CHAPTER

2

Development and Implementation of Respiratory Care Plans

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CHAPTER OUTLINE

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 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**.

Table 2-1
Types of Care Provided in the Respiratory Care Plan

Basic Respiratory Care
- Oxygen therapy
- Secretion management
- Sputum induction
- Management of bronchospasm and mucosal edema
- Lung expansion therapy

Critical Respiratory Care
- Invasive mechanical ventilatory support
- Noninvasive mechanical ventilatory support
- Physiologic monitoring
- Cardiac and hemodynamic monitoring
- Suctioning and airway care
- Airway intubation
- Advanced cardiovascular life support
- Metabolic studies
- Extracorporeal membrane oxygenation
- Mechanical circulatory assistance
- Basic care in the intensive care setting

Diagnostic Testing
- Oximetry
- Arterial blood gases
- Pulmonary function testing
- Cardiac testing (e.g., ECG, invasive cardiology, cardiac catheterization laboratory)
- Ultrasound (echocardiography, other)
- Sleep studies
- Exercise testing

Special Procedures
- Transport
- Patient education
- Smoking cessation
- Disease management
- Pulmonary rehabilitation
- Cardiac rehabilitation

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

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 (O_2) and carbon dioxide (CO_2) 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 CO_2 levels (as assessed by $PaCO_2$) 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 $PaCO_2$ 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. Bedside measurement of SpO_2 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

BOX 2-1

Types of Respiratory Failure

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 [Pao_2] < 50 to 60 mm Hg; arterial oxygen saturation [Sao_2] < 88% to 90%), with or without carbon dioxide retention (arterial partial pressure of carbon dioxide [$Paco_2$] > 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 $Paco_2$ (> 45 to 50 mm Hg). An increased $Paco_2$ may also be called hypoventilation or hypercapnea:

- *Acute ventilatory failure* is defined as a sudden increase in arterial $Paco_2$ with a corresponding decrease in pH.
- *Chronic ventilatory failure* is defined as a chronically elevated $Paco_2$ with a normal or near -normal pH owing to metabolic compensation.
- *Acute on chronic ventilatory failure* is defined as a chronically elevated Pco_2 followed by an acute increase in the 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 Pao_2/Fio_2 ratio. The characteristics of ALI/ARDS are:

- Bilateral pulmonary infiltrates on chest x-ray
- Pulmonary capillary wedge pressure < 18 mm Hg
- Pao_2/Fio_2 < 300 = ALI. This is equivalent to a Pao_2 of less than 63 torr while breathing room air (Fio_2 = 0.21).
- Pao_2/Fio_2 < 200 = ARDS. This is equivalent to a Pao_2 of less than 42 torr while breathing room air (Fio_2 = 0.21)

More recently, the Berlin definition of ARDS was proposed based on symptom timing, chest imaging, and Pao_2/Fio_2 ratio while receiving at least 5 cm H_2O 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 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) $Pao_2/Fio_2 \leq 300$ mm Hg with PEEP or CPAP ≥ 5 cm H_2O where:

- $Pao_2/Fio_2 \leq 300$ mm Hg—mild
- $Pao_2/Fio_2 \leq 200$ mm Hg—moderate
- $Pao_2/Fio_2 \leq 100$ mm Hg—severe

CPAP, continuous positive airway pressure; Fio_2, fraction of inspired oxygen; $Paco_2$, partial pressure of arterial carbon dioxide; Pao_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: [Pao_2/Fio_2 × (barometric pressure/760)].

Data from: ARDS Definition Task Force, Ranieri VM, Rubenfeld GD, Thompson BT, et al. Acute respiratory distress syndrome: the Berlin Definition. *JAMA*. 2012;307(23):2526-2533. doi: 10.1001/jama.2012.5669.

BOX 2-2

Common Causes of Respiratory Failure

Oxygenation Problems

Low ventilation/perfusion ratio (low $\dot{V}/\dot{Q}$)
- 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 $Paco_2$ result in a corresponding decrease in Pao_2

Low blood oxygen content
- Low Pao_2, Sao_2, or hemoglobin
- Examples:
  - Low Pao_2 may be due to low $\dot{V}/\dot{Q}$, 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 $Paco_2$ 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 $Paco_2$ with normal or near-normal pH
- Examples: Chronic bronchitis, severe COPD, obesity-hypoventilation syndrome

West JB. Acute respiratory failure. In: West JB, ed. *Pulmonary Physiology and Pathophysiology: An Integrated, Case-Based Approach*, 2nd ed. Philadelphia: Lippincott, Williams & Wilkins; 2007: 116–133.

therapy, secretion management, treatment of bronchospasm and mucosal edema, and lung expansion therapy.

