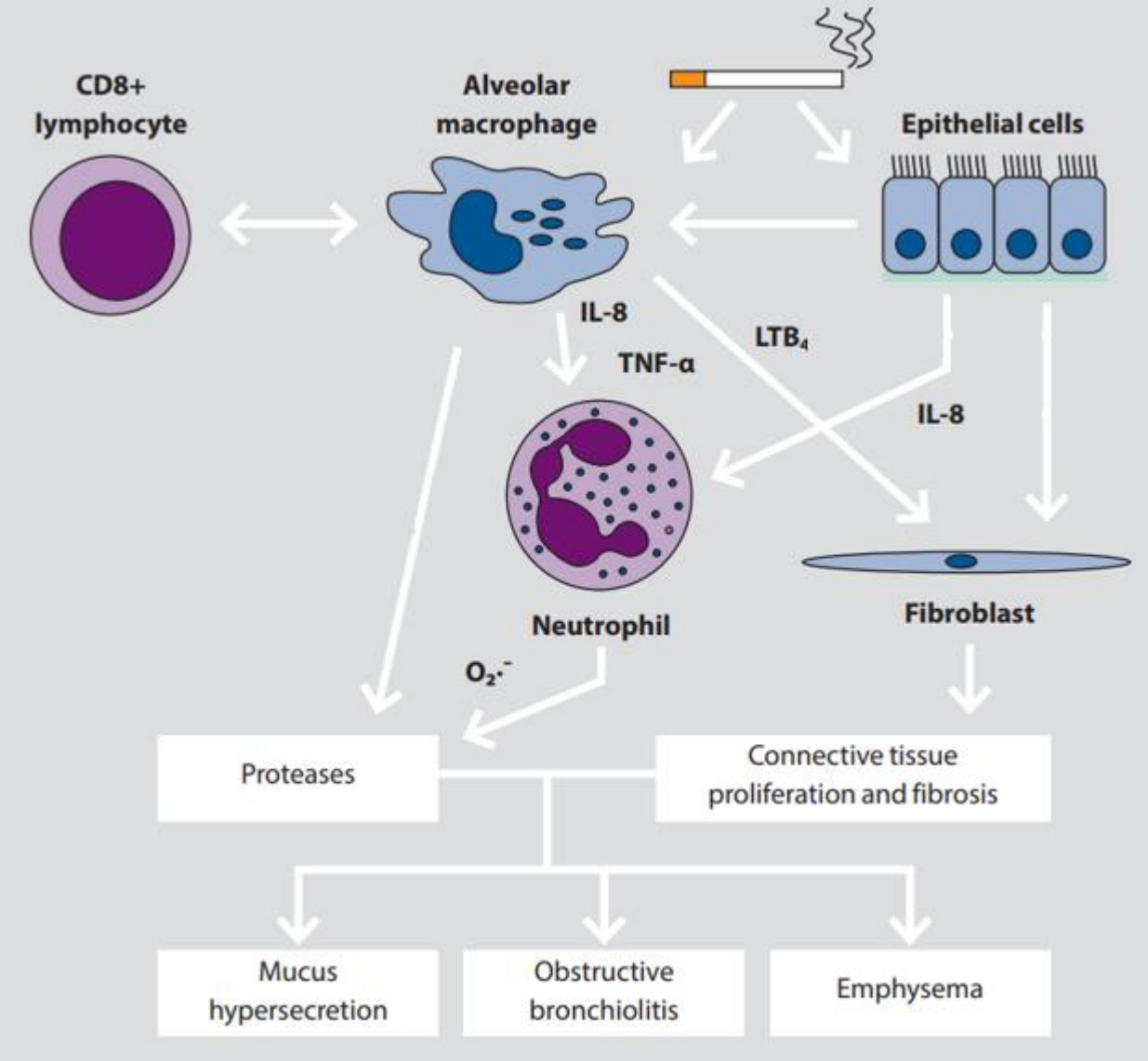
COPD estimated to be the 3rd leading cause of death worldwide by 2030

Exacerbations lead to worsening symptoms and quality of life, as well as increased healthcare utilization

Costs projected to be ~$40 billion per year

COPD is the 2nd leading cause of reduced disability-adjusted life years

COPD Pathophysiology



Three Key Pathological Processes:

- Chronic bronchitis
  - Excess mucus from large airways
- Obstructive bronchiolitis
  - Small airway obstruction with inflammation and fibrosis
- Emphysema
  - Destruction of alveolar walls
  - Abnormal enlargement or airspaces
  - Loss of lung elasticity
  - Impaired gas transfer
  - Airway obstruction

Russell, R. Managing COPD. (pp 9-30).

COPD Assessment

Clinical Presentation

- Dyspnea
- Chronic cough
- Sputum production
- Wheezing
- Chest tightness
- Fatigue

Differential Diagnosis

- Asthma
- Heart failure
- Bronchiectasis
- Tuberculosis
- Obliterative bronchiolitis
- Diffuse panbronchiolitis

