CHAPTER OBJECTIVES

1. Describe the purpose of a respiratory care plan.
2. Identify the key elements of a respiratory care plan.
3. Describe common conditions that may require development of a respiratory care plan.
4. Define respiratory failure, and give examples of several types of respiratory failure.
5. Define ventilatory failure, and contrast acute ventilatory failure and chronic ventilatory failure.
6. Give examples of appropriate outcome measures for a respiratory care plan.
7. Outline the key steps in the development and implementation of a respiratory care plan.
8. Develop a respiratory care plan to maintain adequate tissue oxygenation.
9. Create a respiratory care plan for the treatment and/or prevention of bronchospasm and mucosal edema.
10. Describe the care of patients with asthma and COPD.
11. Design a respiratory care plan to mobilize secretions.
12. Propose a respiratory care plan for the treatment and/or prevention of atelectasis and pneumonia.
13. Give examples of types of respiratory care plans used in the intensive care unit.
14. Explain the role of diagnostic testing in the development of a respiratory care plan.

KEY TERMS

- acute lung injury (ALI)
- acute respiratory distress syndrome (ARDS)
- acute respiratory failure
- acute ventilatory failure (AVF)
- anti-inflammatory agents
- antiasthmatic medications
- asthma
- atelectasis
- bronchial hygiene
- bronchiectasis
- bronchodilator therapy
- bronchospasm
- chest physiotherapy (CPT)
- chronic bronchitis
- chronic ventilatory failure (CVF)
- chronic obstructive pulmonary disease (COPD)
- history
- hypoxemia
- incentive spirometry (IS)
- intermittent positive pressure breathing (IPPB)
- lung expansion therapy
- mechanical ventilation
- mucosal edema
- oxygen therapy
- physical pneumonia
- positive airway pressure (PAP)
- protocol
- pulmonary edema
- respiratory care plan
- retained secretions
- SOAP notes
- treatment menu

Overview

This chapter provides a guide to the development, implementation, and evaluation of respiratory care plans. In order to develop an appropriate respiratory care plan, the clinician must first perform a thorough patient assessment, including a review of the patient’s existing medical record, a patient interview, and a physical assessment. The bedside measurement of clinical parameters related to oxygenation, ventilation, and pulmonary function may be performed. Pulse oximetry ($SpO_2$) is often used to assess oxygenation status. Arterial blood gases should be obtained if there is concern...
regarding the patient’s ventilatory status, acid–base balance, or the reliability of \( \text{SpO}_2 \) values. Laboratory, imaging, and other diagnostic studies may be needed to further define and clarify the patient’s problem and diagnosis. Following establishment and clarification of the patient’s diagnosis and/or problem list (see Chapter 1), a respiratory care plan is developed, implemented, and evaluated.

### Introduction to Respiratory Care Plans

The **respiratory care plan** provides a written description of the care the patient is to receive. The plan is based on a careful patient interview and physical assessment, review of diagnostic test results, and consideration of the treatment modalities available, sometimes known as the **treatment menu**. The respiratory care plan may take the form of physician’s orders, a detailed progress note in the medical record, an established **protocol**, completion of a standardized respiratory care consultation and treatment plan, or the use of problem-oriented medical records (e.g., SOAP notes).

The respiratory care plan can be viewed as an individualized protocol for the patient. A basic respiratory care plan often includes the following elements:

- Goals of therapy
- Device or procedure to be used or medications to be given
- Method or appliance to be used
- Gas source or oxygen concentration
- Device pressure, volume, and/or flow
- Frequency of administration and duration of therapy

**SOAP notes** are sometimes used to document patient care plans:

- **S** (Subjective): Refers to what the patient says or subjective information obtained from chart.
- **O** (Objective): Refers to what the clinician observes or objective test results.
- **A** (Assessment): Refers to the clinician’s assessment.
- **P** (Plan): Refers to the plan of care.

The respiratory care plan may also include a statement of how the intensity and/or duration of therapy will be adjusted and when the therapy will be discontinued. Assessment of the outcomes of therapy may also be included, as well as measurable objectives of the care delivered.

In summary, the respiratory care plan provides the written plan of treatment that the patient will receive. The plan may include goals, rationale, significance, and a description of how care will be assessed. Following a careful patient assessment, the respiratory care plan is developed, implemented, and evaluated. A summary of the types of care often included in the respiratory care plan is provided in **Table 2-1**.

### Common Conditions Requiring Respiratory Care Plan Development

Problems that affect oxygenation and/or ventilation often require the development of a respiratory care plan. Other common respiratory problems include **bronchospasm** and **mucosal edema**, **retained secretions**, airway plugging, infection, consolidation, inadequate lung expansion, **atelectasis**, and **pulmonary edema**. Common disease states or conditions encountered in the physician’s office, clinic, or acute care setting that may require respiratory care include upper respiratory tract infection, **pneumonia**, acute bronchitis, **asthma**, **chronic obstructive pulmonary disease** (COPD; including emphysema and **chronic bronchitis**), pulmonary

**Table 2-1**

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<td>- Secretion management</td>
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<td>- Sputum induction</td>
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<td>- Management of bronchospasm and mucosal edema</td>
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<td><strong>Critical Respiratory Care</strong></td>
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<td>- Noninvasive mechanical ventilatory support</td>
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<td>- Suctioning and airway care</td>
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<td><strong>Diagnostic Testing</strong></td>
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<td>- Cardiac testing (e.g., ECG, invasive cardiology, cardiac catheterization laboratory)</td>
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<td>- Pulmonary rehabilitation</td>
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<td>- Cardiac rehabilitation</td>
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**Chapter 2**

24 Development and Implementation of Respiratory Care Plans
hypertension, congestive heart failure (CHF), lung cancer, pulmonary fibrosis, pulmonary emboli, postoperative pulmonary complications, and acute respiratory failure (see Chapter 1).

**Respiratory Failure**

Respiration refers to the exchange of oxygen (O₂) and carbon dioxide (CO₂) across the lung and pulmonary capillaries (external respiration) and at the tissue level (internal respiration). Respiratory failure, broadly defined, is an inability of the heart and lungs to provide adequate tissue oxygenation and/or carbon dioxide removal. 1,2 **Acute respiratory failure** may be defined as a sudden decrease in arterial blood oxygen levels with or without carbon dioxide retention. 1,2 **Acute lung injury (ALI)** and **acute respiratory distress syndrome (ARDS)** are two special cases of respiratory failure that are characterized by oxygenation problems that generally do not respond well to basic oxygen therapy. The term **hypoxemic respiratory failure** (aka “lung failure”) is sometimes used when the primary problem is oxygenation. 3 Chapter 6 describes the assessment of a patient’s oxygenation status. Box 2-1 summarizes the various types of respiratory failure.

The most common reason for initiation of mechanical ventilatory support is **hypercapnic respiratory failure** (aka “ventilatory failure” or “pump failure”). 3,4 **Acute ventilatory failure (AVF)** can be defined as a sudden rise in arterial CO₂ levels (as assessed by Paco₂) with a corresponding decrease in pH. 5 Respiratory muscle fatigue and an increased work of breathing may lead to acute ventilatory failure. Decreased ventilatory drive due to narcotic or sedative drug overdose, head trauma, or stroke can also result in AVF. Common disease states or conditions associated with the development of AVF include severe pneumonia, ALI, ARDS, massive or submassive pulmonary emboli, CHF, and pulmonary edema. Shock, trauma, smoke or chemical inhalation, aspiration, and near drowning may also cause AVF. Acute exacerbation of COPD, acute severe asthma, severe burns, upper airway obstruction, obesity, and thoracic deformity all predispose patients to the development of AVF. Neuromuscular disease such as Guillain-Barré syndrome, myasthenia gravis, and spinal cord injury may also precipitate AVF.

**Chronic ventilatory failure (CVF)** (aka “chronic hypercapnea”) may be defined as a chronically elevated Paco₂ with a normal (compensated) or near-normal pH. 5 The most common cause is severe COPD, although not all COPD patients develop chronic ventilatory failure. Ventilatory failure usually suggests that less than 25% of alveoli are functioning. Acute pneumonia in COPD patients often will result in AVF that resolves as the pneumonia improves and inflammatory cells are cleared from the airway. Other chronic lung diseases, such as late-stage cystic fibrosis, severe interstitial lung disease, and obesity-hypoventilation syndrome, are associated with the development of CVF. Evaluation of ventilation is described in Chapter 7.

Respiratory failure requires careful patient assessment and then the development and implementation of the respiratory care plan. Common causes of respiratory failure are listed in Box 2-2. Clinical Focus 2-1 provides an example of a specific type of respiratory failure.

**Respiratory Care Plan Development**

The process for respiratory care plan development generally includes the receipt of an order for a specific type of respiratory care or for a respiratory care consult. The process for developing a respiratory care plan may begin when a patient enters the healthcare setting with a problem or complaint. Sometimes the need for respiratory care is not immediately apparent and, in the acute care setting, patients often require respiratory care at some point following admission to the hospital.

Following initial assessment and verification of the patient’s problem or diagnosis by the physician, nurse practitioner, or physician assistant, an order for respiratory care may be written. Upon receipt of an order, the respiratory care clinician performs a medical records review, patient interview, and physical assessment. Blood measurement of So₂ and basic pulmonary function parameters may be performed. Following this assessment, the respiratory care clinician may then select the appropriate care based on the patient’s condition. The goal is to optimize the match between the care needed and the care “menu,” or treatment options that are available. Basic respiratory care options include techniques to improve oxygenation and manage secretions, treatment for bronchospasm and mucosal edema, and lung expansion therapy.

A typical basic respiratory care treatment menu is provided in Table 2-2. Following selection of a respiratory care treatment regimen, the patient’s physician should be notified and given the opportunity to review and/or modify the care plan. The care is then delivered. The patient is monitored, and the care plan is reevaluated based on the patient’s response to therapy. Figure 2-1 summarizes the steps in respiratory care plan development and implementation.

**Goals of Respiratory Care Plans**

Respiratory care plans may be developed for basic and critical respiratory care, diagnostic testing, and specialized procedures (Table 2-1). Goals of the respiratory care plan may include maintaining or improving oxygenation and ventilation, managing secretions, treating or preventing bronchospasm and mucosal edema, and treating and/or preventing atelectasis and pneumonia. Basic respiratory care plans may include oxygen...
Respiratory Failure

Respiratory failure is a general term that indicates the inability of the heart and lungs to provide adequate tissue oxygenation and/or carbon dioxide removal.

Acute Respiratory Failure

Acute respiratory failure may be defined as a sudden decrease in arterial blood oxygen levels (arterial partial pressure of oxygen \([\text{PaO}_2]\) < 50 to 60 mm Hg; arterial oxygen saturation \([\text{SaO}_2]\) < 88% to 90%), with or without carbon dioxide retention (arterial partial pressure of carbon dioxide \([\text{PaCO}_2]\) > 45 mm Hg):

- **Hypoxemic respiratory failure** (lung failure) refers to a primary problem with oxygenation.
- **Hypercapnic respiratory failure** (pump failure) refers to a primary problem with ventilation. Hypercapnic respiratory failure is also known as **ventilatory failure**.

Ventilatory Failure

Ventilatory failure may be defined as an elevated \([\text{PaCO}_2]\) (> 45 to 50 mm Hg). An increased \([\text{PaCO}_2]\) may also be called hypoventilation or hypercapnea:

- **Acute ventilatory failure** is defined as a sudden increase in arterial \([\text{PaCO}_2]\) with a corresponding decrease in pH.
- **Chronic ventilatory failure** is defined as a chronically elevated \([\text{PaCO}_2]\) with a normal or near-normal pH owing to metabolic compensation.
- **Acute on chronic ventilatory failure** is defined as a chronically elevated \([\text{Pco}_2]\) followed by an acute increase in the \([\text{Pco}_2]\) and a corresponding fall in pH.