Diagnostic respiratory care procedures include techniques to assess oxygenation, ventilation, acid–base balance, and pulmonary function and to obtain sputum samples (e.g., sputum induction) for Gram stain, cultures, and cytologic examination. Critical respiratory care may include mechanical ventilatory support, airway care, physiologic monitoring, cardiovascular stabilization, mechanical circulatory assistance, and extracorporeal membrane oxygenation (ECMO). We will now turn to the development of specific respiratory care plans based on an assessment of the patient's needs and the related goals of therapy.

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 FIO_2 of 0.60 are:

pH: 7.36
$PaCO_2$: 36 mm Hg
PaO_2: 62 mm Hg
SaO_2: 90%
HCO_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 PaO_2/FIO_2 ratio of 103, which is consistent with a diagnosis of ARDS.

The definition of ARDS was clarified by a 1992 American-European Consensus Conference. Rubenfeld GD, Herridge MS. Epidemiology and outcomes of acute lung injury. *Chest*. 2007;131(2):554–562.

Table 2-2
Respiratory Care Treatment Menu

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.

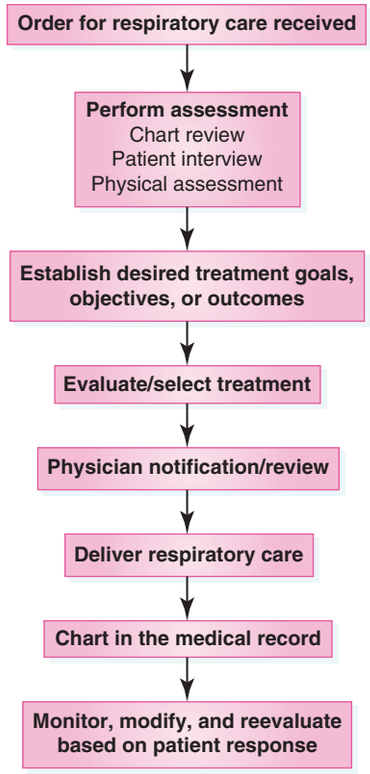

FIGURE 2-1 Steps in the development and implementation of the respiratory care plan.

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.[6] It also may 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.[6] A Pa_{O_2} < 60 and/or a Sp_{O_2} < 90% to 92% are considered clear indications for oxygen therapy in most patients.[6] 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 Pa_{O_2} of ≤ 55 torr with a Sp_{O_2} of ≤ 88% while breathing room air or a Pa_{O_2} of 56 to 59 and a Sa_{O_2} < 89% in the presence of cor pulmonale, pulmonary hypertension, CHF, or erythrocythemia with a hematocrit > 56.[7] A critical Pa_{O_2} for the newborn may be a Pa_{O_2} < 50 torr and/or a Sp_{O_2} < 88% or a capillary P_{O_2} < 40 torr.[8]

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 Sp_{O_2} 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 (F_{IO_2}), and how the therapy will be assessed. In general, the lowest F_{IO_2} needed to ensure adequate tissue oxygenation should be chosen. Generally, this means a target Pa_{O_2} of 60 to 100 with a Sp_{O_2} 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.[6] 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 CO_2 retainers may lead to ventilatory depression and increased $\dot{V}/\dot{Q}$ mismatch when the Pa_{O_2} exceeds 60 torr.[6] Oxygen therapy for the COPD patient with chronically elevated Pa_{CO_2} levels should be targeted at maintaining a Pa_{O_2} of 50 to 59 torr with a Sa_{O_2} 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 Sp_{O_2} of 88% to 92%.[9] However, a Sp_{O_2} > 90% may result in a Pa_{O_2} > 60, and consequently should probably be avoided in patients with documented or suspected CO_2 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

BOX 2-3

Key Elements of a Basic Respiratory Care Plan

Goals of Therapy

- Maintain adequate tissue oxygenation and/or alveolar ventilation.
- Treat/prevent bronchospasm and/or mucosal edema.
- Deliver anti-inflammatory or antiasthmatic agents.
- Manage secretions.
- Induce sputum.
- Prevent or treat atelectasis.