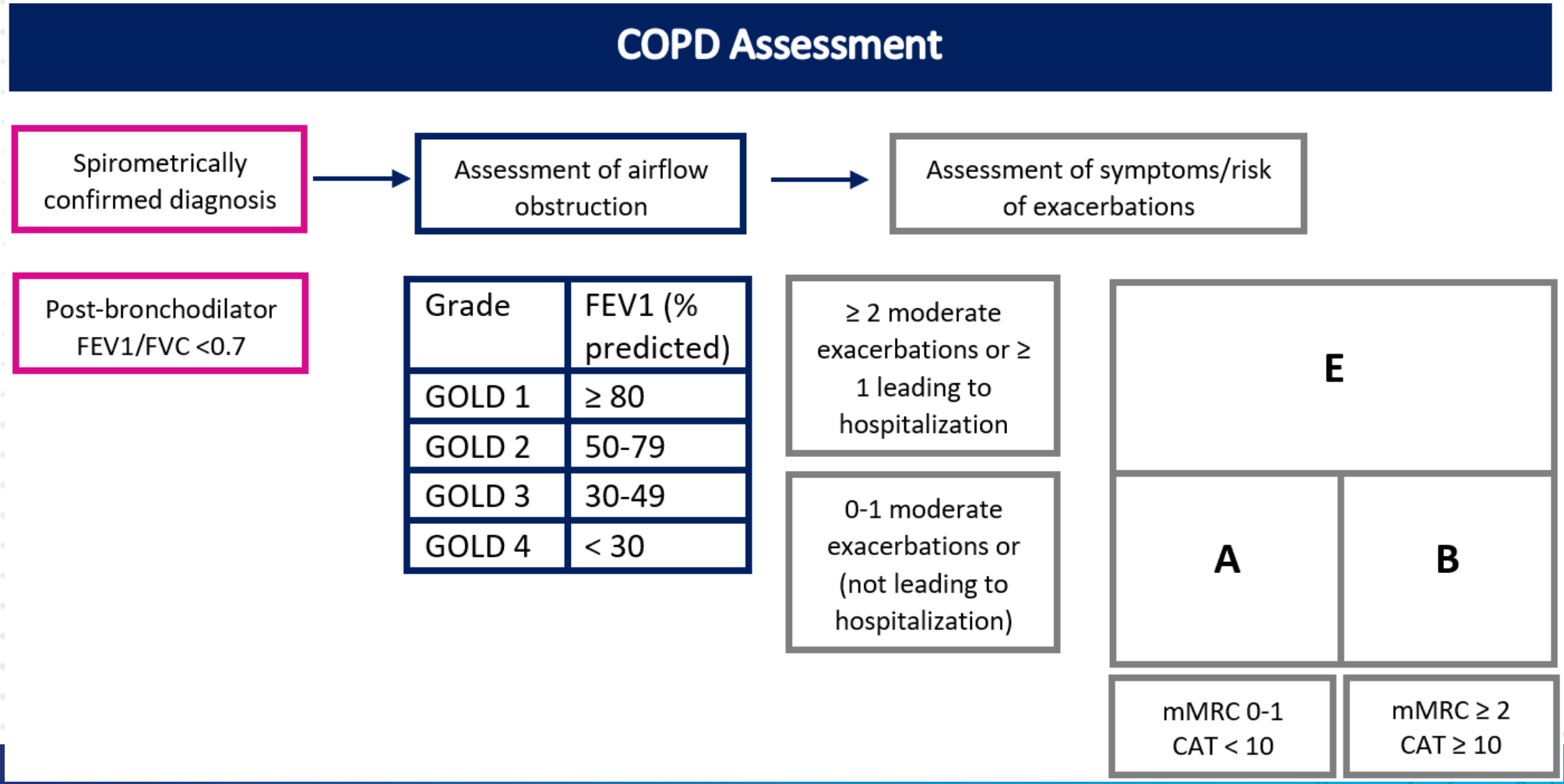
Spirometry

- Reproducible & objective measurement of airflow
- Forced vital capacity (FVC): volume of air forcibly exhaled from the point of maximal inspiration
- Forced expiratory volume in 1 sec (FEV1): volume of air exhaled during the first second of this maneuver
- FEV1/FVC: ratio of the two measurements
- Airway obstruction defined as FEV1/FVC <0.7

Symptom Assessments

- Modified Medical Research Council (mMRC) Dyspnea Scale
- Chronic Respiratory Questionnaire (CRQ)
- St. George's Respiratory Questionnaire (SGRQ)
- COPD Control Questionnaire (CCQ)
- COPD Assessment Test (CAT)

COPD Assessment (Cont'd)



Non-Pharmacologic Management of COPD

NON-PHARMACOLOGIC MANAGEMENT OF COPD

PATIENT GROUP	ESSENTIAL	RECOMMENDED	DEPENDING ON LOCAL GUIDELINES
A	Smoking cessation*	Physical Activity	Flu Vaccination Pneumococcal Vaccination Pertussis Vaccination COVID-19 Vaccination Shingles Vaccination
B and E	Smoking cessation* Pulmonary Rehabilitation	Physical Activity	Flu Vaccination Pneumococcal Vaccination Pertussis Vaccination COVID-19 Vaccination Shingles Vaccination

*Can include pharmacologic treatment

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Non-Pharmacologic Management of COPD

Education & Self-Management

- Aim to motivate, engage, & coach patients to positively adapt their health behaviors
- Smoking cessation, basic information about COPD, approach to therapy, strategies to minimize dyspnea
- Advice on when to seek help, decision making during exacerbations, & when advance directives

Physical Activity

- Pulmonary rehab including setting patient goals and structured layout accounting for the patient's COPD characteristics & comorbidities
- Exercise training including interval training & strength training
- Pursed lip breathing & diaphragmatic breathing can improve pulmonary function & increase exercise capacity

End of Life & Palliative Care

- Working with the patient & family to make informed decisions consistent with patients' values

Non-Pharmacologic Management of COPD

Nutrition

- Malnutrition is associated with impaired lung function, increased hospitalizations, poor exercise tolerance, worsened quality of life, & increased mortality
- Dietary advice & oral supplementation reportedly improve body weight, quality of life, respiratory muscle strength, & 6 minutes walk distance

Oxygen Therapy

- Long-term treatment is indicated for stable patients with:
  - $PaO_2 \leq 55$ mmHg or $SaO_2 \leq 88\%$ with or without hypercapnia
  - PaO_2 between 55-60 mmHg or SaO_2 of 88% if evidence of pulmonary hypertension, peripheral edema, or polycythemia

Ventilatory Support

- Considered in patients with pronounced daytime hypercapnia and recent hospitalization
- Concurrent obstructive sleep apnea (OSA)

Pharmacologic Management: Bronchodilators

β2-Agonists

Mechanism of Action: Relaxes airway smooth muscle by binding β2-adrenergic receptors, resulting in ↑ cAMP and produces functional antagonism to bronchoconstriction

Benefits:

- Reduce dynamic hyperinflation at rest and during exercise, improving exercise performance
- Improve FEV1

Uses:

- Often given on a regular basis to prevent or reduce symptoms
- Short-acting bronchodilators generally not recommended to be used on a regular basis

Short-Acting β2-Agonists (SABAs)		Long-Acting β2-Agonists (LABAs)	
Albuterol Levalbuterol	Regular and PRN use improve FEV1 and symptoms	Formoterol Salmeterol	Improve FEV1, lung volumes, dyspnea, health status, exacerbation rate, and number of hospitalizations No effect on mortality or rate of decline in lung function
		Indacaterol	Improves breathlessness, health status, and exacerbation rate
		Oladaterol Vilanterol	Improves lung function and symptoms

Adverse Effects: sinus tachycardia, tremor

Pharmacologic Management: Bronchodilators (Cont'd)

Antimuscarinics

Mechanism of Action: Block the bronchoconstriction effects of acetylcholine on M3 receptors in the airway smooth muscles

Benefits:

- SAMAs alone provided small benefits over SABAs in terms of lung function, health status, and requirement for oral steroids
- LAMAs improve symptoms, including cough and sputum, as well as health status
- Improve effectiveness of pulmonary rehabilitation and reduce exacerbations and related hospitalizations