Acute Lung Injury and Acute Respiratory Distress Syndrome

Acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) are forms of noncardiogenic hypoxemic respiratory failure as defined by the \([\text{PaO}_2]/\text{FiO}_2\) ratio. The characteristics of ALI/ARDS are:

- Bilateral pulmonary infiltrates on chest x-ray
- Pulmonary capillary wedge pressure < 18 mm Hg
- \([\text{Pao}_2]/\text{FiO}_2\) < 300 = ALI. This is equivalent to a \([\text{Pao}_2]\) of less than 63 torr while breathing room air (\([\text{FiO}_2]=0.21\)).
- \([\text{Pao}_2]/\text{FiO}_2\) < 200 = ARDS. This is equivalent to a \([\text{Pao}_2]\) of less than 42 torr while breathing room air (\([\text{FiO}_2]=0.21\))

More recently, the Berlin definition of ARDS was proposed based on symptom timing, chest imaging, and \([\text{Pao}_2]/\text{FiO}_2\) ratio while receiving at least 5 cm H₂O of PEEP or CPAP. This revised definition combines aspects of ALI and ARDS and requires (1) identification of respiratory symptoms within 1 week of new or worsening symptoms or a known clinical insult; (2) bilateral opacities upon chest imaging (chest x-ray or CT scan); (3) opacities that cannot be due to lobar collapse, lung collapse, pulmonary effusion, or pulmonary nodules; (4) pulmonary edema that cannot be due to cardiac failure or fluid overload as assessed by echocardiography or other measures to exclude hydrostatic edema (e.g. PCWP < 18 mm Hg); and (5) \([\text{Pao}_2]/\text{FiO}_2\) ≤ 300 mm Hg with PEEP or CPAP ≥ 5 cm H₂O where:

- \([\text{Pao}_2]/\text{FiO}_2\) ≤ 300 mm Hg—mild
- \([\text{Pao}_2]/\text{FiO}_2\) ≤ 200 mm Hg—moderate
- \([\text{Pao}_2]/\text{FiO}_2\) ≤ 100 mm Hg—severe

CPAP, continuous positive airway pressure; \([\text{FiO}_2]\), fraction of inspired oxygen; \([\text{PaO}_2]\), partial pressure of arterial oxygen; \([\text{PaCO}_2]\), partial pressure of arterial carbon dioxide; \([\text{Paco}_2]\), partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure. If altitude is higher than 1000 m, then correction factor should be calculated as follow: \([\text{PaO}_2]/\text{FiO}_2 \times (\text{barometric pressure}/760)]\)

BOX 2-2

Common Causes of Respiratory Failure

Oxygenation Problems
Low ventilation/perfusion ratio (low V/Q)
- Underventilation with respect to pulmonary perfusion
  - Examples: Asthma, emphysema, COPD, cystic fibrosis, bronchiectasis
Pulmonary shunt
- No ventilation with respect to pulmonary perfusion
  - Examples: ALI/ARDS, atelectasis, pneumonia, rarely pulmonary edema
Diffusion problems
- Impaired diffusion due to increased diffusion distance, block
  - Example: Early pulmonary fibrosis
Hypoventilation
- Increases in Paco₂ result in a corresponding decrease in Pao₂
Low blood oxygen content
- Low Pao₂, Sao₂, or hemoglobin
  - Examples:
    - Low Pao₂ may be due to low V/Q, shunt, diffusion problems, or hypoventilation
    - Low hemoglobin (anemia), abnormal hemoglobin (carbon monoxide poisoning)
Increased pulmonary dead space
- Examples: Pulmonary embolus, obliteration of the pulmonary capillaries (as in severe emphysema)

Ventilation Problems
Acute ventilatory failure (AVF)
- A sudden increase in Paco₂ with a corresponding decrease in pH
  - Examples of conditions associated with AVF:
    - ALI/ARDS, severe pneumonia.
    - Shock, chest trauma, pneumothorax, head trauma, stroke, spinal cord injury, smoke or chemical inhalation, aspiration, near drowning.
    - Sedative or narcotic drug overdose, paralytic drugs, deep anesthesia.
    - Respiratory muscle fatigue and increased work of breathing due to acute exacerbation of COPD, acute severe asthma, severe obesity, thoracic deformity.
    - Neuromuscular disease associated with respiratory failure, such as Guillain-Barré, amyotrophic lateral sclerosis (ALS), myasthenia gravis, polio, critical illness/steroid myopathy, botulism, tetanus.
    - Patients recovering from abdominal or thoracic surgery may need mechanical ventilatory support.
Chronic ventilatory failure
- A chronically elevated Paco₂ with normal or near-normal pH
  - Examples: Chronic bronchitis, severe COPD, obesity-hypoventilation syndrome

CLINICAL FOCUS 2-1

Respiratory Failure

A 30-year-old male was admitted to the hospital following a motor vehicle accident with chest trauma. The patient's increasing respiratory distress, tachypnea, and hypoxemia while breathing room air led to intubation and the initiation of mechanical ventilation. The chest x-ray shows bilateral pulmonary infiltrates; however, there is no evidence of cardiogenic pulmonary edema. Current arterial blood gases while being supported in the assist-control mode of ventilation with an F\textsubscript{1}\text{O}\textsubscript{2} of 0.60 are:

- pH: 7.36
- Pa\textsubscript{CO}\textsubscript{2}: 36 mm Hg
- Pa\textsubscript{O}\textsubscript{2}: 62 mm Hg
- SaO\textsubscript{2}: 90%
- HCO\textsubscript{3}: 20 mEq/L
- B.D.: –5 mEq/L

How would you describe the patient's respiratory condition? (Hint: Before describing the patient's condition, review the definitions and descriptions of respiratory failure found in Box 2-1).

The patient is in acute respiratory failure. The patient has bilateral pulmonary infiltrates, no evidence of cardiogenic pulmonary edema, and a Pa\textsubscript{O}\textsubscript{2}/Fi\textsubscript{O}\textsubscript{2} ratio of 103, which is consistent with a diagnosis of ARDS.


<table>
<thead>
<tr>
<th>Table 2-2</th>
<th>Respiratory Care Treatment Menu</th>
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| Oxygenation | Nasal cannula  
|        | Oxygen masks (simple/partial/nonrebreather)  
|        | High-flow systems (“Venturi” masks, large-volume air-entrainment nebulizers)  
|        | CPAP by mask  
|        | PEEP (may require invasive mechanical ventilation)  |
| Ventilation | Noninvasive mechanical ventilation (includes BiPAP)  
|        | Invasive mechanical ventilation  |
| Secretion Management | Directed cough and deep-breathing instruction  
|        | Suctioning (NT, ET, tracheostomy suctioning)  
|        | Chest physiotherapy (postural drainage, percussion, vibration)  
|        | High-volume bland aerosol therapy (ultrasonic nebulizer, heated large-volume nebulizer)  
|        | Mucus-controlling agents (mucolytics)  |
| Sputum Induction/Obtain Specimen | Directed cough  
|        | Hypertonic saline aerosol  
|        | Suctioning (NT, ET, tracheostomy suctioning)  |
| Bronchospasm/Mucosal Edema | Bronchodilator therapy (small-volume nebulizer, MDI, DPI)  
|        | Anti-inflammatory agents (steroids)  
|        | Antiasthmatic aerosol agents (cromolyn, etc.)  |
| Lung Expansion Therapy | Cough and deep-breathing techniques  
|        | Suctioning  
|        | Incentive spirometry  
|        | IPPB  |
| Frequency of Treatment Options | Continuous  
|        | Every 1 to 2 hours  
|        | Every 4 hours  
|        | Every 6 hours  
|        | Four times a day  
|        | Three times a day  
|        | Two times a day  
|        | Daily  
|        | As needed  |

CPAP, continuous positive airway pressure; PEEP, positive end expiratory pressure; BiPAP, bilevel positive airway pressure; NT, nasotracheal; ET, endotracheal; MDI, metered dose inhaler; DPI, dry powder inhaler; IPPB, intermittent positive pressure ventilation.
Perform assessment  
Chart review  
Patient interview  
Physical assessment
Establish desired treatment goals, objectives, or outcomes
Evaluate/select treatment
Physician notification/review
Deliver respiratory care
Chart in the medical record
Monitor, modify, and reevaluate based on patient response

FIGURE 2-1 Steps in the development and implementation of the respiratory care plan.

Key Elements of a Respiratory Care Plan
The key elements of a basic respiratory care plan are listed in Box 2-3 and include the goals of therapy, devices, medications, methods, gas source, and frequency of administration. Assessment of basic respiratory care should note improvement in oxygenation and ventilation, work of breathing, breath sounds, and, in some cases, pulmonary function and blood gases. Box 2-4 lists the key elements of a respiratory care plan for mechanical ventilatory support.

Maintain Adequate Tissue Oxygenation
Oxygen therapy is indicated for documented or suspected hypoxemia, severe trauma, acute myocardial infarction (MI), and immediate postoperative recovery. It may also be indicated to support the patient with chronic lung disease during exercise and to prevent or treat right-side CHF (cor pulmonale) due to chronic pulmonary hypertension. A PaO₂ < 60 and/or a SaO₂ < 90% are considered clear indications for oxygen therapy in most patients. Exceptions to this rule include patients with chronic carbon dioxide retention and the premature neonate. A critical value in the COPD patient may be a PaO₂ of ≤ 55 torr with a SaO₂ of ≤ 88% while breathing room air or a PaO₂ of 56 to 59 and a SaO₂ < 89% in the presence of cor pulmonale, pulmonary hypertension, CHF, or erythrocythemia with a hematocrit > 56. A critical PaO₂ for the newborn may be a PaO₂ < 50 torr and/or a SaO₂ < 88% or a capillary Po₂ < 40 torr.

Hypoxemia should be suspected whenever the patient is exhibiting the signs and symptoms of hypoxia. Initial signs of hypoxia include tachycardia, increased blood pressure, tachypnea, hyperventilation, dyspnea, and use of accessory muscles. Other early manifestations of hypoxia include restlessness, disorientation, dizziness, excitement, headache, blurred vision, impaired judgment, and confusion. Clinical manifestations of severe hypoxia may include slow, irregular respirations; bradycardia; hypotension; dysrhythmias; loss of consciousness; somnolence; convulsions; and coma. These later findings are more common when hypoxia and hypercapnea coexist. Severe hypoxia may lead to respiratory and/or cardiac arrest. The respiratory care clinician should obtain a SaO₂ or arterial blood gas study in order to confirm the presence of hypoxemia. The indications for oxygen therapy in the acute care setting are summarized in Box 2-5.

Once it is established that oxygen therapy is required, the respiratory care clinician must decide on the appropriate equipment, the correct oxygen flow (F₂O₂), and how the therapy will be assessed. In general, the lowest F₂O₂ needed to ensure adequate tissue oxygenation should be chosen. Generally, this means a target PaO₂ of 60 to 100 with a SaO₂ of 92% to 98% for most patients, with the exception of the COPD patient and the premature infant.

One should also avoid high oxygen levels (> 50% to 60%) for extended periods of time because of the threat of oxygen toxicity, absorption atelectasis, and depression of ciliary and/or leukocytic function. If high levels of oxygen are needed for more than a brief period of time, alternative methods to improve oxygenation should be considered.

Excessive oxygen levels in patients who are chronic CO₂ retainers may lead to ventilatory depression and increased V/Q mismatch when the PaO₂ exceeds 60 torr. Oxygen therapy for the COPD patient with chronically elevated PacO₂ levels should be targeted at maintaining a PaO₂ of 50 to 59 torr with a SaO₂ of 88% to 90% in order to avoid oxygen-induced hypercapnea. The Global Initiative for Chronic Obstructive Lung Disease (GOLD) guide suggests that oxygen therapy in the treatment of COPD exacerbations be titrated to achieve a SaO₂ of 88% to 92%. However, a SaO₂ > 90% may result in a PaO₂ > 60, and consequently should probably be avoided in patients with documented or suspected CO₂ retention. Therefore, titration to a goal of 90% may be ideal.

Providing high oxygen levels to premature infants has been associated with retinopathy of prematurity, a disorder caused by high arterial oxygen concentrations...
in the newborn that may result in blindness. In the past, maintenance of a Pao\(_2\) in the range of 50 to 70 was thought to be safe; however, current guidelines suggest a Pao\(_2\) ≤ 80 torr be maintained in preterm infants of less than 37 weeks gestation.\(^{10}\)

Other techniques that may improve the patient’s oxygenation status include positive end-expiratory pressure (PEEP) or continuous positive airway pressure (CPAP), bronchial hygiene techniques to mobilize secretions, and bronchodilator therapy. Prone positioning has been shown to improve oxygenation in patients with ARDS; however, prone positioning has not been shown to improve survival.\(^{11-13}\) Rotational therapy (turning the patient) may reduce the occurrence of
BOX 2-4

Key Elements of a Respiratory Care Plan for Mechanical Ventilatory Support

Goals of Therapy

- Maintain adequate tissue oxygenation.
- Maintain adequate ventilation and CO₂ removal.
- Maintain adequate acid-base balance.
- Maintain adequate circulation, blood pressure, and cardiac output.
- Treat bronchospasm/mucosal edema/excess secretions.
- Maintain lung volumes/prevent or treat atelectasis.