Device or Procedure

- Oxygen therapy (nasal cannula, air-entrainment mask, other masks)
- Aerosol medication via small-volume nebulizer
- MDI via holding chamber
- Incentive spirometry
- IPPB
- Chest physiotherapy (postural drainage and chest percussion)
- High-volume bland aerosol with or without supplemental oxygen
- Directed cough
- Suctioning
- Mechanical ventilators (invasive and noninvasive ventilation; see also Box 2-4)

Medications

- Bronchodilators
- Mucolytics (Mucomyst, Pulmonzyme)
- Anti-inflammatory agents and decongestants (steroids, racemic epinephrine, others)
- Antiasthmatic agents (cromolyn, Tilade)
- Bland aerosol (normal saline, one-half normal saline, sterile distilled water)

Method or Appliance

Mask, mouthpiece, mouthseal, tracheostomy mask, nose clips, aerochamber, etc.

Gas Source, Flow, and/or Pressure

- Oxygen or compressed air
- Liter flow and/or F_{IO_2}
- Pressure (IPPB)

Frequency and Duration of Therapy

- Twice daily, three times daily, four times daily, every 6 hours, every 4 hours, every 2 hours, every 1 hour, continuous, as needed, etc.
- Duration of therapy in minutes or continuous

Volume Goals

- Incentive spirometry minimum of one-third of predicted IC (1/3 × IBW in kg × 50 mL/kg)
- IPPB minimum of one-third predicted IC (or at least 10 mL/kg)

Assessment

- Improvement and/or reversal of clinical signs and symptoms of respiratory failure
- Reversal of the manifestations of hypoxia and/or hypoventilation
- Decreased work of breathing
- Decreased cardiac work
- Improved breath sounds (air movement, wheezing, rhonchi, crackles)
- Pulse oximetry and arterial blood gases
- Bedside pulmonary function (rate, volumes, inspiratory force, PEF, IC, FVC, FEV_1)
- Chest x-ray or other imaging techniques

MDI, metered dose inhaler; IPPB, intermittent positive pressure breathing; IC, inspiratory capacity; IBW, ideal body weight; PEF, peak expiratory flow rate; FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second.
Data from West JB. Acute respiratory failure. In: West JB. Pulmonary Physiology and Pathophysiology: An Integrated, Case-based Approach, 2nd ed. Philadelphia: Lippincott, Williams & Wilkins; 2007: 116–133.

in the newborn that may result in blindness. In the past, maintenance of a Pa_{O_2} in the range of 50 to 70 was thought to be safe; however, current guidelines suggest a $Pa_{O_2} \leq 80$ 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 CO_2 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 (Spo_2 or arterial blood gases):
- Adults and children: $Pao_2 < 60$ and/or $Spo_2 < 90$
- Neonates (< 28 days): $Pao_2 < 50$ and/or $Spo_2 < 88\%$ or a capillary $Po_2 < 40$ torr

Suspected hypoxemia based on patient condition and/or clinical manifestations of hypoxia (follow with Spo_2 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:
- $Pao_2 \leq 55$ and/or Spo_2 of $\leq 88\%$ while breathing room air with COPD

OR

- COPD patients with cor pulmonale or hematocrit > 56, Pao_2 of 56 to 59, $Sao_2 < 89\%$, 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 FIO_2, 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 $\dot{V}/\dot{Q}$ 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 FIO_2 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 FIO_2 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

CLINICAL FOCUS 2-2

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 CO_2 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 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
- 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 Spo_2 of 88% to 90% and a Pao_2 of 50 to 59 due to the patient's documented history of CO_2 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, 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% O_2 at 5 to 10 L/min), a partial rebreathing mask (40% to 70% O_2 at 5 to 10 L/min), or a non-rebreathing mask (60% to 80% 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 Fio_2. The Misty Ox high-flow, high-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 Fio_2 of 0.28 to 0.50 and a high-flow, high-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.