Short-Acting Antimuscarinics (SAMAs)	Long-Acting Antimuscarinic (LAMAs)
Ipratropium	Tiotropium Umeclidinium Aclidinium Glycopyrrolate

Adverse Effects: bitter metallic taste, dry mouth

Pharmacologic Management: Inhaled Corticosteroids

Inhaled Corticosteroids (ICS)

Mechanism of Action: Suppress airway inflammation by activating anti-inflammatory genes, switching off inflammatory gene expression, and inhibiting inflammatory cells

Considerations:

- ICS alone
  - Does not modify long-term decline in FEV1 nor mortality
- ICS combination with Long-Acting Bronchodilators
  - In moderate to very severe COPD and exacerbations, triple therapy was more effective than individual components (ICS+LABA, LAMA+LABA, or LAMA monotherapy) in improving lung function, heath status, and reducing exacerbations
  - Data suggests a benefit from triple therapy vs fixed dose LAMA+LABA on mortality in symptomatic patients with a history of frequent and/or severe exacerbations
- Blood Eosinophil count
  - Can predict the magnitude of the effect of ICS in preventing future exacerbations
  - Recommended if eosinophil count is ≥ 300 cells/µL

Combination Inhalers

Budesonide/Formoterol	Mometasone/Formoterol	Beclometasone/formoterol/glycopyrronium
Fluticasone/Salmeterol	Tiotropium/Olodaterol	Budesonide/formoterol/glycopyrrolate
Fluticasone/Vilanterol	Umeclidinium/Vilanterol	Fluticasone/Umeclidinium/ Vilanterol

Adverse Effects: oral candidiasis, hoarse voice, skin bruising, pneumonia

Pharmacologic Management: Methylxanthines

Methylxanthines

Mechanism of Action: Inhibit phosphodiesterase (PDE III and to a lesser extent PDE IV) resulting in bronchodilation and suppresses the response of the airways to stimuli

Considerations:

- Modest bronchodilator effect compared to placebo in stable COPD
- Addition to Salmeterol resulted in greater improvement in FEV1 and breathlessness compared to Salmeterol alone
- Conflicting evidence on effect on exacerbation rates
- Metabolized by CYP450
- Clearance of theophylline declines with age

Agents	
Theophylline	Aminophylline

Adverse Effects: atrial and ventricular arrhythmias, grand mal convulsions, headaches, insomnia, nausea, and heartburn

Drug Interactions: antibiotics (erythromycin, quinolones), allopurinol, cimetidine, serotonin uptake inhibitors, zileuton

Pharmacologic Management: Phosphodiesterase-4 Inhibitors & Mucolytics

Phosphodiesterase-4 Inhibitors

Mechanism of Action: Inhibit the breakdown of intracellular cAMP, leading to reduced inflammation

Considerations:

- Reduces moderate-severe exacerbations treated with systemic corticosteroids in patients with chronic bronchitis, severe to very severe COPD, and a history of exacerbations
- Improvement in lung function is noted when added to long-acting bronchodilators and when uncontrolled with fixed dose ICS+LABA
- Benefits seen in patients with a prior history of hospitalization for acute exacerbation

Agents

Roflumilast

Adverse Effects: diarrhea, nausea, reduced appetite, weight loss, abdominal pain, sleep disturbance, and headache

Mucolytics

Mechanism of Action: Reduces mucus viscosity by binding disulfide bonds in mucoproteins

Considerations:

- If not receiving ICS, may reduce exacerbations and modestly improve health status

Agents

N-acetylcysteine

Carbocysteine

Adverse Effects: nausea, vomiting

Pharmacologic Management: Oral Glucocorticoids & Antibiotics

Oral Glucocorticoids

Mechanism of Action: Reduce inflammation by suppressing migration of polymorphonuclear leukocytes and reversal of increased capillary permeability

Considerations:

- Steroid induced myopathy can contribute to muscle weakness, reduced functionality, and respiratory failure in very severe COPD
- For exacerbations, can reduce the rate of treatment failure, the rate of relapse, and improve lung function and breathlessness

Adverse Effects: nausea, vomiting, insomnia, dizziness, headaches, hyperglycemia, hypertension, infection