Device or Procedure

- Volume ventilators
- Pressure ventilators (includes BiPAP devices)
- Humidifiers
- Nebulizers
- MDI and holding chamber
- Positive pressure masks (nasal/oral)
- Artificial airways (endotracheal tracheostomy tubes)
- Suctioning equipment

Medications

- Bronchodilators, anti-inflammatory agents, decongestants, antiasthmatic drugs
- Drugs to treat infection
- Drugs to support circulation, cardiac function, blood pressure
- Sedatives, tranquilizers, pain medications, paralytic agents

Method or Appliance

- Mask (oral/nasal)
- Endotracheal tube
- Tracheostomy tube

Mode of Ventilation

- Invasive or noninvasive
- Volume limited (volume ventilation) or pressure limited (pressure control and pressure support ventilation)

Assist/control, SIMV, SIMV with pressure support, other
Breath initiation (time or patient trigger)
Inspiratory termination (volume, time, pressure, or flow)

Gas Source, Flow, and/or Pressure

- Oxygen concentration
- Patient trigger (pressure or flow trigger)
- Inspiratory flow or time
- Termination of inspiration (pressure, volume, or flow)

Frequency and Duration of Therapy

- Continuous mechanical ventilatory support
- Intermittent support (ventilator weaning, night only, or for acute distress)

Volume and Pressure

- Volume-limited ventilation (mL/kg IBW or mL)
- Inspiratory pressure or pressure limit
- Baseline pressure (PEEP or CPAP)
- Pressure support for “spontaneous” breaths

Assessment

- Improvement and/or reversal of clinical signs and symptoms
- Reversal of the manifestations of hypoxia and/or hypoventilation
- Cardiovascular/hemodynamics (pulse, blood pressure, cardiac output, CVP, other)
- Work of breathing
- Improved breath sounds (air movement, wheezing, rhonchi, crackles)
- Pulse oximetry and arterial blood gases
- Bedside pulmonary function (spontaneous respiratory rate, volumes, RSBI, inspiratory force, IC, VC)
- Chest x-ray or other imaging techniques

BiPAP, bilevel positive airway pressure; MDI, metered dose inhaler; SIMV, synchronized intermittent mandatory ventilation; IBW, ideal body weight; PEEP, positive end-expiratory pressure; CPAP, continuous positive airway pressure; CVP, central venous pressure; RSBI, rapid shallow breathing index; IC, inspiratory capacity; VC, vital capacity.
**BOX 2-5**

**Indications for Oxygen Therapy**

Documented hypoxemia (SpO₂ or arterial blood gases):
- Adults and children: PaO₂ < 60 and/or SpO₂ < 90
- Neonates (< 28 days): PaO₂ < 50 and/or SpO₂ < 88% or a capillary Po₂ < 40 torr

Suspected hypoxemia based on patient condition and/or clinical manifestations of hypoxia (follow with SpO₂ or arterial blood gas measurement)*
- Clinical manifestations of hypoxia include:
  - Tachycardia, increased blood pressure, dysrhythmias
  - Dyspnea, tachypnea, hyperventilation, use of accessory muscles
  - Restlessness, disorientation, dizziness, excitement, headache, blurred vision, impaired judgment, and confusion
- Clinical manifestations of severe hypoxia may include:
  - Slowed, irregular respirations
  - Bradycardia, hypotension
  - Loss of consciousness, somnolence, convulsions, or coma

Severe trauma
- Acute myocardial infarction
- Postoperative recovery

Treat or prevent pulmonary hypertension secondary to chronic hypoxemia:
- PaO₂ ≤ 55 and/or SpO₂ of ≤ 88% while breathing room air with COPD
  OR
- COPD patients with cor pulmonale or hematocrit > 56, PaO₂ of 56 to 59, SaO₂ < 89%, and preexisting pulmonary hypertension

*Hypoxemia should be suspected in the presence of the clinical manifestations of hypoxia.

atelectasis and ventilator-associated pneumonia (VAP), and thus improve oxygenation; however, improvements in length of stay have not been shown.¹⁴

Attention to maintaining cardiac output and blood pressure is required to ensure adequate oxygen delivery to the tissues in patients with cardiovascular instability. Replacement of blood in patients with severe anemia may also be helpful.

The selection of an oxygen delivery method should be based on the desired FiO₂, as well as patient-specific factors such as disease state or condition, ventilatory pattern, patient comfort, and patient acceptance of the oxygen appliance. Generally, hypoxemia due to low V /Q or hypoventilation responds well to low to moderate concentrations of oxygen. This includes patients with asthma, emphysema, chronic bronchitis, bronchiectasis, and cystic fibrosis. Oftentimes, patients with CHF without acute pulmonary edema and patients with coronary artery disease (CAD) also respond well to low to moderate concentrations of oxygen.

The device of choice for most patients requiring low to moderate concentrations of oxygen is the nasal cannula. Setting the nasal cannula oxygen flow at 0.5 to 6.0 L/min will deliver approximately 22% to 40% oxygen.⁶ The nasal cannula is well tolerated, easy to use, and effective for most patients and does not require humidification at flows ≤ 4 L/min. The only major problem associated with the cannula is that the delivered FiO₂ will vary with the patient’s ventilatory pattern and tidal volume (amount of air moved with each breath). An air-entrainment mask should be considered in patients with a variable ventilatory pattern or those with rapid, shallow breathing. Air-entrainment (“Venturi”) masks will deliver a stable FiO₂ for most patients and are available to deliver percentages of 24%, 28%, 30%, 35%, and 40% oxygen.⁶ A sample respiratory care plan for providing oxygen therapy by nasal cannula using the SOAP note format is provided in Clinical Focus 2-2. Figure 2-2 presents a simple oxygen therapy protocol.

Patients with hypoxemia due to pulmonary shunting (ARDS or severe pneumonia) and patients suffering from cardiogenic shock (severe acute MI) or trauma may require moderate to high concentrations of oxygen.
Oxygen Therapy Respiratory Care Plan

A 65-year-old man with a history of COPD has come to the emergency department with worsening shortness of breath, increased sputum production, and production of thick, yellow sputum. The patient has a 50-pack-year history of smoking; however, he quit smoking 3 years ago. The patient has been admitted to the hospital several times over the past 3 years, most recently 8 months ago due to acute exacerbation of COPD with documented CO₂ retention. On physical assessment, the patient displays accessory muscle use and tachypnea with an increased pulse and blood pressure. Oximetry on room air reveals a \( \text{SpO}_2 \) of 85%. On his previous admission, blood gas analysis demonstrated chronic ventilatory failure.

Respiratory Care Plan

S (Subjective): “I’m feeling really bad and can barely get my breath. I am having trouble walking, and I have been coughing up some awful-looking stuff.”

O (Objective):
- Vital signs: Respiratory rate, 28; pulse, 116; BP, 142/92 mm Hg; temperature, 99.6 °F
- \( \text{SpO}_2 = 85\% \) while breathing room air
- Physical assessment: Accessory muscle use, diminished breath sounds bilaterally, cough with purulent sputum production

A (Assessment): Acute respiratory failure due to exacerbation of COPD

P (Plan):
- Begin oxygen via nasal cannula at 1 to 2 L/min and titrate by oximetry.
- Titrate oxygen flow based on oximetry to maintain an \( \text{SpO}_2 \) of 88% to 90% and a \( \text{PaO}_2 \) of 50 to 59 due to the patient’s documented history of CO₂ retention (chronic ventilatory failure).
- Obtain arterial blood gases on oxygen to access ventilatory status.
- Begin albuterol and ipratropium bromide (Atrovent) bronchodilator administration per protocol to relieve airflow obstruction.
- Consider administration of systemic corticosteroids to improve outcomes and decrease length of stay
- Consider antibiotics for pulmonary infection.
- Consider labs (CBC, electrolytes) and chest radiograph
- Continue to monitor patient (level of consciousness, dyspnea, vital signs, \( \text{SpO}_2 \), blood gases) and be alert to possible comorbidities (pneumonia, cardiovascular disease, lung cancer, diabetes, etc.)

Therapy. Short-term oxygen therapy for patients who need moderate to high concentrations of oxygen can be provided using a simple mask (35% to 50% \( \text{O}_2 \) at 5 to 10 L/min), a partial rebreathing mask (40% to 70% \( \text{O}_2 \) at 5 to 10 L/min), or a non-rebreathing mask (60% to 80% \( \text{O}_2 \) at 6 to 10 L/min). Air-entrainment nebulizers via aerosol mask, tracheostomy mask, or “T” piece can be very useful in providing a stable oxygen concentration from 28% to 50%. Above 50% oxygen, most air-entrainment nebulizers do not have an adequate total gas flow to deliver a dependable \( \text{FIO}_2 \). The Misty Ox high-flow, high-\( \text{FIO}_2 \) nebulizer, however, will deliver 60% to 96% oxygen with total gas flows of 42 to 80 L/min. The Thera-Mist air-entrainment nebulizer is designed to provide 36% to 96% oxygen at flows of 47 to 74 L/min.¹⁵

Patients with conditions that are unresponsive to basic oxygen therapy may require the use of PEEP or CPAP. PEEP and CPAP may be applied through the use of specialized face masks. Often, however, administration of PEEP or CPAP will require intubation and the use of mechanical ventilatory support.

To summarize, if the patient requires a low to moderate concentration of oxygen, the nasal cannula is the device of choice for oxygen delivery. In patients with unstable ventilatory patterns or rapid shallow breathing, an air-entrainment (“Venturi”) mask may be considered. For moderate to high concentrations of oxygen therapy for short-term use, consider a simple, partial-rebreathing or non-rebreathing mask. For stable oxygen concentration via aerosol mask, tracheostomy mask, or “T” piece, consider a standard air-entrainment nebulizer for an \( \text{FIO}_2 \) of 0.28 to 0.50 and a high-flow, high-\( \text{FIO}_2 \) entrainment nebulizer for 60% to 96% oxygen. In patients who do not respond to basic oxygen therapy, the use of PEEP or CPAP should be considered.
Oxygen therapy by nasal cannula indicated?

Begin therapy at 0.5 to 6 L/min

Measure SpO₂

SpO₂ ≥ 92%?

↑O₂ flow to achieve SpO₂ ≥ 92%*

Adjust flow to maintain SpO₂ of 92% to 98%

Recheck SpO₂

SpO₂ ≥ 92%?

Continue to ↑O₂ flow; consider alternate administration device* (e.g., O₂ mask)

Does patient require O₂ to maintain SpO₂ ≥ 92%?

Is SpO₂ ≥ 92% on room air?

Restart O₂

Recheck on next shift (while awake)

Is SpO₂ ≥ 92% on room air?

Restart O₂

Maintain SpO₂ ≥ 92% Recheck

Discontinue (D/C) O₂

Discontinue (D/C) O₂

Yes

No

FIGURE 2-2 Protocol for oxygen therapy by nasal cannula.

Treat and/or Prevent Bronchospasm and Mucosal Edema

Bronchodilator Therapy

The primary indication for bronchodilator therapy is to treat or prevent bronchospasm. Bronchodilator therapy is indicated in the treatment of acute asthma, COPD (to include chronic bronchitis and cystic fibrosis), and whenever wheezing is due to reversible bronchoconstriction. A documented response to bronchodilator therapy may be demonstrated by an improvement in peak expiratory flow rate (PEF), forced expiratory volume in 1 second (FEV₁), or forced vital capacity (FVC) following therapy.¹⁶ An improvement in clinical findings such as decreased wheezing or improved aeration or a subjective improvement in the respiratory status of the patient are also important indicators of bronchodilator effectiveness.¹⁶ In mechanically ventilated patients, bronchodilator therapy may be helpful with increased airway resistance. An improvement in peak inspiratory pressures or expiratory gas flow curves may be useful in documenting the effectiveness of the therapy in these patients. Box 2-6 summarizes the indications for bronchodilator therapy.

Once the respiratory care clinician has determined that bronchodilator therapy is indicated, the specific medication, method of delivery, and frequency of administration must be determined. Bronchodilators are most commonly administered by inhalation via a metered-dose inhaler (MDI), a small-volume nebulizer (SVN), or a dry powder inhaler (DPI). Bronchodilators may be classified as β₂-agonists or anticholinergics and as short acting or long acting. Short-acting β₂-agonists include albuterol, levalbuterol, and pirbuterol. All have a rapid onset and a duration of effect of 5 to 8 hours. Anticholinergic bronchodilators include ipratropium bromide (short-acting) and tiotropium bromide (long-acting). Asthma and COPD represent two conditions that often require bronchodilator therapy.

Respiratory Care Plans for Asthma

Excellent clinical practice guidelines for the management of asthma have been developed by the National Institutes of Health.¹⁷ Inhaled asthma medications include quick-relief bronchodilators and long-term control agents, usually inhaled corticosteroids. Patients with persistent asthma usually require both types of medications. Most patients with persistent asthma can maintain good control of their asthma with proper patient education (including symptom monitoring and a written asthma action plan), avoidance of asthma triggers, and an appropriate regimen of both bronchodilators (rescue medications) and anti-inflammatory agents (controller medications).