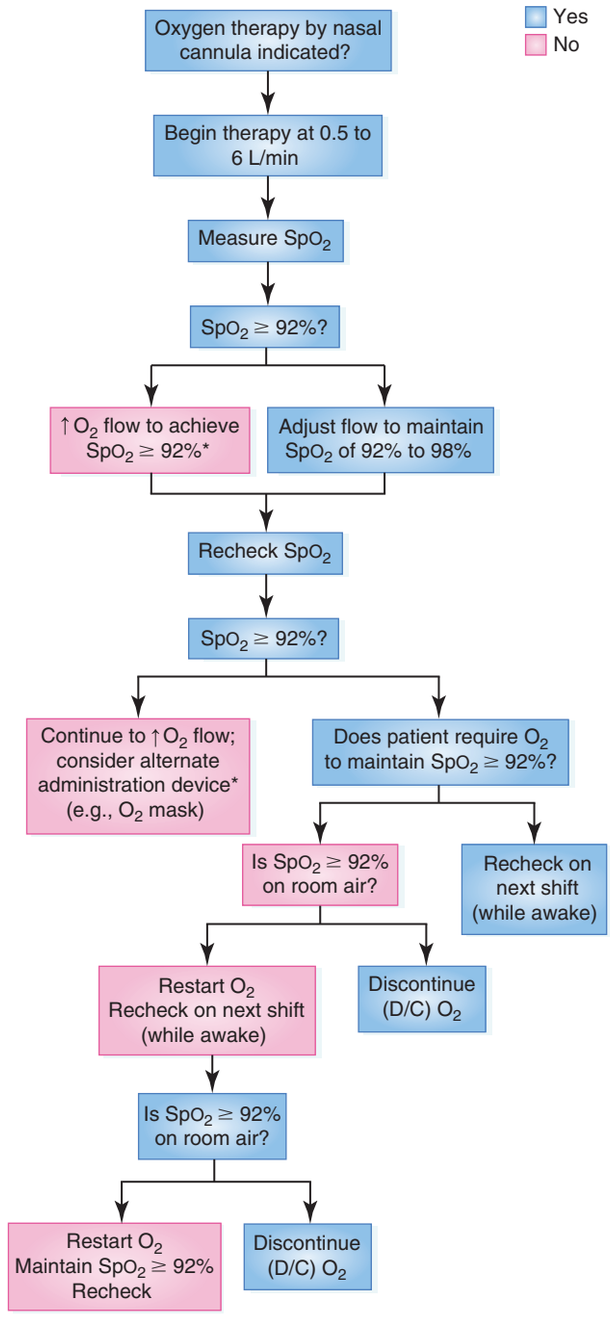

FIGURE 2-2 Protocol for oxygen therapy by nasal cannula.

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 (FEV_1), 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 β_2-agonists or anticholinergics and as short acting or long acting. Short-acting β_2-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

BOX 2-6

Indications for Bronchodilator Therapy

Asthma
COPD (emphysema/chronic bronchitis)
Cystic fibrosis
Wheezing
Documented response to a bronchodilator:

- Increase in FEV_1 > 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.
FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow rate

for three rounds, and then every 2 to 4 hours as needed. Newer guidelines suggest ipratropium may only be beneficial during the initial treatment of acute asthma. These medications may be given via MDI and holding chamber with equal effectiveness, if the patient is able to coordinate the use of the MDI. The frequency of administration is then reduced based on the patient's response and measurement of PEF or FEV_1. **Table 2-3** lists the medication dosages for treatment of asthma exacerbations. An outline of a protocol for management of acute asthma exacerbation is provided in **Figure 2-3**.

Respiratory Care Plans for COPD

Inhaled bronchodilator therapy is central to the management of COPD, as described in the GOLD standards.[18] 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.[18] Combination of a β_2-agonist and anticholinergic bronchodilator (combination therapy) may result in greater bronchodilation than either drug when used alone. Inhaled triple therapy, which combines a β_2-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 β_2-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 β_2-agonist. High-risk patients with severe to very severe airflow limitation (FEV_1/FVC < 0.70 and FEV_1 < 50% predicted) require the addition of an inhaled corticosteroid to a long-acting bronchodilator. A severe exacerbation of COPD may require a short-acting β_2-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 2-3
Medication Dosages for Treatment of Asthma Exacerbation