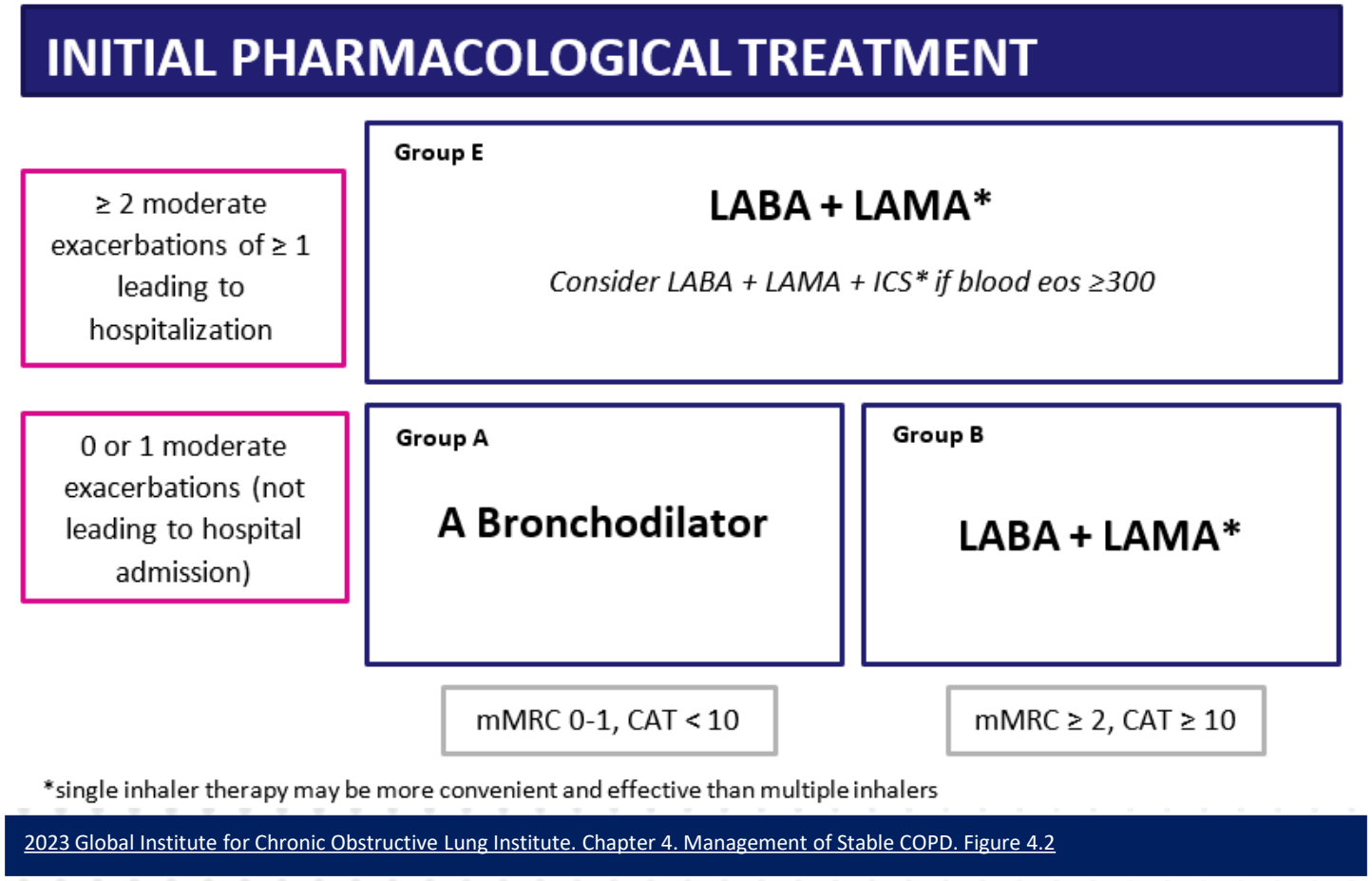
Antibiotics

Macrolides	Tetracyclines	Penicillins
Azithromycin Erythromycin	Doxycycline	Amoxicillin-Clavulanate

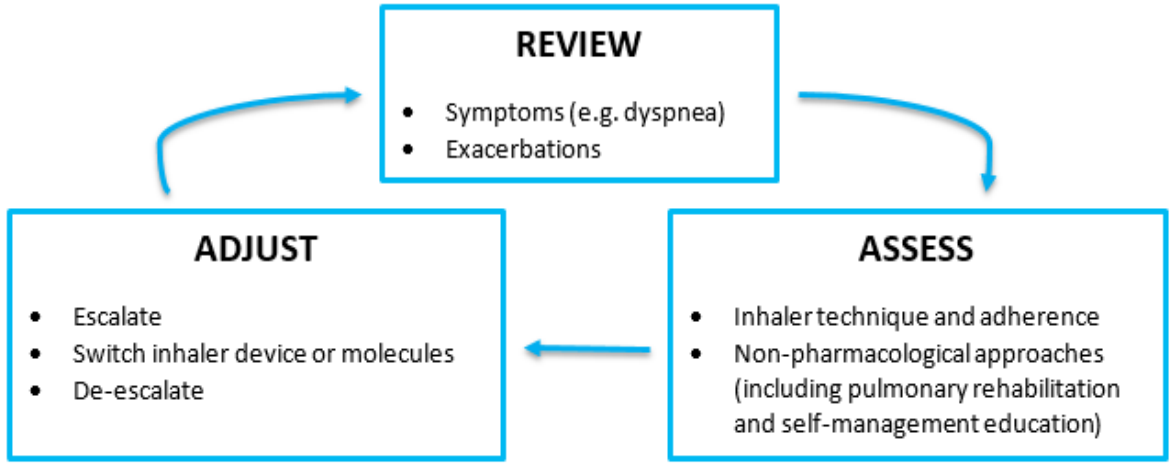
Considerations:

- Older studies showed prophylactic continued use had no effect on frequency of exacerbations
- Later studies have shown regular use of some antibiotics may reduce exacerbation rate
  - Macrolides for one year in patients prone to exacerbations shown to reduce the risk of exacerbations vs usual care
    - Lesser benefit in active smokers
    - No data to support use beyond 1 year
  - Quinolones in patients with chronic bronchitis and frequent exacerbations showed no benefit in exacerbation rates
- When indicated for exacerbations, ABXs shorten recovery time, reduce risk of relapse, treatment failure, and hospitalization
- Duration should not exceed 5 days

Initial Pharmacologic Management of Stable COPD



Follow Up Pharmacologic Management of Stable COPD



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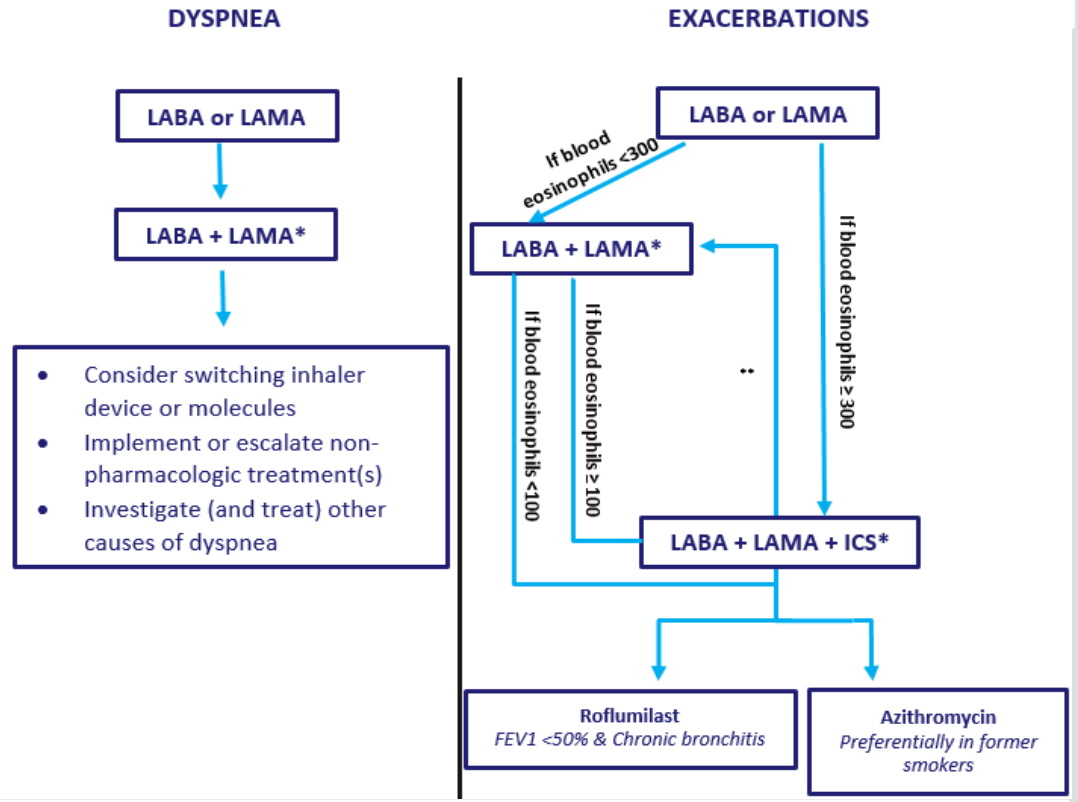
FOLLOW-UP PHARMACOLOGICAL TREATMENT