With poorly controlled asthma, acute asthma exacerbations often result in visits to the emergency department (ED). Initial ED treatment of acute asthma exacerbation in the adult often includes administration of 2.5 to 5.0 mg (per dose) of aerosolized albuterol via SVN every 20 minutes for a total of three doses. Following the initial bronchodilator administration of three doses, 2.5 to 10 mg of albuterol is then administered by SVN every 1 to 4 hours as needed (or 10 to 15 mg/hour nebulized continuously). Ipratropium may be added, initially beginning with 0.5 mg every 20 minutes.
**Indications for Bronchodilator Therapy**

- **Asthma**
- **COPD** (emphysema/chronic bronchitis)
- **Cystic fibrosis**
- **Wheezing**

Documented response to a bronchodilator:

- Increase in FEV₁ > 12% following therapy and at least 200 mL

  OR

- Increase in FVC > 12% following therapy and at least 200 mL

  OR

- Increase in PEF*:
  - PEF to > 80% of predicted or > 80% personal best = good response
  - PEF to 50% to 79% of predicted or 60% to 80% of personal best = not well controlled.
  - Increased airway resistance in patients receiving mechanical ventilation

*PEF monitoring is recommended for patients with moderate to severe chronic asthma. A peak flow > 80% of predicted or > 80% personal best suggests that asthma is in good control; 50% to 79% of predicted or 50% to 79% of personal best suggests that asthma is not well controlled; < 50% suggests asthma is poorly controlled and represents a medical alert that requires immediate treatment and contact with the patient’s physician.

FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow rate

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Respiratory Care Plans for COPD

Inhaled bronchodilator therapy is central to the management of COPD, as described in the GOLD standards. Bronchodilators are prescribed on an as-needed basis to prevent or reduce symptoms, improve exercise capacity, and reduce airflow limitation. Some evidence suggests that long-acting bronchodilators, such as tiotropium, may improve health status, reduce exacerbations, decrease the number of hospitalizations, and improve the efficacy of pulmonary rehabilitation. Combination of a β₂-agonist and anticholinergic bronchodilator (combination therapy) may result in greater bronchodilation than either drug when used alone. Inhaled triple therapy, which combines a β₂-agonist, anticholinergic agent, and inhaled corticosteroid, has been advocated for use with severe COPD. Table 2-4 lists common COPD medications and dosages. Box 2-7 outlines the management of patients with stable COPD.

Generally, low-risk COPD patients with intermittent symptoms are treated with two puffs of an inhaled short-acting anticholinergic bronchodilator or a short-acting β₂-agonist via MDI, as needed. Low-risk patients with regular or daily symptoms may be treated with a long-acting inhaled anticholinergic bronchodilator or a long-acting inhaled β₂-agonist. High-risk patients with severe to very severe airflow limitation (FEV₁/FVC < 0.70 and FEV₁ < 50% predicted) require the addition of an inhaled corticosteroid to a long-acting bronchodilator. A severe exacerbation of COPD may require a short-acting β₂-bronchodilator via MDI or SVN every one-half to 2 hours and/or increasing the dose of ipratropium. Hospitalized patients with acute exacerbation of COPD are also treated with oral corticosteroids and antibiotics. Figure 2-4 outlines the pharmacologic management of stable COPD; Figure 2-5 describes the treatment of COPD exacerbation.

**Bronchodilator Therapy for Other Conditions**

For other disease states or conditions where bronchospasm is suspected, the frequency of administration of a short-acting bronchodilator generally ranges from...
<table>
<thead>
<tr>
<th>Medication</th>
<th>Child Dose (≤ 12 years)</th>
<th>Adult Dose</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inhaled Short-Acting Selective ( \beta_2 )-Agonists</strong> (SABA)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albuterol</td>
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</tr>
<tr>
<td>Nebulizer solution (0.63 mg/3 mL, 1.25 mg/3 mL, 2.5 mg/3 mL, 5.0 mg/mL)</td>
<td>0.15 mg/kg (minimum dose 2.5 mg every 20 minutes for three doses then 0.15–0.3 mg/kg up to 10 mg every 1–4 hours as needed, or 0.5 mg/kg/hour by continuous nebulization.)</td>
<td>2.5–5 mg every 20 minutes for three doses, then 2.5–10 mg every 1–4 hours as needed or 10–15 mg/hour continuously.</td>
<td>Dilute aerosols to minimum of 3 mL at gas flow of 6–8 L/min. Use large-volume nebulizers for continuous administration. May mix with ipratropium nebulizer solution.</td>
</tr>
<tr>
<td>MDI (90 mcg/puff)</td>
<td>4–8 puffs every 20 minutes for three doses, then every 1–4 hours inhalation maneuver as needed. Use VHC; add mask in children &lt; 4 years.</td>
<td>4–8 puffs every 20 minutes up to 4 hours, then every 1–4 hours as needed.</td>
<td>In mild to moderate exacerbations, MDI plus HC is as effective as nebulized therapy with appropriate administration technique and coaching by trained personnel.</td>
</tr>
<tr>
<td>Bitolterol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nebulizer solution (2 mg/mL)</td>
<td>See albuterol dose; thought to be half as potent as albuterol on per mg basis.</td>
<td>See albuterol dose.</td>
<td>Not studied in severe asthma exacerbations. Do not mix with other drugs.</td>
</tr>
<tr>
<td>MDI (370 mcg/puff)</td>
<td>See albuterol MDI dose.</td>
<td>See albuterol MDI dose.</td>
<td>Not studied in severe asthma exacerbations.</td>
</tr>
<tr>
<td>Levalbuterol (R-albuterol)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nebulizer solution (0.63 mg/3 mL, 1.25 mg/0.5 mL, 1.25 mg/3 mL)</td>
<td>0.075 mg/kg (minimum dose 1.25 mg every 20 minutes for three doses, then 0.075–0.15 mg/kg up to 5 mg every 1–4 hours as needed.)</td>
<td>1.25–2.5 mg every 20 minutes for three doses, then 1.25–5 mg every 1–4 hours as needed.</td>
<td>Levalbuterol administered in one-half the mg dose of albuterol provides comparable efficacy and safety. Has not been evaluated by continuous nebulization.</td>
</tr>
<tr>
<td>MDI (45 mcg/puff)</td>
<td>See albuterol MDI dose.</td>
<td>See albuterol MDI dose.</td>
<td></td>
</tr>
<tr>
<td>Pirbuterol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MDI (200 mcg/puff)</td>
<td>See albuterol MDI dose; thought to be half as potent as albuterol on a per mg basis.</td>
<td>See albuterol MDI dose.</td>
<td>Has not been studied in severe asthma exacerbations.</td>
</tr>
<tr>
<td><strong>Systemic (Injected) ( \beta_2 )-Agonists</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epinephrine</td>
<td></td>
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</tr>
<tr>
<td>1:1,000 (1 mg/mL)</td>
<td>0.01 mg/kg up to 0.3–0.5 mg SQ every 20 minutes for three doses.</td>
<td>0.3–0.5 mg every 20 minutes for three doses.</td>
<td>No proven advantage of systemic therapy over aerosol.</td>
</tr>
<tr>
<td>Terbutaline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1 mg/mL)</td>
<td>0.01 mg/kg SQ every 20 minutes for three doses then every 2–6 hours as needed.</td>
<td>0.25 mg SQ every 20 minutes for three doses.</td>
<td>No proven advantage of systemic therapy over aerosol.</td>
</tr>
<tr>
<td><strong>Anticholinergics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ipratropium bromide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nebulizer solution (0.25 mg/mL)</td>
<td>0.25–0.5 mg every 20 minutes for three doses, then as needed.</td>
<td>0.5 mg every 20 minutes for three doses, then as needed.</td>
<td>May mix in nebulizer with albuterol. Should not be used as first-line therapy; add to SABA therapy for severe exacerbations. The addition of ipratropium not shown to provide further benefit once the patient is hospitalized.</td>
</tr>
</tbody>
</table>
every 4 hours to four times a day, depending on the patient’s response and the duration of effect of the medication. For example, the recommended dosage of albuterol by SVN is 2.5 mg three or four times per day, with the onset of action occurring in about 15 minutes, a peak effect in 30 to 60 minutes, and a duration of action of 5 to 8 hours. Salmeterol, a long-acting β₂-agonist, has an onset within 20 minutes, a peak effect in 180 to 300 minutes, and a duration of action of 12 hours. The normal dose for salmeterol via DPI is one inhalation every 12 hours. Formoterol also has a duration of 12 hours but an onset of action similar to albuterol. The usual dose for formoterol via MDI is two puffs every 12 hours.

Anti-inflammatory Agents and Antiasthmatic Medications

Anti-inflammatory aerosol agents and antiasthmatic medications include inhaled corticosteroids; cromolyn sodium (a mast cell stabilizer); and antileukotrienes, such as zafirlukast (Accolate), montelukast (Singulair), and zileuton (Zyflo), the latter three medications being administered in tablet form. The indications for anti-inflammatory aerosol agents and antiasthmatic agents are listed in Box 2-8.

Corticosteroids are the strongest and most effective anti-inflammatory agents currently available and are more effective in asthma control than any other single long-term medication. The appropriate use of corticosteroids in the treatment of asthma is well described in the NIH Guidelines. Inhaled corticosteroids are taken daily on a long-term basis to control persistent asthma; and short courses of oral corticosteroids are often used to gain rapid control during asthma exacerbations. Cromolyn sodium, administered by inhalation, stabilizes the mast cells in the lungs and may prevent or reduce the inflammatory response in asthma. As a prophylactic agent, cromolyn sodium may be added to the care regimen as an alternative in the long-term

<table>
<thead>
<tr>
<th>Medication</th>
<th>Child Dose (≤ 12 years)</th>
<th>Adult Dose</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDI (18 mcg/puff)</td>
<td>4–8 puffs every 20 minutes as needed up to 3 hours.</td>
<td>8 puffs every 20 minutes as needed up to 3 hours.</td>
<td>Use with HC and face mask for children &lt; 4 years.</td>
</tr>
<tr>
<td>Ipratropium with albuterol</td>
<td>1.5–3 mL every 20 minutes for three doses, then as needed.</td>
<td>3 mL every 20 minutes for three doses, then as needed.</td>
<td>Used for up to 3 hours in initial management of severe exacerbations. Addition of ipratropium to albuterol not shown to provide further benefit once the patient is hospitalized.</td>
</tr>
<tr>
<td>MDI (each puff contains 18 mcg ipratropium bromide and 90 mcg of albuterol)</td>
<td>4–8 puffs every 20 minutes as needed up to 3 hours.</td>
<td>8 puffs every 20 minutes as needed up to 3 hours.</td>
<td>Use with HC and face mask for children &lt; 4 years.</td>
</tr>
<tr>
<td>Systemic Corticosteroids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prednisone</td>
<td>1–2 mg/kg in two divided doses (maximum = 60 mg/day) until PEF is 70% of predicted or personal best.</td>
<td>40–80 mg/day in one or two divided doses until PEF reaches 70% of predicted or personal best.</td>
<td>Outpatient “burst”: use 40–60 mg in one or two divided doses for total of 5–10 days in adults (children: 1–2 mg/kg/day maximum 60 mg/day for 3–10 days).</td>
</tr>
<tr>
<td>Methylprednisolone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prednisolone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• There is no advantage for intravenous administration over oral therapy provided gastrointestinal transit time or absorption is not impaired.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Course of systemic corticosteroids for asthma exacerbation requiring ED visit or hospitalization may be 3–10 days. For less than 1 week, no need to taper dose. For courses up to 10 days, tapering may not be necessary, especially if patients are concurrently taking inhaled corticosteroids.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>• Inhaled corticosteroids can be started at any point in the treatment of an asthma exacerbation.</td>
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</tr>
</tbody>
</table>

MDI, metered-dose inhaler; HC, holding chamber; PEF, peak expiratory flow; ED, emergency department; SQ, subcutaneous.

Patient Assessment

- **Review of the patient record and patient interview**: Assess for severity of exacerbation and risk factors associated with death from asthma:
  - **Asthma history**
    - Level of dyspnea (mild, moderate, or severe?)
    - Previous history of exacerbation?
    - Previous emergency department visits (>3 in the past year?)
    - Previous hospitalizations (>2 in the past year?)
    - ICU admission and/or intubation for asthma?
    - Use of MDI β₂-adrenergic agonist canisters (>2 per month?)
    - Difficulty perceiving asthma symptoms or severity of exacerbations?
    - Written action plan (in place and followed)?
    - Sensitivity to Alternaria (a fungus associated with hay fever and allergic asthma)?
  - **Social history**
    - Low socioeconomic status or inner-city resident?
    - Illicit drug use?
    - Major psychological problems?
  - **Comorbidities**
    - Cardiovascular disease?
    - Other chronic lung disease?
    - Chronic psychiatric disease?

- **Physical assessment**: Observe for:
  - Breathlessness at rest?
  - Ability to talk in sentences, phrases, or only words due to dyspnea?
  - Alertness (agitated, drowsy, confused)?
  - Increased respiratory rate (>30 is severe)?
  - Tachycardia (>120 is severe)? Pulsus paradoxus?
  - Accessory muscle use?
  - Wheezing? (Absence of wheeze may signal an imminent respiratory arrest.)