Medication	Child Dose (≤ 12 years)	Adult Dose	Comments
Inhaled Short-Acting Selective β_2-Agonists (SABA)			
Albuterol			
Nebulizer solution (0.63 mg/3 mL, 1.25 mg/3 mL, 2.5 mg/3 mL, 5.0 mg/mL)	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.	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.	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.
MDI (90 mcg/puff)	4–8 puffs every 20 minutes for three doses, then every 1–4 hours inhalation maneuver as needed. Use VHC; add mask in children < 4 years.	4–8 puffs every 20 minutes up to 4 hours, then every 1–4 hours as needed.	In mild to moderate exacerbations, MDI plus HC is as effective as nebulized therapy with appropriate administration technique and coaching by trained personnel.
Bitolterol			
Nebulizer solution (2 mg/mL)	See albuterol dose; thought to be half as potent as albuterol on per mg basis.	See albuterol dose.	Not studied in severe asthma exacerbations. Do not mix with other drugs.
MDI (370 mcg/puff)	See albuterol MDI dose.	See albuterol MDI dose.	Not studied in severe asthma exacerbations.
Levalbuterol (R-albuterol)			
Nebulizer solution (0.63 mg/3 mL, 1.25 mg/0.5 mL, 1.25 mg/3 mL)	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.	1.25–2.5 mg every 20 minutes for three doses, then 1.25–5 mg every 1–4 hours as needed.	Levalbuterol administered in one-half the mg dose of albuterol provides comparable efficacy and safety. Has not been evaluated by continuous nebulization.
MDI (45 mcg/puff)	See albuterol MDI dose.	See albuterol MDI dose.	
Pirbuterol			
MDI (200 mcg/puff)	See albuterol MDI dose; thought to be half as potent as albuterol on a per mg basis.	See albuterol MDI dose.	Has not been studied in severe asthma exacerbations.
Systemic (Injected) β_2-Agonists			
Epinephrine			
1:1,000 (1 mg/mL)	0.01 mg/kg up to 0.3–0.5 mg SQ every 20 minutes for three doses.	0.3–0.5 mg every 20 minutes for three doses.	No proven advantage of systemic therapy over aerosol.
Terbutaline			
(1 mg/mL)	0.01 mg/kg SQ every 20 minutes for three doses then every 2–6 hours as needed.	0.25 mg SQ every 20 minutes for three doses.	No proven advantage of systemic therapy over aerosol.
Anticholinergics			
Ipratropium bromide			
Nebulizer solution (0.25 mg/mL)	0.25–0.5 mg every 20 minutes for three doses, then as needed.	0.5 mg every 20 minutes for three doses, then as needed.	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.

Table 2-3
Medication Dosages for Treatment of Asthma Exacerbation (*continued*)

Medication	Child Dose (≤ 12 years)	Adult Dose	Comments
MDI (18 mcg/puff)	4–8 puffs every 20 minutes as needed up to 3 hours.	8 puffs every 20 minutes as needed up to 3 hours.	Use with HC and face mask for children < 4 years.
Ipratropium with albuterol			
Nebulizer solution (each 3 mL vial contains 0.5 mg ipratropium bromide and 2.5 mg albuterol)	1.5–3 mL every 20 minutes for three doses, then as needed.	3 mL every 20 minutes for three doses, then as needed.	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.
MDI (each puff contains 18 mcg ipratropium bromide and 90 mcg of albuterol)	4–8 puffs every 20 minutes as needed up to 3 hours.	8 puffs every 20 minutes as needed up to 3 hours.	Use with HC and face mask for children < 4 years.
Systemic Corticosteroids			
	(Applies to all three corticosteroids)		
Prednisone Methylprednisolone Prednisolone	1–2 mg/kg in two divided doses (maximum = 60 mg/day) until PEF is 70% of predicted or personal best.	40–80 mg/day in one or two divided doses until PEF reaches 70% of predicted or personal best.	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).
• There is no advantage for intravenous administration over oral therapy provided gastrointestinal transit time or absorption is not impaired. • 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. • Inhaled corticosteroids can be started at any point in the treatment of an asthma exacerbation.			

MDI, metered-dose inhaler; HC, holding chamber; PEF, peak expiratory flow; ED, emergency department; SQ, subcutaneous.
Reproduced from: National Institutes of Health, National Heart, Lung, and Blood Institute Guidelines for the Diagnosis and Management of Asthma: Expert Panel 3 Report. (NIH publication). Bethesda, MD: US Department of Health and Human Services; 2007.