- IF RESPONSE TO INITIAL TREATMENT IS APPROPRIATE, MAINTAIN IT
- IF NOT:
  - Check adherence, inhaler technique and possible interfering comorbidities
- Consider the predominant treatable train to target (dyspnea or exacerbations)
  - Use exacerbation pathway if both exacerbations and dyspnea need to be targeted
- Place patient in box corresponding to current treatment and follow indications
- Assess response, adjust and review
- These recommendations do not depend on the ABE assessment at diagnosis



*Single inhaler therapy may be more convenient and effective than multiple inhalers
** Consider de-escalation of ICS if pneumonia or other considerable side effects. In case of blood eos ≥ 300 cells/ul de-escalation is more likely to be associated with the development of exacerbations

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Management of Exacerbations

MANAGEMENT OF SEVERE BUT NOT LIFE-THREATENING EXACERBATIONS

- **Assess severity of symptoms**
- **Administer supplemental oxygen therapy if available and obtain vitals**
- **Bronchodilators**
  - Increase doses and/or frequency of short-acting bronchodilators
  - Combine short-acting beta2-agonists and anticholinergics
  - Consider use of long-acting bronchodilators when patient becomes stable
  - Use spacers or air-driven nebulizers when appropriate
- **Consider corticosteroids**
  - Exacerbations characterized by breathlessness that interferes with daily activities
  - Treatment may consist of Prednisone 40mg daily x 5 days or an equivalent glucocorticoid
- **Consider antibiotics when signs of bacterial infection are present**
  - Cardinal symptoms: increased dyspnea, sputum volume, and sputum purulence
    - Must have all 3 of the cardinal symptoms
    - May have 2 of the cardinal symptoms, if increased sputum purulence is one of the symptoms
  - Treatment may consist of an aminopenicillin with clavulanic acid, macrolide, or tetracycline and should not exceed 5 days
- **At all times:**
  - Maintain adequate fluid balance
  - Identify and manage associated conditions

Follow Up Post-Exacerbation

1-4 Weeks	12-16 Weeks
• Evaluate ability to cope in usual environment • Review understanding of treatment regimen • Reassess inhaler technique • Reassess need for long-term oxygen • Document capacity to do physical activity and consider patient eligibility for pulmonary rehabilitation • Document symptoms: CAT or mMRC • Determine status of comorbidities	• Evaluate ability to cope in usual environment • Review understanding of treatment regimen • Reassess inhaler technique • Reassess need for long-term oxygen • Document capacity to do physical activity and activities of daily living • Measure spirometry: FEV1 • Document symptoms: CAT or mMRC • Determine status of comorbidities

Remote Patient Monitoring in COPD

Impact of Frequent Exacerbations

- Greater mortality
- Reduced quality of life
- Economic burden
- Higher rates of readmissions
- Societal healthcare expenditures and resource utilization
- Increased absenteeism from work
- Decreased productivity

Chalupsky MR, et al. *Journal of Investigative Medicine.* doi: 10.1136/jim-2022-002430.

Parameters to Consider for Patient Monitoring

Parameter	Data Obtained	Device
Physiologic Monitoring	• Oxygen Saturation • Respiratory Rate • Heart Rate • Temperature • Activity Level • Spirometry	• Spirometer • Pulse Oximeter • Continuous monitoring: wristbands, watches, armbands, adhesive sensors
Symptom Assessment	• Change in breathing, cough, phlegm, chest tightness, energy level, sleep activity	• Tablet, smart phone • Passive monitoring
Medication Adherence/Usage	• Adherence to prescribed regimen, usage of rescue medications	• Tablet, smart phone • Device actuation sensors
Environmental Factors	• Air pollution, temperature changes, circulating viruses	• External sensors on the patient or surrounding environment

Chalupsky MR, et al. *Journal of Investigative Medicine*. doi: 10.1136/jim-2022-002430.
Pepin J-L, et al. *Life*. 2022; 12(4):499.

Impact of RPM in COPD

Patient Outcomes	Patient Satisfaction & Health-related Quality of Life	Healthcare Cost & Utilization
Some studies have shown a reduction in symptoms and improved QoL	RPM may provide opportunity to address comorbid mood disorders that lead to increased symptom burden and mortality	Potential cost savings of $710 to $4359 per patient per year
Limited studies have shown patients improved their self-management skills	Daily education and objective measures of exacerbation, along with real-time support can improve QoL	Mixed results on risk of ED visits and hospitalizations

Chalupsky MR, et al. *Journal of Investigative Medicine.* doi: 10.1136/jim-2022-002430.

Walker PP, et al. (2018)

Telemonitoring in Chronic Obstructive Pulmonary Disease (CHROMED): A Randomized Clinical Trial		
Study Design	• Multi-center, randomized, unblinded, parallel-group clinical trial over a 9 month period	
Population	• N=312 (154 in intervention group) • Patients were recruited from Spain, UK, Slovenia, Estonia, and Sweden • Median age of 71 years, had at least 1 comorbidity, COPD stage II-III	
Intervention	• Continuous wearable wristband • CHROMED monitoring platform daily: a device that measured within-breath respiratory mechanical impedance using FOT, a touch screen computer, and a mobile modem • Patients with a diagnosis of HF also received another wearable device to assess blood pressure, oxygen saturation, heart rate, and body temperature over a 4-minute period	

Endpoints	• Co-primary outcomes:
	  • Time to first hospitalization
	  • Change in EQ-5D utility index score
		• Secondary outcomes:
		  • Rate of moderate exacerbations
		  • Hospitalizations and rehospitalizations
		  • Length of stay
		  • Final scores of the CAT and PHQ-9 questionnaires
		• Cost-Utility Analysis
		  • Compared healthcare costs and quality-adjusted life years (QALYs)