- **Pulmonary function**:
  - PEF percent predicted or percent personal best (for asthma):
    - Mild severity: ≥70%
    - Moderate severity: 40% to 60%
    - Severe: <40%

- **Oximetry and arterial blood gases breathing room air**:
  - Normal: SpO₂ > 95% and/or PaO₂ 80 to 100 on room air
  - Moderate severity: SpO₂ 90% to 95% and/or PaO₂ ≥ 60 but < 80
  - Severe: SpO₂ < 90% and/or PaO₂ < 60 – severe
  - Mild or normal: PaCO₂ < 42 mm Hg; ≥ 42 mm Hg may progress to ventilatory failure requiring mechanical ventilation

- **Treatment**
  - Supply oxygen therapy to relieve hypoxemia and maintain SaO₂ ≥ 90%.
  - Administer inhaled short-acting β₂-agonist to relieve airflow obstruction, with addition of inhaled ipratropium bromide in severe exacerbations.
  - Administer systemic corticosteroids to decrease airway inflammation in moderate or severe exacerbations or for patients who fail to respond promptly and completely to a short-acting β₂-agonist.
  - Monitor vital signs, SaO₂.
  - Consider adjunct therapy in severe exacerbations unresponsive to the initial treatment:
    - Intravenous magnesium sulfate
    - Heliox
  - Monitor response with serial measurements of lung function (FEV1 or PEF).
  - Prevent recurrence:
    - Refer to follow-up asthma care within 1 to 4 weeks of discharge.
    - Provide asthma care plan with instructions for medications prescribed at discharge and for increasing medications or seeking medical care if asthma worsens.
    - Review/teach inhaler use/techniques.
    - Consider initiating inhaled corticosteroids.

**FIGURE 2-3 Management of acute asthma exacerbation.**

<table>
<thead>
<tr>
<th>Drug</th>
<th>Trade Names</th>
<th>Inhaler (mcg)</th>
<th>DPI/MDI Dose</th>
<th>Solution for Nebulizer</th>
<th>Nebulizer Dose</th>
<th>Duration of Action (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>β₂-agonists</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Short Acting</strong></td>
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</tr>
<tr>
<td>Albuterol</td>
<td>Proventil HFA; Ventolin HFA; ProAir HFA; AccuNeb; VoSpire ER</td>
<td>90 mcg/puff (MDI)</td>
<td>2 puffs three to four times per day</td>
<td>0.5% solution—0.5 mL (2.5 mg), or 0.63 mg, 1.25 mg, and 2.5 mg unit dose</td>
<td>2.5 mg in 3 mL normal saline three to four times per day</td>
<td>5–8</td>
</tr>
<tr>
<td>Levalbuterol</td>
<td>Xopenex; Xopenex HFA</td>
<td>45 mcg/puff (MDI)</td>
<td>2 puffs every 4–6 hours</td>
<td>0.31 mg, 0.63 mg, 1.25 mg in 3 mL solution</td>
<td>3 mL three times per day</td>
<td>5–8</td>
</tr>
<tr>
<td>Pirbuterol</td>
<td>Maxair Autohaler</td>
<td>200 mcg/puff (MDI)</td>
<td>2 puffs every 4–6 hours</td>
<td>NA</td>
<td>NA</td>
<td>5–8</td>
</tr>
<tr>
<td><strong>Long Acting</strong></td>
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<td></td>
</tr>
<tr>
<td>Arformoterol</td>
<td>Brovana</td>
<td>NA</td>
<td>NA</td>
<td>15 mcg/2 mL unit dose vial</td>
<td>2 mL every 12 hours</td>
<td>12</td>
</tr>
<tr>
<td>Formoterol</td>
<td>Perforomist, Foradil</td>
<td>12 mcg/inhalation (DPI)</td>
<td>1 inhalation every 12 hours</td>
<td>20 mcg/2 mL unit dose vial</td>
<td>2 mL every 12 hours</td>
<td>12</td>
</tr>
<tr>
<td>Indacaterol</td>
<td>Arcapta Neohaler</td>
<td>75 mcg/inhalation (DPI)</td>
<td>1 inhalation every day</td>
<td>NA</td>
<td>NA</td>
<td>24</td>
</tr>
<tr>
<td>Salmeterol</td>
<td>Serevent Diskus</td>
<td>50 mcg/inhalation (DPI)</td>
<td>1 inhalation every 12 hours</td>
<td>NA</td>
<td>NA</td>
<td>12</td>
</tr>
<tr>
<td><strong>Anticholinergics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Short Acting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ipratropium bromide</td>
<td>Atrovent HFA</td>
<td>17 mcg/puff (MDI)</td>
<td>2 puffs four times daily</td>
<td>0.2 mg/mL (0.02% solution) in a 2.5 mL unit dose</td>
<td>2.5 mL unit dose/500 mcg three to four times daily</td>
<td>4–6</td>
</tr>
<tr>
<td>Oxitropium bromide (available outside United States)</td>
<td>Oxivent, Tersigan, Tersigat, Ventilat, Ventox</td>
<td>100 mcg (MDI)</td>
<td>2 puffs two to three times daily</td>
<td>NA</td>
<td>NA</td>
<td>7–9</td>
</tr>
<tr>
<td><strong>Long Acting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tiotropium</td>
<td>Spiriva</td>
<td>18 mcg/inhalation (DPI)</td>
<td>1 inhalation every day</td>
<td>NA</td>
<td>NA</td>
<td>24</td>
</tr>
<tr>
<td><strong>Combination Short-Acting β₂-Agonists Plus Anticholinergic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Albuterol/ Ipratropium | Combivent DuoNeb                | Albuterol: 90 mcg Ipratropium: 18 mcg/puff | 2 puffs four times a day of 18 mcg/puff Ipratropium and 90 mcg/puff albuterol | Albuterol: 2.5 mg Ipratropium: 0.5 mg in 3 mL | 3 mL four times a day | 4–6 | (continues)
Table 2-4
COPD Medications (continued)

<table>
<thead>
<tr>
<th>Drug</th>
<th>Trade Names</th>
<th>Inhaler (mcg)</th>
<th>DPI/MDI Dose</th>
<th>Solution for Nebulizer</th>
<th>Nebulizer Dose</th>
<th>Duration of Action (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fenoterol/ Ipratropium (available in Canada)</td>
<td>Duovent UDV</td>
<td>NA</td>
<td>NA</td>
<td>Fenoterol: 1.25 mg Ipratropium: 0.5 mg in 4 mL</td>
<td>4 mL every 6 hours</td>
<td>6–8</td>
</tr>
</tbody>
</table>

**Methylxanthines**

| Aminophylline | Phyllocontin; Truphylline (Canada) | • IV 5.7 mg/kg loading dose in patients not currently receiving<br>• IV maintenance dose in adults 16–60 years: 0.51 mg/kg/hr; maximum 400 mg/day to achieve a serum theophylline level of 5–10 mcg/mL<br>• IV maintenance dose in adults > 60 years: 0.38 mg/kg/hr; maximum 400 mg/day<br>• Dose should be adjusted for shock, sepsis, cardiac decompensation, cor pulmonale, or liver dysfunction to 0.25 mg/kg/hr; maximum 400 mg/day | Variable, up to 24 |
| Theophylline | Theochron, Elixophyllin, Theo-24 | • Initial dose (oral): 300–400 mg once daily<br>• Maintenance: 400–600 mg once daily (maximum 600 mg/day) | Variable, up to 24 |

**Phosphodiesterase-4 inhibitors**

| Roflumilast | Dalisresp | 500 mcg oral tablet once daily | 24 |

**Inhaled Corticosteroids**

| Beclomethasone diproprionate HFA | Qvar | 40 mcg/puff and 80 mcg/puff (MDI) | 40–80 mcg twice daily or 40–160 mcg twice daily* | NA | NA | NA |
| Budesonide | Pulmicort, Pulmicort Respules | 90 mcg/actuation and 180 mcg/actuation (DPI) | 180–360 mcg twice daily or 360–720 mcg twice daily** | NA | NA | NA |
| Fluticasone propionate | Flovent HFA, Flovent Diskus | 44 mcg/puff, 110 mcg/puff, and 220 mcg/puff (MDI) | 88 mcg twice daily*** | NA | NA | NA |

**Combination Long-Acting β<sub>2</sub>-Agonists Plus Corticosteroids**

| Formoterol/ Budesonide | Symbicort | 160 mcg budesonide/4.5 mcg formoterol per puff (MDI) | 2 puffs twice daily | NA | NA | NA |
| Salmeterol/ Fluticasone | Advair Diskus, Advair HFA | 100, 250, or 500 mcg fluticasone/50 mcg salmeterol (DPI) 45, 115, or 230 mcg fluticasone/21 mcg salmeterol (MDI) | 1 inhalation every 12 hours (DPI) 2 puffs every 12 hours (MDI) | NA | NA | 12 |
**Table 2-4**  
**COPD Medications (continued)**

<table>
<thead>
<tr>
<th>Drug</th>
<th>Trade Names</th>
<th>Inhaler (mcg)</th>
<th>DPI/MDI Dose</th>
<th>Solution for Nebulizer</th>
<th>Nebulizer Dose</th>
<th>Duration of Action (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylprednisolone</td>
<td>Medrol; Meprolone</td>
<td>Methylprednisolone suggested dosage for COPD exacerbation with impending respiratory failure is 60 mg IV, one to two times daily.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prednisone</td>
<td>Prednisone Intenso™</td>
<td>Oral prednisone dose of 30–60 mg/day for 7–10 days has been suggested.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MDI, metered dose inhaler; DPI, dry powder inhaler; SMI, smart mist inhaler; NA = not applicable.

*Beclomethasone recommended starting dose if previously taking inhaled corticosteroids.

**Budesonide starting dose if only taking bronchodilators and/or inhaled corticosteroids previously. Starting dose should be higher (360 to 720 mcg twice daily) if previously taking oral corticosteroids.

***Fluticasone starting dose if only taking bronchodilators previously. Starting dose should be 88 to 220 mcg twice daily if previously taking inhaled corticosteroids and 880 mcg twice daily if previously taking oral corticosteroids.


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**BOX 2-7**  
**Management of Stable COPD**

- Smoking cessation
- Pharmacological therapy
  - Short-acting β₂-agonists (albuterol)
  - Short-acting anticholinergic bronchodilator (ipratropium)
  - Combined short-acting β₂-agonists and short-acting anticholinergic bronchodilators
  - Long-acting inhaled β₂-agonists (salmeterol, formoterol)
  - Long-acting anticholinergic bronchodilator (tiotropium)
  - Combined long-acting β₂-agonists and long-acting anticholinergic bronchodilators
  - Phosphodiesterase-4 inhibitor (roflumilast)*
  - Inhaled corticosteroids (beclomethasone, budesonide, triamcinolone, fluticasone, flunisolide)
  - Combining long-acting inhaled β-agonists and inhaled corticosteroids in one inhaler
  - Mucolytics/antioxidant therapy (oral N-acetylcysteine)
  - α-Trypsin augmentation therapy (identified α₁-antitrypsin deficiency)
- Vaccination (influenza, pneumococcal disease)
- Oxygen therapy
- Long-term oxygen therapy
- Pulmonary rehabilitation
- Nutrition
- Surgery in or for COPD
- Sleep (assess for sleep issues and/or sleep disorders)
- Air travel considerations (evaluate the need for oxygen)

*For chronic bronchitis with frequent exacerbations

LESS RISK, LESS SYMPTOMS

Patients with low risk, less symptoms, and mild to moderate airflow limitation (FEV₁/FVC < 0.70 and FEV₁ > 50% predicted) and one or fewer exacerbations per year.

First Choice
Short-acting anticholinergic bronchodilator PRN OR Short acting β₂-agonist PRN

Second Choice
Long-acting anticholinergic bronchodilator OR Long-acting β₂-agonist OR Long-acting anticholinergic and long-acting β₂-agonist

LESS RISK, MORE SYMPTOMS

Patients with low risk, more symptoms, and mild to moderate airflow limitation (FEV₁/FVC < 0.70 and FEV₁ > 50% predicted) and one or fewer exacerbations per year.

First Choice
Long-acting anticholinergic bronchodilator OR Long-acting β₂-agonist

Second Choice
Long-acting anticholinergic bronchodilator and long-acting β₂-agonist

HIGH RISK, LESS SYMPTOMS, BUT SEVERE AIRFLOW LIMITATION

Patients with high risk, less symptoms, but severe to very severe airflow limitation and two or more exacerbations per year (FEV₁/FVC < 0.70 and FEV₁ < 50% predicted [severe] or FEV₁ < 30% predicted [very severe]).

First Choice
Inhaled corticosteroids AND Long-acting β₂ agonist OR long-acting anticholinergic

Second Choice
Long-acting anticholinergic and long-acting β₂-agonist

HIGH RISK, MORE SYMPTOMS, AND SEVERE AIRFLOW LIMITATION

Patients with high risk, more symptoms, and severe to very severe airflow limitation and two or more exacerbations per year.