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.[19] Salmeterol, a long-acting β_2-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.[19] 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.[17] The appropriate use of corticosteroids in the treatment of asthma is well described in the NIH Guidelines.[17] 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

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 β_2-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: SpO_2 > 95% and/or PaO_2 80 to 100 on room air
  - Moderate severity: SpO_2 90% to 95% and/or PaO_2 ≥ 60 but <80
  - Severe: SpO_2 < 90% and/or PaO_2 < 60 – severe
  - Mild or normal: $PaCO_2$ < 42 mm Hg; ≥42 mm Hg may progress to ventilatory failure requiring mechanical ventilation
- **Treatment**
  - Supply oxygen therapy to relieve hypoxemia and maintain SaO_2 ≥ 90%.
  - Administer inhaled short-acting β_2-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 β_2-agonist/
  - Monitor vital signs, SaO_2.
  - 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.

Data from: National Institutes of Health, National Heart, Lung, and Blood Institute Guidelines for the Diagnosis and Management of Asthma: Expert Panel 3 Report. NIH publication. Bethesda, MD: U.S. Department of Health and Human Services; 2007.

Table 2-4
COPD Medications

Drug	Trade Names	Inhaler (mcg)	DPI/MDI Dose	Solution for Nebulizer	Nebulizer Dose	Duration of Action (hours)
β_2-agonists						
Short Acting						
Albuterol	Proventil HFA; Ventolin HFA; ProAir HFA; AccuNeb; VoSpire ER	90 mcg/puff (MDI)	2 puffs three to four times per day	0.5% solution—0.5 mL (2.5 mg), or 0.63 mg, 1.25 mg, and 2.5 mg unit dose	2.5 mg in 3 mL normal saline three to four times per day	5–8
Levalbuterol	Xopenex; Xopenex HFA	45 mcg/puff (MDI)	2 puffs every 4–6 hours	0.31 mg, 0.63 mg, 1.25 mg in 3 mL solution	3 mL three times per day	5–8
Pirbuterol	Maxair Autohaler	200 mcg/puff (MDI)	2 puffs every 4–6 hours	NA	NA	5–8
Long Acting						
Arformoterol	Brovana	NA	NA	15 mcg/2 mL unit dose vial	2 mL every 12 hours	12
Formoterol	Perforomist, Foradil	12 mcg/inhalation (DPI)	1 inhalation every 12 hours	20 mcg/2 mL unit dose vial	2 mL every 12 hours	12
Indacaterol	Arcapta Neohaler	75 mcg/inhalation (DPI)	1 inhalation every day	NA	NA	24
Salmeterol	Serevent Diskus	50 mcg/inhalation (DPI)	1 inhalation every 12 hours	NA	NA	12
Anticholinergics						
Short Acting						
Ipratropium bromide	Atrovent HFA	17 mcg/puff (MDI)	2 puffs four times daily	0.2 mg/mL (0.02% solution) in a 2.5 mL unit dose	2.5 mL unit dose/500 mcg three to four times daily	4–6
Oxitropium bromide (available outside United States)	Oxivent, Tersigan, Tersigat, Ventilat, Ventox	100 mcg (MDI)	2 puffs two to three times daily	NA	NA	7–9
Long Acting						
Tiotropium	Spiriva	18 mcg/inhalation (DPI)	1 inhalation every day	NA	NA	24
Combination Short-Acting β_2-Agonists Plus Anticholinergic						
Albuterol/ Ipratropium	Combivent DuoNeb	Albuterol: 90 mcg Ipratropium: 18 mcg/puff	2 puffs four times a day of 18 mcg/puff ipratropiumand 90 mcg/puff albuterol	Albuterol: 2.5 mg Iprotropium: 0.5 mg in 3 mL	3 mL four times a day	4–6

(*continues*)

Table 2-4
COPD Medications (*continued*)

Drug	Trade Names	Inhaler (mcg)	DPI/MDI Dose	Solution for Nebulizer	Nebulizer Dose	Duration of Action (hours)
Fenoterol/ Ipratropium (available in Canada)	Duovent UDV	NA	NA	Fenoterol: 1.25 mg Ipratropium: 0.5 mg in 4 mL	4 mL every 6 hours	6–8
Methylxanthines						
Aminophylline	Phyllocontin; Truphylline (Canada)	• IV 5.7 mg/kg loading dose in patients not currently receiving • 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 • IV maintenance dose in adults > 60 years: 0.38 mg/kg/hr; maximum 400 mg/ day • 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 • 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_2-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*)