Results	• 48% of patients in the intervention group having a hospitalization, had an alert in the preceding 2 weeks
	  • 27% of these alerts were managed by an RD/clinician
	• Time to first hospitalization: mean of 224 days (IQR, 209-240 d) in the intervention group vs 254 days (IQR, 240-270 d) (P=0.342)
	• No statistical difference between groups for:
	  • Rate of moderate exacerbations: 1.74 vs 1.52 (P=0.499)
	  • Hospitalizations: 0.79 vs 0.99 (P=0.276)
	• Rehospitalization: 34 patients in the intervention group vs 62 in the control group
		• Average length of hospital stay (all-cause hospitalization): 4 (IQR, 1-9) days for control group vs 1 (IQR, 1-6.7) for intervention group (P=0.045)
		• No significant between-group differences in EQ-5D, CAT, or PHQ-9 scores at 9 months
		• No statistically significant difference in QALYs between intervention and control group (0.485 vs 0.491; P=0.731)
		• Mean cost per patient in the intervention group was lower vs control group in all subgroups except severe-very severe COPD

Conclusion	• >50% reduction in re-hospitalizations and exacerbations in recently hospitalized patients • Although combining symptom assessments with physiological variables can identify COPD exacerbations, this did not show any effect on time to admission or patient's quality of life • Cost-utility analysis found an average cost savings of ~ $1935 per patient-year (based on UK healthcare system)	

Walker PP, et al. AM J Respir Crit Care Med. 2018;198(5):620-628.

Koff PB, et al. (2021)

Impact of Proactive Integrated Care on Chronic Obstructive Pulmonary Disease

Study Design	• Prospective, quasi-randomized clinical trial over a 22-month period between September 2006 and June 2008	
Population	• N=511 (122 withdrew or stopped participating resulting in 389 participants being analyzed – 140 in usual care vs 249 in intervention group) • Recruited from primary care and pulmonary specialty clinics at the University of Colorado Hospital, Kaiser Permanente Colorado, the Denver Veterans Affairs Medical Center, primary care practices within the Colorado front-range urban corridor, and rural counties in part through collaboration with the High Plains Research Network • Average of 68 years old, male, with an FEV1 of 37% predicted	

Intervention	• 9-month disease management program including: COPD education, exacerbation education, direct communication with study coordinators, and remote home monitoring
	  • Remote monitoring included: telecommunication platform, a finger pulse oximeter, a hand-held spirometer, and a pedometer
	  • 2-hour enrollment call
	  • Weekday sessions receiving COPD education and symptom-based questionnaires, measuring FEV1 and SpO2 at rest, perform a 6MWT with a post-exertion SpO2
	  • SGRQ at baseline, 3, 6, and 9 months
	  • An alert system in place based on changes in symptoms, activity, FEV1, SpO2, and 6MWD	

Endpoints	• Primary outcome:
	  • Healthcare costs
		• Secondary outcomes:
		  • QoL through SGRQ at baseline, 3, 6, and 9 months
		  • Respiratory symptoms, COPD and non-COPD related health care utilization, and 6MWT at baseline and 9 months

Results	• Healthcare costs
	  • Intervention decreased COPD-related urgent care visits by 76 visits per 100 patients ($p<0.0001$) and non-significantly decreased COPD-related ED visits ($p=0.09$)
	  • With the intervention, they found an estimated cost savings of $4,359 per patient per year
	• Mortality:
	  • 4 of 352 (1.1%) participants in the intervention group died vs 6 of 159 (3.8%) participants in usual care ($p=0.08$)
	• QoL:
	  • Intervention improved the total SGRQ by 6.7 units, 9.5 units and 8.4 units ($p < 0.0001$) at 3, 6 and 9 months, respectively, compared with the usual care group
		• Smoking rates, Symptoms, Exercise Capacity:
		  • After 9 months, the intervention group reported less smoking, cough, sputum, and breathlessness, and increased post-exercise SpO2 compared to usual care
		  • The intervention group was able to walk 42m further (~15% increase from baseline) during the 6MWT compared to ~1% of usual care seeing improvement
		• Early warning for exacerbations
		  • A total of 352 participants in the intervention group had 210 COPD exacerbations
		  • 262 red flags and 258 yellow flags occurred in the 3 days prior to the exacerbation
		  • Most common flags were related to increased shortness of breath, decreased physical activity, lower oxygen saturation, and increased cough
		  • 55% of exacerbations were treated with an oral corticosteroid, 64% with an antibiotic, and 33% with a short-acting bronchodilator alone

Polsky M, et al. (2023)

Use of Remote Cardiorespiratory Monitoring is Associated with Reduction in Hospitalizations in Subjects with COPD

Study Design

- Retrospective analysis of data pre- and post-initiation of RPM between May 2019 and February 2022

Population

- N=126
- Large outpatient pulmonology practice in mid-Atlantic metropolitan city in the US
- Average of 74 years old, female, with an FEV1 of 60% predicted

Intervention

- At least 12 months of RPM
  - Device: undergarment-adhered cardiorespiratory sensors, data hub, web based clinical dashboard
  - Data collected: intermittent photoplethysmography for pulse, continuous respiratory force, and tri-axis accelerometers for activity
  - Alerts: sustaining elevation in RR of 10% and HR of 20% over rolling baselines, along with individual readings of RR >35 brpm and HR >135 bpm
  - Risk assessment phone call: 24-48 hours after alert or monthly check-in if no alert received to assess change in symptoms
    - If change noted in this assessment, patients were required to have an in-office or virtual visit with MD

Endpoints

Primary Outcome

- Unplanned all-cause hospitalizations

Secondary Outcomes

- Unplanned cardiopulmonary hospitalizations
- Length of stay
- ER visits
- Outpatient pulmonary visits
- Systemic corticosteroid use
- Adherence to RPM
- Time-to-visit (RPM escalation to provider visit)

Results

Healthcare Resource Utilization – Hospital Admissions

- All-Cause Hospitalizations: decreased by 65% (from 137 to 48)
  - Per-patient: significant decrease from pre-initiation to post-initiation (**P<0.001**)
  - Length of Stay: 0.6 days shorter post-initiation (P=0.612)
- Cardiopulmonary Hospitalizations: decreased by 64% (from 88 to 32)
  - Per-patient: significant decrease from pre-initiation to post-initiation (**P<0.001**)
  - Length of Stay: 1.28 days shorter post-initiation (P=0.097)

Healthcare Resource Utilization – ER Visits

- All-Cause: decreased 44% (from 61 to 34)
  - Per-Patient: significant decrease from pre-initiation to post-initiation (**P<0.001**)
- Cardiopulmonary: decreased 44% (from 36 to 20)
  - Per-Patient: significant decrease from pre-initiation to post-initiation (**P=0.002**)

- **Outpatient Pulmonary Visits**
  - Number: Increased 13% (from 532 to 602)
  - Per-Patient: significant decrease from pre-initiation to post-initiation (**P=0.038**)
- **Corticosteroid Use**
  - Number: Increased 3% (from 116 to 120)
  - Per-Patient: slight reduction from pre-initiation to post-initiation (P=0.589)
- **RPM Utilization**
  - Adherence: most patients were adherent ≥ 90% of the 12 month post-initiation period
    - Waned over time but overall per-patient: 89%
  - RPM Escalations: resulted in 52 office visits
    - Time-to-Visit: 2.5-3 days

Patient Barriers to RPM

- Social determinants in COPD patients
- Technological – access to devices, adjunct technology
- Health literacy
- Physical – poor vision, dexterity, time limitations

Chalupsky MR, et al. *Journal of Investigative Medicine.* doi: 10.1136/jim-2022-002430.