First Choice
Inhaled corticosteroids AND Long-acting β₂-agonist OR long-acting anticholinergic

Second Choice
Inhaled corticosteroids and long-acting anticholinergic OR Inhaled corticosteroids and long-acting β₂-agonist and long-acting anticholinergic OR Inhaled corticosteroids and long-acting β₂-agonist and phosphodiesterase-4 inhibitor OR Long-acting anticholinergic and long-acting β₂-agonist OR Long-acting anticholinergic and phosphodiesterase-4 inhibitor

FIGURE 2.4 Pharmacologic treatment for the stable COPD.

Patient Assessment

- **Interview:** Question patient regarding increased dyspnea, orthopnea, cough, sputum production, sputum purulence, decreased ability to conduct activities of daily living (ADLs).

- **Physical assessment:** Observe for increased respiratory rate, tachycardia, color (cyanosis, pale, skin flushed/red), accessory muscle use, pursed-lip breathing, chest configuration (overinflation; barrel chest), level of consciousness (oriented, anxiety, sleepy, lethargic, somnolent), breath sounds (diminished, crackles, gurgles, wheezing), cough, purulent sputum.

- **Oximetry and arterial blood gases**
  - $\text{SpO}_2 < 88\%$ to $90\%$ is consistent with a $\text{PaO}_2 < 55$ to $58$ ($\text{SpO}_2 < 85\%$ is consistent with a $\text{PaO}_2 < 50$).
  - $\text{PaO}_2 < 60$ on $\text{FiO}_2 = 0.21$ (with or without $\text{CO}_2$ elevation) indicates respiratory failure.

- **Chest radiograph:** Review for infiltrates, pneumonia, exclude alternative diagnoses.

- **Laboratory studies**
  - Complete blood count (polycythemia, anemia, elevated WBC)
  - Electrolytes
  - Renal function

Treatment

- **Oxygen therapy**
  - Low-flow cannula (0.5 to 4 L/min) to achieve $\text{SpO}_2$ of 90% to 92% and $\text{PaO}_2$ of 60 to 70 mm Hg.
  - High-flow air-entrainment mask (24% to 28%) may be considered in the presence of an irregular ventilatory pattern or rapid shallow breathing.

- **Bronchodilators:** Short-acting $\beta_2$-agonist with or without short-acting anticholinergics for treatment of an exacerbation.

- **Systemic corticosteroids**
  - Corticosteroids may improve patient outcomes and reduce length of stay.
  - IV or oral prednisone 30 to 60 mg, once daily for 7 to 10 days (dose may be tapered for another 7 days; however, tapering is not necessary for therapy of less than 3 weeks).
  - Prednisolone dose suggested by the GOLD standards is 30 to 40 mg/day for 10 to 14 days (oral route preferred).

- **Antibiotics:** Antibiotics should be considered in the presence of:
  - Increased dyspnea, increased sputum volume and increased sputum purulence OR
  - Increased sputum purulence AND
  - Increased sputum volume OR increased dyspnea OR
  - Ventilatory failure requiring mechanical ventilatory support.

- **Other therapy:** Attention should be paid to:
  - Fluid balance (consider diuretics for fluid overload)
  - Nutrition
  - Treatment of comorbidities such as pneumonia, cardiovascular disease (ischemic heart disease, CHF, hypertension, atrial fibrillation), lung cancer, renal failure, liver failure, osteoporosis, diabetes, anxiety and depression.

FIGURE 2-5 Outline of the management of COPD exacerbation.


Management of asthma and as a preventive measure prior to exercise or exposure to known allergens.\(^{17}\)

Leukotriene modifiers that reduce or block inflammation include montelukast (Singular), zafirlukast (Accolate), and zileuton (Zyflo). Montelukast and zafirlukast are leukotriene receptor antagonists (LTRAs) and may be useful as alternatives in the treatment of mild to moderate asthma.\(^{17}\) LTRAs may be used in combination with inhaled corticosteroids, although in adults the addition of long-acting bronchodilators should be considered first.\(^{17}\) Zileuton is a 5-lipoxygenase pathway inhibitor that may also be considered for asthma prophylaxis. Zileuton requires assessment of liver enzymes prior to initiation and ongoing liver function monitoring.\(^{19}\)
**Indications for Anti-inflammatory and Antiasthma Agents**

**Anti-inflammatory Aerosol Agents (Inhaled Steroids)**
- Asthma
- COPD (emphysema, chronic bronchitis, cystic fibrosis)
- Upper airway edema (postextubation, croup)

**Antiasthmatic Aerosol Agents (Cromolyn, Antileukotrienes)**
- Asthma

**Treatment of Upper Airway Inflammation**

A cool, bland aerosol is indicated in the treatment of upper airway edema, including laryngotracheobronchitis and subglottic edema, and for postoperative management of the upper airway. Upper airway edema is common following extubation, and the use of a cool, bland aerosol with supplemental oxygen is recommended. Nebulized racemic epinephrine (0.5 mL of 2.25% in 3 mL of diluent) or dexamethasone (1 mg in 4 mL of diluent) by nebulizer have also been suggested for the treatment of postextubation laryngeal edema; however, the evidence to support this recommendation is weak. Helium–oxygen mixtures (60% He and 40% O₂) by nonrebreathing mask may be helpful in decreasing the severity of stridor and reducing the need for reintubation. Helium–oxygen therapy (60% to 80% helium) may also be of value in treatment of acute severe asthma exacerbation and has been used in an attempt to reduce the need for intubation and mechanical ventilation in these patients.

For pediatric patients suffering from croup (laryngotracheobronchitis), treatment typically consists of cool mist therapy. Aerosolized racemic epinephrine (0.05 mL/kg of a 2.25% solution not to exceed 0.5 mL per dose diluted to 3 mL) may provide rapid improvement in upper airway obstruction in moderate to severe croup. Aerosolized dexamethasone or budesonide may also be effective in reducing severity of symptoms in patients suffering from croup, although dexamethasone is most commonly administered intravenously (IV), intramuscularly (IM), or orally.

**Mobilize and Remove Secretions**

Disease states or conditions in which mucus clearance may be a problem include chronic bronchitis, bronchiectasis, and cystic fibrosis. Mucus hypersecretion, inflammation, and bronchospasm are sometimes seen in asthma, acute bronchitis, and acute pulmonary infections. Mucus plugging can cause atelectasis, and copious secretions are sometimes seen with atelectasis and pneumonia.

**Techniques to Mobilize Secretions**

Techniques to mobilize or remove secretions include directed cough, suctioning, use of high-volume aerosol therapy, and bronchial hygiene. Bronchial hygiene techniques include chest physiotherapy (CPT) (postural drainage, percussion, and vibration), kinetic therapy (turning), and directed cough. Indications for bronchial hygiene therapy include difficulty with secretion clearance, evidence of retained secretions, the presence of copious secretions (generally expectorated sputum production > 25 to 30 mL/day in the adult), atelectasis associated with mucus plugging, and the presence of a foreign body in the airway. Bronchial hygiene therapy is probably not helpful in acute exacerbation of COPD, pneumonia without excess secretion production, and acute asthma exacerbation. A complete list of bronchial hygiene techniques are listed in Box 2-9. Specific indications for therapy to mobilize secretions are listed in Box 2-10.

**Directed Cough**

Directed cough to clear secretions may be employed in patients with an inadequate spontaneous cough and should be included as an integral part of other bronchial hygiene therapies to mobilize and remove secretions. The indications for a directed cough include retained secretions, atelectasis, and lung disease with excess secretions (chronic bronchitis, bronchiectasis, cystic fibrosis, and necrotizing pulmonary infection). Directed cough is also indicated in patients at risk of developing postoperative complications and to obtain sputum specimens for diagnostic analysis, and it has been suggested for patients with spinal cord injury. A mechanically provided artificial cough, using an insufflation–exsufflation device (also known as cough-assist device) may be especially helpful in patients with spinal cord injury or neuromuscular disease.

**High-Volume Bland Aerosol Therapy**

High-volume heated, bland aerosols (normal saline, half normal saline, and sterile, distilled water) may minimize or eliminate humidity deficits in patients with artificial airways and thus help maintain mucociliary clearance. Heated bland aerosols are used routinely to
BOX 2-9

Bronchial Hygiene Techniques

Directed cough: A cough technique taught and supervised by a healthcare professional.
Postural drainage: The use of gravity and position to mobilize secretions.
Chest percussion (aka clapping or cupping) and vibration: Manual or mechanical percussion and vibration of the chest wall in order to mobilize secretions.
Kinetic therapy (turning): Rotation of the body to improve lung expansion, oxygenation, and secretion mobilization.
High-frequency chest wall oscillation (HFCWO): A technique that uses a mechanical device attached to an inflatable vest worn by the patient. Air is pulsed into the vest at a high frequency to vibrate the chest and lungs and thus improve mucus clearance.
Positive airway pressure (PAP): Adjunct techniques for secretion mobilization that incorporates the use of a mechanical device to generate continuous positive airway pressure (CPAP), positive expiratory pressure (PEP), or expiratory positive airway pressure (EPAP).
Flutter valve: A mechanical device that combines EPAP and high-frequency airway oscillations at the airway as the patient exhales through the device.
Intrapulmonary percussive ventilation (IPV): An IPV device is used to produce high-frequency oscillation of the inspired gas in combination with PAP.
Forced expiratory technique (FET): A modified version of the directed cough, also known as a “huff” cough.
Active cycle breathing (ACB): A breathing exercise cycle that incorporates the FET.
Autogenic drainage: A modification of the directed cough that incorporates diaphragmatic breathing at varied lung volumes.
Mechanical insufflation–exsufflation: The use of a mechanical device that uses positive pressure on inspiration to produce a deep breath followed by negative pressure on exhalation to simulate a cough.

BOX 2-10

Indications for Therapy to Mobilize Secretions

Directed Cough

Retained secretions
Atelectasis
At risk for postoperative pulmonary complications
Cystic fibrosis, bronchiectasis, chronic bronchitis, necrotizing pulmonary infection, or spinal cord injury
During/following other bronchial hygiene therapies
To obtain sputum specimens

Suctioning

Presence of endotracheal or tracheostomy tube
Inability to clear secretions in spite of best cough effort (secretions audible in large/central airways)
Need to remove accumulated pulmonary secretions in presence of an artificial airway
Coarse or noisy breath sounds (rhonchi, gurgles)
Increased PIP during mechanical ventilation or decreased VT during pressure-controlled ventilation
Ineffective spontaneous cough
Visible secretions in airway

(continues)
Suspected aspiration
Increased work of breathing
Deterioration of arterial blood gases
Chest radiograph changes consistent with retained secretions
To obtain sputum specimen
To maintain artificial airway patency
To stimulate cough
Presence of atelectasis or consolidation presumed to be associated with secretion retention

Chest Physiotherapy (Postural Drainage and Percussion)
Suggestion/evidence of problems with secretion clearance
Difficulty clearing secretions with volume > 25 to 30 mL/day (adult)
Retained secretions in presence of an artificial airway
Atelectasis caused/suspected to be due to mucus plugging
Cystic fibrosis, bronchiectasis, cavitating lung disease
Presence of a foreign body in airway

Mucolytic Therapy
Evidence of viscous/retained secretions that are not easily removed via other therapy
Chronic bronchitis, cystic fibrosis, bronchiectasis

High-Volume Bland Aerosol
Cool Large-Volume Nebulizer with Bland Solution
Following extubation
Delivery of precise F\textsubscript{1}O\textsubscript{2} via aerosol mask and humidity
Upper airway edema:
  • Laryngotracheobronchitis (croup)
  • Subglottic edema

Heated Large-Volume Nebulizer with Bland Solution
Evidence/potential for secretion clearance problem
Deliver precise F\textsubscript{1}O\textsubscript{2} via aerosol mask and high humidity
Mobilization of secretions

Hypertonic Saline Administration
Need to induce sputum specimens

PIP, peak inspiratory pressure; V\textsubscript{T}, tidal volume.

provide humidification in patients with artificial airways for which there is evidence or potential for secretion problems. High-volume bland aerosols may be useful for mobilization of secretions and induction of sputum specimens; however, the efficacy of using bland aerosols to reduce mucus has not been established.\textsuperscript{20} Most pneumatic cool-mist aerosol generators do not deliver a substantial amount of water to the airway and have little potential for mobilizing secretions. Heated pneumatic nebulizers and ultrasonic nebulizers may deliver sufficient volumes of water to the airway to assist in mobilizing secretions; however, the physical properties of mucus are only minimally affected by the use of bland aerosols.\textsuperscript{20,21} Heated aerosols and ultrasonic nebulizers are used to administer either sterile distilled water or a hypertonic saline solution (3% to 7% NaCl) for sputum induction.