Drug	Trade Names	Inhaler (mcg)	DPI/MDI Dose	Solution for Nebulizer	Nebulizer Dose	Duration of Action (hours)
Systemic Corticosteroids May Improve Outcomes When Used in the Treatment of Acute Exacerbation of COPD						
Methyl-prednisolone	Medrol; Meprolone	Methylprednisolone suggested dosage for COPD exacerbation with impending respiratory failure is 60 mg IV, one to two times daily.				
Prednisone	Prednisone Intensol™	Oral prednisone dose of 30–60 mg/day for 7–10 days has been suggested.				

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.
From Gardenhire D. *Rau's Respiratory Care Pharmacology*, 8th ed. St. Louis: Elsevier Health; 2012: 98–108; Global Initiative for Chronic Obstructive Lung Disease. *Pocket Guide to COPD Diagnosis, Management, and Prevention: A Guide for Health Care Professionals*. 2011. Available at: http://www.goldcopd.org/uploads/users/files/GOLD_PocketGuide_2011_Jan18.pdf.

BOX 2-7

Management of Stable COPD

Smoking cessation
Pharmacological therapy
- Short-acting β_2-agonists (albuterol)
- Short-acting anticholinergic bronchodilator (ipratropium)
- Combined short-acting β_2-agonists and short-acting anticholinergic bronchodilators
- Long-acting inhaled β_2-agonists (salmeterol, formoterol)
- Long-acting anticholinergic bronchodilator (tiotropium)
- Combined long-acting β_2-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 α_1-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
Data from the American Thoracic Society–European Respiratory Society Standards for the Diagnosis and Management of Patients with COPD. http://www.thoracic.org/clinical/copd-guidelines/resources/copddoc.pdf.

LESS RISK, LESS SYMPTOMS

Patients with low risk, less symptoms, and mild to moderate airflow limitation ($FEV_1/FVC < 0.70$ and $FEV_{1.0} > 50\%$ predicted) and one or fewer exacerbations per year.

First Choice

Short-acting anticholinergic bronchodilator PRN OR
Short acting β_2-agonist PRN

Second Choice

Long-acting anticholinergic bronchodilator OR
Long-acting β_2-agonist OR
Long-acting anticholinergic and long-acting β_2-agonist

LESS RISK, MORE SYMPTOMS

Patients with low risk, more symptoms, and mild to moderate airflow limitation ($FEV_1/FVC < 0.70$ and $FEV_1 > 50\%$ predicted) and one or fewer exacerbations per year.

First Choice

Long-acting anticholinergic bronchodilator OR
Long-acting β_2-agonist

Second Choice

Long-acting anticholinergic bronchodilator and long-acting β_2-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 ($FEV_1/FVC < 0.70$ and $FEV_1 < 50\%$ predicted [severe] or $FEV_1 < 30\%$ predicted [very severe]).

First Choice

Inhaled corticosteroids AND
Long-acting β_2 agonist OR long-acting anticholinergic

Second Choice

Long-acting anticholololinergic and long-acting β_2-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 β_2-agonist OR long-acting anticholinergic

Second Choice

Inhaled corticosteroids and long-acting anticholinergic OR
Inhaled corticosteroids and long-acting β_2-agonist and long-acting anticholinergic OR
Inhaled corticosteroids and long-acting β_2-agonist and phosphodiesterase-4 inhibitor OR
Long-acting anticholinergic and long-acting β_2-agonist OR
Long-acting anticholinergic and phosphodiesterase-4 inhibitor

FIGURE 2-4 Pharmacologic treatment for the stable COPD.

Data from: Global Initiative for Chronic Obstructive Lung Disease. *Pocket Guide to COPD Diagnosis, Management, and Prevention 2011*. Available at: http://www.goldcopd.org/guidelines-pocket-guide-to-copd-diagnosis.html.

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**
  - $SpO_2 < 88\%$ to 90% is consistent with a $PaO_2 < 55$ to 58 ($SpO_2 < 85\%$ is consistent with a $PaO_2 < 50$).
  - $PaO_2 < 60$ on $FIO_2 = 0.21$ (with or without 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 SpO_2 of 90% to 92% and 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 β_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.