Key Take Away Points

- COPD is a major public health problem
- COPD exacerbations can lead to reduced quality of life, economic burden, increased healthcare utilization, and greater mortality
- RPM can lead to early detection of exacerbations, prompt access to clinical services and treatment, potentially reduce healthcare utilization and costs
- There are a variety of devices that can be utilized and incorporating multiple options could lead to better outcomes
- Be aware of your intended patient population and work to minimize barriers to participation

Managing a Patient with COPD through RPM

Checklist for Monitoring

Initial Visit **(within 2 weeks from enrollment)**	• Complete medication reconciliation • Comorbidities, vaccine history, and COPD history (exacerbations/ED visits, previous medications) • Symptoms (weekly CAT score) and physiological parameters (goals, trend) • Medications/oxygen/NIV (adherence, barriers, side effects, frequency of use of rescue medications, inhaler technique) • Lifestyle and self-management (smoking status, triggers, stress/anxiety management, diet, exercise) • COPD Action Plan
Follow Up Visits **(every 1-4 weeks)**	• Recent change in symptoms • Medications/oxygen/NIV (adherence, barriers, side effects, frequency of use of rescue medications) • Review of COPD Action Plan and if required use since last visit • Urgent care visits, ED visits, or hospitalizations since last visit • Self-management behaviors (reducing exposure to triggers, breathing control, anxiety/stress management, exercise, smoking status)

Meet MH

55 yo AA F with a PMH of asthma/COPD overlap, OSA, HTN, and depression
Social Hx: Current every day smoker, social drinker during family events
Exacerbation Hx: hospitalized for a ECOPD in 5/2022, felt chest tightness and SOB
Not actively using oxygen supplementation or non-invasive ventilation
Blood eosinophil count (2/2022): 300 cells/µL
PFTs (11/2021) revealed an FEV1 of 37%

Meet MH

Active Medications at Enrollment	
Albuterol nebulizer 2.5mg/0.5mL	0.5 mLs Q6H PRN SOB
Albuterol inhaler 90mcg/actuation	2 puffs Q4H PRN SOB
Budesonide-Formoterol 160-4.5 mcg/actuation	2 puffs BID
Montelukast 10mg	1 tablet QHS
Roflumilast 500mcg	1 tablet QD
Tiotropium Handihaler	1 capsule inhaled QD
Escitalopram 20mg	1 tablet QD
Losartan 100mg	1 tablet QD
Nifedipine ER 90mg	1 tablet QD

Vaccination History	
Influenza Vaccine	10/2021
Pfizer COVID-19 Vaccine	7/2021, 8/2021, 7/2022
Pneumococcal 13 Conjugate Vaccine	1/2018
Pneumococcal 23-Valent Vaccine	3/2019
Shingrix Vaccine	11/2019
Tdap Vaccine	12/2021

Knowledge Check

What GOLD Grade of COPD does MH have?

A. GOLD Grade 1
B. GOLD Grade 2
C. GOLD Grade 3
D. GOLD Grade 4

Knowledge Check

What next steps for management should we consider for MH? (select all that apply)

A. Discuss smoking cessation and assess willingness to quit
B. Recommend an influenza vaccine
C. Maximize her regimen
D. Start an antibiotic

MH's Course in Remote Monitoring

8/31/2022	9/26/2022
Enrolled in remote patient monitoring	**Initial Video Visit with PharmD**
	Medications: confirmed previously listed medications and performed appropriate technique for MDI and Handihaler
	Rescue Inhaler Use: ~3x/week
	Known exacerbation triggers: when summer changes to fall, feeling acutely sick, walking/going up stairs, perfume, and cleaning products
	Diet: reported excess weight gain and concerns for diet quality
	Exercise: Able to walk up 1 flight and <1 block before becoming SOB
	Smoking: ~2 cigarettes/day + vaping (nicotine free) Noted side effects from NRT/pharmacologic options

	9/22	9/23	9/24	9/25
Heart Rate (BPM)	70	70	71	73
Oxygen Saturation (%)	96	96	94	95
Respiratory Rate (breaths/min)	20	20	20	20
Skin Temperature (F)	93.2	94	93.8	93
Activity Level	5	5	5	3

Next Steps:

- Receive influenza vaccine for 2022-2023
- Transition to co-management with dietician
- Reduce # of cigarettes/day
- Avoid known triggers

MH's Course in Remote Monitoring

10/20/2022
Follow Up Telephone Visit with PharmD
Alerts: hypoxia (81-85%) from 7 AM-1PM
Medications: confirmed adherence with current medications
Rescue Inhaler Use: <3x/week (less often)
Symptoms: weakness/low energy, fatigue, SOB on exertion, worsened dry/itchy cough, chest tightness on ambulation; denies subjective fevers, changes in baseline sputum
Smoking: ~4 cigarettes/day + vaping (nicotine free)
Exercise: Becomes SOB after walking up some steps and <1 block

	10/17	10/18	10/19	10/20
Heart Rate (BPM)	68	69	72	73
Oxygen Saturation (%)	96	89	95	83
Respiratory Rate (breaths/min)	20	18	22	19
Skin Temperature (F)	93	92	94	91
Activity Level	5	5	3	3

Next Steps:

- Escalated to MD – agreed to start **Prednisone 40mg QD x 5 days & scheduled in-office visit for 10/27**
- **Start using Albuterol inhaler or nebulizer Q6H ATC**
- Reduce smoking
- Advised to seek urgent care/ER if symptoms worse

MH's Course in Remote Monitoring

10/26/2022	10/27/2022
Follow Up Telephone Visit with PharmD	**Office Visit with MD**
Alerts: none	
Medications: completed Prednisone course, reported not using Albuterol ATC	Medications: confirmed using medications as prescribed, started using Albuterol more
Rescue Inhaler Use: ~3x/week	Rescue Inhaler Use: Using Albuterol twice today
Symptoms: improvement in cough, chest tightness, less SOB on exertion, no longer weak; feeling tired but not sleeping much due to familial stress	Symptoms: continued dry cough, usual phlegm, improvement in chest tightness, no recent fevers, soreness in chest
Smoking: ~4 cigarettes/day + vaping (nicotine free)	Exercise: Walking test performed & was desatting on RA to 87% (stopped due to chest tightness)
Exercise: Able to walk a little more without becoming as SOB	Smoking: ~4 cigarettes/day + vaping (nicotine free)
	Sleep study performed 10/19 revealed mild OSA