Mucolytic Therapy
Mucolytic agents may promote secretion clearance by reducing mucus viscosity. Aerosolized dornase alfa (Pulmozyme) is indicated for clearance of purulent secretions in cystic fibrosis.\textsuperscript{18,19} Acetylcysteine (Mucomyst) thins mucus by breaking down mucoprotein disulfide bonds. Acetylcysteine may be given orally, by inhaled aerosol, or directly installed into the airway. Aerosolized acetylcysteine should always be accompanied by a bronchodilator to avoid inducing bronchospasm. There is little evidence to support the use of aerosolized acetylcysteine in patients.
Respiratory Care Plan to Mobilize Secretions in a Hospitalized Patient with Bronchiectasis

A 68-year-old man with a history of bronchiectasis is admitted to the hospital for acute exacerbation. The patient has been coughing up more than approximately 25 mL/day of thick, dark yellow mucopurulent sputum and has some difficulty clearing secretions. The patient is short of breath, has some pleuritic chest pain, and is receiving oxygen by nasal cannula at 2 L/min with a resultant \( \text{SpO}_2 \) of 92%.

Treatment of acute exacerbation of bronchiectasis is aimed at treating infection, providing supportive care, and delivering bronchial hygiene therapy. The following is the care plan for this patient:

- The goals of therapy are to treat infection, provide bronchial hygiene, manage secretions, maintain oxygenation, and treat/prevent bronchospasm associated with inflammation.
- Obtain a sputum sample for culture and sensitivity followed by antibiotics to treat acute infection.
- Ensure adequate patient hydration via oral liquids.
- Provide 2.5 mg of albuterol in 3 mL of 0.9% NaCl by small-volume nebulizer every 4 hours while awake and as needed at night powered by compressed air (keep cannula in use during therapy; see below).
- Follow aerosol therapy with postural drainage and chest percussion to right lower lobe and left lower lobe and anterior, posterior, and lateral segments.
- Directed cough following aerosol therapy and chest physiotherapy.
- Continue nasal cannula at 1 to 4 L/min to maintain \( \text{SpO}_2 \) > 90% to 92% with a \( \text{PaO}_2 \) of 60 to 70. Monitor \( \text{SpO}_2 \) during chest physiotherapy.
- Assessment includes monitoring breath sounds, cough, sputum production (color, volume consistency), shortness of breath, \( \text{SpO}_2 \) and vital signs. Review results of sputum culture and sensitivity to tailor antibiotic therapy.

Note that inhaled corticosteroids may improve lung function and dyspnea and reduce cough in bronchiectasis and may be added. Bronchiectasis may be accompanied by gastroesophageal reflux, requiring medication to suppress gastric acid.

Chest Physiotherapy

Chest physiotherapy may include postural drainage, percussion, and vibration accompanied by directed cough. Postural drainage positions are generally applied for 3 to 15 minutes per position for a total treatment time of 30 to 40 minutes, as tolerated by the patient.\(^{22,23}\) Chest percussion or vibration may be applied for each postural drainage position for 3 to 5 minutes per position.\(^{22}\) Frequency of performance of chest physiotherapy should be based on the patient’s ability to tolerate the procedure and the effectiveness of the procedure in mobilizing secretions. Generally, postural drainage and chest percussion in the acute care setting are applied every 4 to 6 hours.

Other techniques sometimes used as an aid to mobilizing secretions include the use of the huff cough (forced expiratory technique, or FET), active-cycle breathing, autogenic drainage, mechanical insufflation–exsufflation, positive expiratory pressure (PEP), and high-frequency compression/oscillation (high-frequency chest wall compression, flutter valve, and intrapulmonary percussive ventilation).\(^{22,24}\)

An example of a respiratory care plan designed to assist in mobilizing secretions in a patient with bronchiectasis is found in Clinical Focus 2-3.

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**Clinical Focus 2-3**

**Respiratory Care Plan to Mobilize Secretions in a Hospitalized Patient with Bronchiectasis**

A 68-year-old man with a history of bronchiectasis is admitted to the hospital for acute exacerbation. The patient has been coughing up more than approximately 25 mL/day of thick, dark yellow mucopurulent sputum and has some difficulty clearing secretions. The patient is short of breath, has some pleuritic chest pain, and is receiving oxygen by nasal cannula at 2 L/min with a resultant \( \text{SpO}_2 \) of 92%.

Treatment of acute exacerbation of bronchiectasis is aimed at treating infection, providing supportive care, and delivering bronchial hygiene therapy. The following is the care plan for this patient:

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- Assessment includes monitoring breath sounds, cough, sputum production (color, volume consistency), shortness of breath, \( \text{SpO}_2 \) and vital signs. Review results of sputum culture and sensitivity to tailor antibiotic therapy.

Note that inhaled corticosteroids may improve lung function and dyspnea and reduce cough in bronchiectasis and may be added. Bronchiectasis may be accompanied by gastroesophageal reflux, requiring medication to suppress gastric acid.
Nasotracheal Suctioning
Nasotracheal (NT) suctioning is indicated in cases where the patient’s spontaneous or directed cough is ineffective. Specifically, NT suctioning may be required to maintain a patent airway in the presence of excess pulmonary secretions, blood, saliva, vomitus, or foreign material in the trachea or central airways. NT suctioning may also be useful to stimulate a cough or to obtain a sputum sample for microbiologic or cytologic analysis. NT suctioning is contraindicated with nasal bleeding, epiglottitis, croup, laryngospasm, bronchospasm, or an irritable airway. It also is contraindicated in the presence of coagulopathy or bleeding disorders; acute head, facial, or neck injury; gastric surgery with high anastomosis; and myocardial infarction.

Provide Lung Expansion Therapy
The primary indications for lung expansion therapy are in the treatment and/or prevention of atelectasis and the prevention of the development of respiratory failure, particularly in postoperative patients. Patients who are bedridden, immobilized, or prone to shallow breathing with a weak cough may also be candidates for lung expansion therapy. The two primary techniques for applying lung expansion therapy are incentive spirometry (IS) and intermittent positive pressure breathing (IPPB). In addition, positive airway pressure (PAP) is sometimes used to mobilize secretions and treat atelectasis.

Incentive spirometry should be considered in patients who are able to perform the maneuver every 1 to 2 hours while awake and are able to achieve an inspired volume of at least one-third of the predicted inspiratory capacity (IC). Inspiratory capacity may be estimated by multiplying the patient’s calculated ideal body weight (IBW) in kilograms by 50 mL (i.e., IBW kg × 50 mL/kg).

Clinical Focus 2-4 provides an example of the application of incentive spirometry. Recommended frequency and duration of an incentive spirometry session should be every hour while awake for 10 to 15 breaths of at least one-third predicted IC each (or > 10 mL/kg). Also see the RC Insight.

**RC Insights**
Inspiratory capacity (IC) in adults can be estimated as follows:

\[
IC = 50 \text{ mL/kg of ideal body weight (IBW)}
\]

where IBW in kg is:

- IBW men = \(106 + 6(H – 60)/2.2\)
- IBW women = \(105 + 5(H – 60)/2.2\)

**CLINICAL FOCUS 2-4**
**Application of Incentive Spirometry**
A preoperative 54-year-old coronary artery bypass graft (CABG) patient is seen by the respiratory care clinician for assessment and patient education. The patient is alert, awake, and cooperative, and has no history of pulmonary disease. Vitals signs, breaths sounds, and oximetry are normal, and the patient is in no distress. The patient's spontaneous inspiratory capacity prior to surgery is 3000 mL. The patient is 5'11" and weighs 200 pounds.

In order to prevent postoperative atelectasis and related respiratory problems, a respiratory care plan for this patient should include lung expansion therapy:

- Goal of therapy is to prevent postoperative atelectasis and respiratory failure.
- Device or procedure is incentive spirometry every hour while awake for 10 to 15 breaths followed by directed cough.
- Calculated ideal body weight (IBW) for this patient 172 pounds, or 78 kg:

\[
\text{IBW (lbs.)} = 106 + 6(H – 60) = 106 + 6(71 – 70) = 172 \text{ lbs.}
\]

\[
\text{kg} = \text{lbs}/2.2 = 172/2.2 = 78 \text{ kg}
\]

- Predicted inspiratory capacity (IC) for this patient is approximately 3900 mL:

\[
\text{Predicted IC} = 50 \text{ mL/IBW (kg)} = 50 \times 78 = 3900 \text{ mL}
\]

- Volume goal should be at least one-third predicted IC, or about 1200 mL per breath:

\[
1/3 \times 3900 \text{ mL} = 1287 \text{ mL}
\]

- Assessment includes monitoring volumes and compliance with IS and watching patient for development of the signs and symptoms of atelectasis and postoperative respiratory failure:

\[
\text{Minimum volume for incentive spirometry} = \text{IBW} \times 50 \text{ mL/kg} \times 1/3
\]
Indications for Lung Expansion Therapy

**Incentive Spirometry**

Patient is able to achieve an inspired volume of at least one-third of predicted IC (or VC ≥ 10 mL/kg).

AND

Patient is able to perform the maneuver every 1 to 2 hours while awake.

AND ONE OR MORE OF THE FOLLOWING:

- Patient is predisposed to development of atelectasis: upper/lower abdominal, cardiac, or thoracic surgery; surgery in COPD; patient debilitated/bedridden; acute chest syndrome in patients; sickle cell disease.
- Preoperative screening/instruction for surgical patients to obtain baseline volume or flow
- Presence of atelectasis
- Quadriplegic and/or dysfunctional diaphragm
- Lack of pain control
- Thoracic or abdominal binders
- Restrictive lung defect with a dysfunctional diaphragm or involving the respiratory musculature
- IC < 2.5 L
- Neuromuscular disease or spinal cord injury

**Intermittent Positive Pressure Breathing (IPPB)**

Other therapy has been unsuccessful (incentive spirometry, chest physical therapy, deep breathing exercises, positive airway pressure).

AND AT LEAST ONE OF THE FOLLOWING:

- Clinically important atelectasis
- At risk for postoperative pulmonary complications (e.g. atelectasis, pneumonia, respiratory failure)
- Inability to spontaneously deep breath with inadequate cough and/or secretion clearance (inspired volumes less than one-third predicted IC or VC < 10 mL/kg)
- To deliver aerosol medication in patients unable to adequately deep breath and/or unable to coordinate the use of other aerosol devices
- For short-term ventilatory support in an attempt to avoid intubation and continuous mechanical ventilation, a noninvasive positive pressure (NPPV) device should be considered

IC, inspiratory capacity; VC, vital capacity.
Assess Patient
- Chart Review
- Patient Interview
- Physical Assessment
- Measure Inspiratory Capacity

Is Lung Expansion Therapy Indicated?
- Patient predisposed to development of atelectasis
- Upper abdominal surgery
- Thoracic surgery
- Coronary artery bypass graft
- Lower abdominal surgery
- Surgery in patients with COPD
- Patient debilitated/bedridden
- Presence of atelectasis
- Quadriplegic and/or dysfunctional diaphragm/spinal cord injury
- Presence of thoracic or abdominal binders
- Lack of pain control
- IC < 2.5L
- Neuromuscular disease
- Acute chest syndrome (sickle cell disease)

Is the patient’s spontaneous IC ≥ 1/3 (or VC ≥ 10 mL/kg) predicted? Yes
Is patient able to perform incentive spirometry every hour while awake? Yes
Consider IPPB (see next page)

Can patient self-administer incentive spirometry? No
Supervised incentive spirometry

Instruct patient on proper use, target volumes (≥ 1/3 predicted IC) and frequency (every hour while awake)

Assess Outcomes
- Adequate volumes achieved
- Improved cough effectiveness/secretion clearance
- Improved breath sounds
- Improved chest radiograph
- Patient’s subjective comments

FIGURE 2-6 Protocol for lung expansion therapy.

also concerned with maintaining adequate circulation, blood pressure, and cardiac output and monitoring ventilatory and hemodynamic function. Chapters 6 and 7 describe assessment of oxygenation and ventilation; Chapter 8 reviews arterial blood gases and acid–base balance. The focus of Chapter 14 is acute and critical care monitoring and assessment.

Diagnostic Testing
Patient assessment and care plan development may require measurement of clinical parameters related to oxygenation, ventilation, and cardiopulmonary function. Chapters 6 and 7 describe assessment of oxygenation and ventilation; Chapter 8 reviews arterial blood gases and acid-base balance. Laboratory, imaging, and
Is IPPB indicated?

- Presence of clinical significant atelectasis when other therapy (incentive spirometry, chest physiotherapy, deep breath exercises, positive airway pressure) has been unsuccessful.
- Inability to spontaneously deep breath (inspired volumes less than 1/3 predicted IC or VC < 10 mL/kg) in patients with inadequate cough and/or secretion clearance and other therapy has been unsuccessful.
- Patient at risk for postoperative pulmonary complications (e.g., atelectasis, pneumonia, respiratory failure) AND other lung-expansion therapy has been unsuccessful.
- To deliver aerosol medication in patients who are unable to adequately deep breathe and/or coordinate the use of other aerosol devices and therapy (metered-dose inhaler [MDI], small-volume nebulizer) has been unsuccessful.
- Patients with ventilatory muscle fatigue, neuromuscular disease, kyphoscoliosis, spinal injury or chronic conditions requiring intermittent ventilatory support may also benefit from IPPB to deliver aerosol therapy.
- Provide short-term ventilatory support as an alternative to tracheal intubation and continuous mechanical ventilation. Devices specifically for noninvasive positive pressure ventilation (NPPV) should be considered.
- Decrease dyspnea and discomfort during nebulized therapy in patients with severe hyperinflation.

Is IPPB contraindicated?

- Absolute contraindication: untreated tension pneumothorax
- Relative contraindications:
  - Intracranial pressure (ICP) > 15 mm Hg
  - Hemodynamic instability
  - Recent facial, oral, or skull surgery
  - Tracheoesophageal fistula
  - Recent esophageal surgery
  - Active hemoptysis
  - Nausea
  - Air swallowing
  - Active untreated tuberculosis
  - Radiographic evidence of bleb
  - Singulation (hiccups)

Determine volume goals, medications, and frequency of administration

- ≥ 1/3 predicted IC or ≥ 10 mL/kg or ≥ 1200 mL in most adults
- Frequency for critical care: every 1–6 hours
- Frequency for acute care or home care: two to four times daily
- Bronchodilators are normally administered with IPPB

Apply Therapy

Reassess Patient

- Adequate volumes achieved?
- Improved cough effectiveness?
- Secretion clearance/sputum production?
- Chest radiograph improved?
- Breath sounds improved?
- Patient's subjective comments?
- Improved FEV₁ or peak flow following bronchodilator administration?

FIGURE 2-6 (continued)

other diagnostic studies may be needed to further define and clarify the patient’s problem and diagnosis. Chapter 9 reviews laboratory studies, Chapter 10 describes the use of the electrocardiogram (ECG), and Chapter 11 describes medical imaging. Chapter 13 reviews pulmonary function testing. Following establishment the patient’s diagnosis, a respiratory care plan is developed, implemented, and evaluated.
Respiratory Care Plan Format

Many institutions have developed various forms and formats for use in writing and organizing the respiratory care plan. One common format uses problem-oriented charting, including the use of a SOAP note for the respiratory care plan, as described earlier. Figure 2-7 contains a suggested format for organizing a respiratory care plan using the SOAP technique. Another format may include problems or complaints, possible sources of problems or complaints, actions taken to relieve problems or complaints, short- and long-term goals, and evaluation and documentation.

A third possible format for the respiratory care plan is found in Figure 2-8. This format includes patient demographic data, indications for specific respiratory care, and a care plan oriented towards maintaining oxygenation, treating and preventing bronchospasm and/or mucosal edema, delivering anti-inflammatory and antiasthmatic medications, initiating therapy to mobilize and remove secretions, and providing lung expansion therapy.

FIGURE 2-7 SOAP format for organizing a respiratory care plan. The problem-oriented medical record (POMR) may be used to collect and document data, assess the patient, and develop an appropriate treatment plan. The most common POMR technique is the SOAP note. The SOAP note allows the clinician to report a patient assessment and treatment plan. The four letters of the acronym are described in the figure.
**CHART REVIEW**

Patient Name: _____________________________  Age: ____________  
Physician(s): _____________________________  Height: ____________  
Hospital ID No.: _____________________________  Weight: ____________  
Floor/Unit: _____________________________  Sex: ____________  
Admitting Diagnosis: ___________________________________________________________________________________________

Other Problems from Problem List or Patient History and Physical: 
1. ____________________________  4. __________________________
2. ____________________________  5. __________________________
3. ____________________________  6. __________________________

Current Physician Orders for Respiratory Care: _________________________________________________________________  
_______________________________________________________________________________________________________

Most Recent ABGs and/or SpO₂: ____________________________________________________________________________  
_______________________________________________________________________________________________________

Most Recent Chest X-ray Reports: ___________________________________________________________________________  
_______________________________________________________________________________________________________

Most Recent Pulmonary Function Testing: ______________________________________________________________________

**PATIENT INTERVIEW**

Cough: ___________________________  Sputum Production: ___________________________________________________
Hemoptysis: _______________________  Wheezing, Whistling or Chest Tightness: ____________________________
Breathlessness: _____________________  Chest Illness: _______________________________________________________
Smoking: ___________________________  Occupational History: _____________________________________________
Hobby and Leisure History: ______________________________________________________________________________
Medicines or Respiratory Care Used: ______________________________________________________________________
Response to Current Respiratory Care: ______________________________________________________________________

**PHYSICAL ASSESSMENT**

General Appearance: _______________________  Pulse: _____________  Respirations: ______________  Blood Pressure: __________________________________________
Level of Consciousness: _____________________  Chest Inspection: ___________________________________________
Auscultation: __________________________________________________________________________________________
Percussion: ____________________________________________________________________________________________
Palpation: ______________________________________________________________________________________________
Bedside Spirometry: IC: ________  PEFR: ________  VC: ________  FEV₁: _________________________________

**ASSESSMENT FOR THERAPY**

Evaluate whether each specific therapy listed is indicated and/or appropriate for this patient based on your chart review, patient interview, and physical assessment data. NOTE: Check all indications present REGARDLESS of whether the patient is currently receiving a particular therapy or not.

**Assessment for Oxygen Therapy** (check all indications present for oxygen therapy; see Box 2-5)

Yes  No  
□  □  documented hypoxemia  
□  □  corrected hypoxemia  
□  □  suspected hypoxemia  
□  □  severe trauma  
□  □  acute M.I.  
□  □  immediate post-op recovery (recovery room or ICU)

**Assessment for Bronchodilator Therapy** (check all indications present for bronchodilator therapy; see Box 2-6)

Yes  No  
□  □  asthma  
□  □  COPD  
□  □  wheezing  
□  □  documented response to a bronchodilator

**FIGURE 2-8 Detailed respiratory care plan format.** Format includes patient demographic data, indications for specific respiratory care, and a care plan oriented towards maintenance of oxygenation, treatment and prevention of bronchospasm and/or mucosal edema, delivery of anti-inflammatory and antiasthmatic medications, therapy to mobilize and remove secretions, and lung expansion therapy.
### Assessment for Anti-inflammatory Aerosol Agents (inhaled steroids)
(check all of the indications present; see Box 2-8)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>asthma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COPD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>upper airway edema</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Assessment for Antiasthmatic Aerosol Agents (cromolyn, etc.)
(check all of the indications present; see Box 2-8)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>asthma</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Assessment for Directed Cough
(check all of the indications present for this patient; see Box 2-10)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>retained secretions, excess secretion production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>following bronchial hygiene therapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>at risk for atelectasis/post-op pulmonary complications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to obtain sputum specimen</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Assessment for Suctioning
(check all of the indications present for this patient; see Box 2-10)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>inability to clear secretions with cough</td>
<td></td>
<td></td>
</tr>
<tr>
<td>need to remove secretions with artificial airway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>need to stimulate cough</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to obtain sputum specimen</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Assessment for Mucolytic Therapy
(check the indications present for this patient; see Box 2-10)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>evidence of viscous/retained secretions which are not easily removed via other therapy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chronic bronchitis, cystic fibrosis, bronchiectasis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Assessment for Chest Physiotherapy
(check all of the indications present for this patient; see Box 2-10)

**Postural Drainage and Percussion**

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>suggestion/evidence of problems with secretion clearance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>difficulty clearing secretions with volume ~25–30 mL/day (adult)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>retained secretions in presence of an artificial airway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>atelectasis caused/suspected to be due to mucus plugging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cystic fibrosis, bronchiectasis, cavitating lung disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>presence of a foreign body in airway</td>
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</tbody>
</table>

### Assessment for High Volume Bland Aerosol
(see Box 2-10)

**Cool Mist Bland Solution**

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>post extubation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>deliver precise FiO₂ via air-entrainment nebulizer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>upper airway edema</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to obtain sputum specimen</td>
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</tbody>
</table>

**Heated Large-Volume Nebulizer**

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>evidence/potential for secretion clearance problem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>deliver precise FiO₂ with high humidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mobilize secretions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hypertonic Saline Administration**

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>induce sputum</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary

The respiratory care plan is simply a written explanation of the respiratory care that the patient is to receive. The respiratory care plan may take the form of physician’s orders, a detailed progress note in the medical record, an established protocol, completion of a standardized respiratory care plan form, or the use of problem-oriented medical records using SOAP notes. In the clinical setting, respiratory care plan development requires an initial physician’s order, a well-designed protocol or policy, and careful patient assessment. The physician’s order may be specific, or it may simply state “respiratory care per protocol.”

Developing and implementing the respiratory care plan requires a careful patient assessment. Following the patient assessment, the respiratory care clinician selects the appropriate care based on the patient’s condition and the indications for each type of therapy. The respiratory care plan may include the goals of therapy, the device or procedure that will be used, medications given, method or appliance used, gas source and/or flow, volume goals, frequency of therapy, and duration of therapy. The care plan may also include a statement of how the intensity and/or duration of therapy will be adjusted and when the therapy will be discontinued. Assessment of the outcomes of therapy may also be included. These may include evidence of clinical improvement, measurement of bedside pulmonary function data such as PEF or FEV₁, improvement in oxygenation or \( \text{SpO}_2 \), improved quality of life, patient subjective improvement, and the absence of adverse side effects.

In summary, the respiratory care plan is the written plan of treatment that the patient will receive. The respiratory care plan may include goals, rationale, and significance and a description of how care will be assessed.

Key Points

- The respiratory care plan provides a written description of the care the patient is to receive.
- Respiratory care plans include the goals of therapy, the device or procedure to be used, medications to be given, frequency of administration, and duration of therapy.
- SOAP refers to Subjective, Objective, Assessment, and Plan.
- Acute respiratory failure (ARF) is defined as a sudden decrease in arterial oxygen levels with or without carbon dioxide retention.
- Acute ventilatory failure (AVF) is defined as a sudden rise in PaCO₂ with a corresponding decrease in pH.
- Chronic ventilatory failure is defined as a chronically elevated PaCO₂ with a normal (compensated) or near-normal pH.
Respiratory care plans may be developed for basic and critical respiratory care, diagnostic testing, or specialized procedures.

Oxygen therapy is indicated for documented or suspected hypoxemia, severe trauma, acute myocardial infarction (MI), and immediate postoperative recovery.

For delivery of low to moderate concentration of oxygen, the nasal cannula is the device of choice.

With unstable ventilatory patterns or rapid, shallow breathing, an air-entrainment mask may be considered.

For moderate to high concentrations of oxygen therapy for short-term use, consider a simple partial-rebreathing or nonrebreathing mask.

The primary indication for bronchodilator therapy is to treat or prevent bronchospasm.

Bronchodilator therapy is indicated in acute asthma, COPD, and whenever wheezing is due to reversible bronchoconstriction.

Anti-inflammatory aerosol agents and antiasthmatic drugs include inhaled corticosteroids, cromolyn sodium, and antileukotrienes.

Techniques to mobilize or remove secretions include directed cough, suctioning, use of high-volume aerosol therapy, and bronchial hygiene.

Directed cough should be included as an integral part of bronchial hygiene therapy.

Forced expiratory technique (FET), also known as a “huff” cough, is a modified version of the directed cough.

A cool bland aerosol is indicated in the treatment of upper airway edema and for postoperative management of the upper airway.

Bronchial hygiene techniques include chest physiotherapy, kinetic therapy, high-frequency chest wall oscillation (HFCWO), positive airway pressure (PAP), the flutter valve, intrapulmonary percussive ventilation (IPV), and mechanical insufflation–exsufflation.

Nasotracheal (NT) suctioning is indicated in cases where the patient’s spontaneous or directed cough is ineffective.

The primary indications for lung expansion therapy are in the treatment and/or prevention of atelectasis.

Lung expansion therapy may be used to prevent the development of respiratory failure, particularly in postoperative patients.

The two primary techniques for applying lung expansion therapy are incentive spirometry and intermittent positive pressure breathing (IPPB).

Incentive spirometry should be considered in patients who are able to perform the maneuver every 1 to 2 hours while awake and are able to achieve an adequate inspired volume.

IPPB should generally be reserved for patients who have clinically important atelectasis in which other therapy has been unsuccessful.

PAP is sometimes used to mobilize secretions and treat atelectasis.

The goals of ventilatory support in the ICU include maintaining adequate tissue oxygenation, ventilation, and acid–base balance.

Patient assessment and care plan development may require measurement of clinical parameters related to oxygenation, ventilation, and cardiovascular function.

References