	10/25	10/26	10/27
Heart Rate (BPM)	-	68	66
Oxygen Saturation (%)	-	94	96
Respiratory Rate (breaths/min)	-	22	20
Skin Temperature (F)	-	94	94
Activity Level	-	5	5

Next Steps:

- Budesonide nebs BID x at least 1 week
- RX for home oxygen 1L NC PRN activity
- Mild OSA – RX for CPAP
- Reduce smoking

MH's Course in Remote Monitoring

11/4/2022

Follow Up Telephone Visit with PharmD

Alerts: hypoxia (74-80%) for 1 hour, during this time was bradycardic (HR: 34-58)

Medications: reports adherence with maintenance regimen but not using Albuterol ATC and hasn't received Budesonide nebs
Oxygen: not using as prescribed due to dry/sore nostril – did not receive CPAP yet

Rescue Inhaler Use: ~1x/day

Symptoms: SOB at rest (having to catch breath while on phone), dry cough, chest tightness, subjective fevers, itchy throat

Smoking: ~4 cigarettes/day + vaping (nicotine free)

Next Steps:

- Instructed to use home oxygen and take an Albuterol nebulizer treatment (repeat every 15 minutes if continued SOB/chest tightness)
- Escalated to MD and agreed to activating hospital paramedic program
- Referral placed, however patient deemed not a candidate and recommendation made to activate EMS
- Discussed with MD & patient – agreeable to EMS
- Activated EMS

MD followed up post-EMS

- SpO2 improved to mid-90s on 1L NC and patient not sent to ED
- CXR ordered for following week
- Azithromycin 500mg QD x 5 days
- Budesonide nebs BID

	11/2	11/3	11/4
Heart Rate (BPM)	-	-	75
Oxygen Saturation (%)	-	-	85
Respiratory Rate (breaths/min)	-	-	20
Skin Temperature (F)	-	-	94.2
Activity Level	-	-	5

MH's Course in Remote Monitoring

11/9/2022	11/23/2022
Follow Up Telephone Visit with PharmD	**Follow Up Telephone Visit with PharmD**
Alerts: hypoxia (83-89%) periodically throughout the day	Alerts: none
Medications: Azithromycin completed yesterday, confirmed use of Budesonide nebs BID Oxygen: using at bedtime and during activity – did not receive CPAP yet	Medications: maintenance and rescue PRN Oxygen: using at bedtime and during activity – did not receive CPAP yet
Rescue Inhaler Use: 1x/day	Rescue Inhaler Use: PRN, ~3x/week
Symptoms: no SOB at rest (some on exertion), no chest tightness/pain, continued dry cough, occasional phlegm, & congestion	Symptoms: SOB on exertion occasionally, hoarse voice, fatigue/low energy level (improved since last visit); denies worsening cough, phlegm, congestion, chest tightness/pain
Smoking: ~4 cigarettes/day, hasn't been vaping	Smoking: ~4 cigarettes/day, hasn't been vaping
CXR 11/8: clear	

	11/8	11/9	11/19	11/23
Heart Rate (BPM)	73	74	80	-
Oxygen Saturation (%)	91	94	93	-
Respiratory Rate (breaths/min)	21	22	19	-
Skin Temperature (F)	94	94.2	95	-
Activity Level	5	5	7	-

Next Steps:

- Reduce # of cigarettes/day
- Avoid known triggers
- Continue using oxygen PRN and at bedtime until CPAP machine arrives

Conclusion

RPM allows for additional data to enhance visits, detect exacerbations earlier, permit increased touchpoints with the healthcare team and access to treatment, and potentially reduce healthcare utilization and cost

In addition to physiologic monitoring, incorporating multiple patient monitoring options leads to better outcomes

Daily education and frequent interactions with the team can enhance the patient's understanding of their condition and improve self-management skills

References

1. Koskimies, O. The Future of Remote Patient Monitoring is in Artificial Intelligence. Med Devops. October 9, 2019. Accessed January 25, 2023.
2. Telehealth and Remote Patient Monitoring. Health and Human Services. Updated November 23, 2022. Accessed January 25, 2023. https://telehealth.hhs.gov/providers/preparing-patients-for-telehealth/telehealth-and-remote-patient-monitoring/
3. 2023 Global Initiative for Chronic Obstructive Lung Disease (https://goldcopd.org/2023-gold-report-2/)
4. Russell, R., Ford, P., Barnes, P.J., Russell, S. (2013). Epidemiology, Risk Factors and Pathophysiology. In: Managing COPD. Springer Healthcare, Tarporley. https://doi-org.eresources.mssm.edu/10.1007/978-1-907673-52-8_2
5. Pépin J-L, Degano B, Tamisier R, Viglino D. Remote Monitoring for Prediction and Management of Acute Exacerbations in Chronic Obstructive Pulmonary Disease (AECOPD). *Life*. 2022; 12(4):499. https://doi.org/10.3390/life12040499
6. Chalupsky MR, Craddock KM, Schivo M, et al. Remote patient monitoring in the management of chronic obstructive pulmonary disease. *Journal of Investigative Medicine.* 16 June 2022. doi: 10.1136/jim-2022-002430
7. Walker PP, Pompilio PP, Zanaboni P, et al. Telemonitoring in Chronic Obstructive Pulmonary Disease (CHROMED). A Randomized Clinical Trial. *Am J Respir Crit Care Med*. 2018;198(5):620-628. doi:10.1164/rccm.201712-2404OC
8. Koff PB, Min SJ, Freitag TJ, et al. Impact of Proactive Integrated Care on Chronic Obstructive Pulmonary Disease. *Chronic Obstr Pulm Dis*. 2021;8(1):100-116. doi:10.15326/jcopdf.2020.0139
9. Polsky M, Moraveji N, Hendricks A, Teresi RK, Murray R, Maselli DJ. Use of Remote Cardiorespiratory Monitoring is Associated with a Reduction in Hospitalizations for Subjects with COPD. *International Journal of Chronic Obstructive Pulmonary Disease.* 2023;18:219-229. doi:https://doi.org/10.2147/COPD.S388049

Role of Remote Patient Monitoring in Chronic Obstructive Pulmonary Disease

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