Data from: Global Initiative for Chronic Obstructive Lung Disease. *Pocket Guide to COPD Diagnosis, Management, and Prevention*—2011. Available at: http://www.goldcopd.org/guidelines-pocket-guide-to-copd-diagnosis.html; Jong YP, Vil SM, Grotjohan HP, Postma DS, Kerstjens H, Vanden Berg J. Oral or IV prednisolone in the treatment of COPD exacerbations: a randomized controlled, double-blind study. *Chest.* 2007;132(6):1741–1747.

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 (Singulair), 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]

BOX 2-8

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.[20] 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% O_2) 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.[20] 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.[20–25] 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.[25] 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).[25] 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.[25] 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.[26]

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 V_T 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 FIO_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 FIO_2 via aerosol mask and high humidity
Mobilization of secretions

Hypertonic Saline Administration

Need to induce sputum specimens

PIP, peak inspiratory pressure; VT, 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.[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.[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.[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.

Oral acetylcysteine may be helpful in COPD patients with viscid secretions, but oral acetylcysteine is not approved for use in the United States.[18]

The least expensive and effective method for mobilization of secretions should be selected. For example, a well-hydrated patient with chronic bronchitis who is able to easily expectorate secretions using a directed cough probably has no need for chest physiotherapy or use of an oral mucolytic. A cystic fibrosis patient with abundant secretions that are not easily cleared by directed cough might require vigorous chest physiotherapy or use of alternative techniques for secretion management, such as administration of aerosolized dornase alfa.

Frequency of therapy will vary with the respiratory care modality selected and the patient's condition. For example, aerosolized dornase alfa is indicated specifically in the management of cystic fibrosis using 2.5 mg in a 2.5 mL solution administered once daily.

Directed cough should follow any therapy used to mobilize secretions and may be useful in obtaining a sputum specimen. Suctioning should be applied to patients with artificial airways on an as-needed basis. Routine suction schedules (every 2 hours, every 4 hours, etc.) should be avoided.

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**.

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 a been coughing up more than approximately 25 mL/day of thick, dark yellow muco-purulent 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 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/m to maintain Spo_2 > 90% to 92% with a Pao_2 of 60 to 70. Monitor Spo_2 during chest physiotherapy.
- Assessment includes monitoring breath sounds, cough, sputum production (color, volume consistency), shortness of breath, 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.[27] NT suctioning may also be useful to stimulate a cough or to obtain a sputum sample for microbiologic or cytologic analysis.[27] 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.[27]

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.[26,28,29] 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.[24]

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).[25] 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 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:

$$\text{IBW (lbs.)} = 106 + 6(\text{H} - 60) = 106 + 6(71 - 70) = 172 \text{ lbs.}$$
$$\text{kg} = \text{lbs}/2.2 = 172/2.2 = 78 \text{ kg}$$

- 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:

$$\text{Minimum volume for incentive spirometry} = \text{IBW} \times 50 \text{ mL/kg} \times 1/3$$

IPPB should generally be reserved for patients who have clinically important atelectasis in which other therapy has been unsuccessful.[26] When used as a form of lung expansion therapy, minimum delivered tidal volumes during IPPB therapy should probably be at least one-third of predicted IC, or about 1200 mL in a typical adult.[26] IPPB may also be considered for patients at risk for developing atelectasis who cannot or will not take a deep breath on their own. IPPB may also be useful in a few patients for delivery of bronchodilators or other medications where patient coordination and the ability to take a deep breath is compromised. IPPB as a form of lung expansion therapy usually includes the administration of an aerosolized bronchodilator, and therapy is usually given three times a day, four times a day, or every 2 to 4 hours for approximately 10 to 20 minutes. The indications for lung expansion therapy are listed in **Box 2-11**. A sample protocol for delivery of lung expansion therapy is found in **Figure 2-6**.

Critical Care and Mechanical Ventilation

Respiratory care plans for patients in the intensive care unit (ICU) may include therapy to improve oxygenation and/or ventilation, provide secretion management and airway care, treat bronchospasm and mucosal edema, or deliver lung expansion therapy to treat or prevent atelectasis. The goals of invasive and noninvasive ventilatory support in the ICU include maintaining adequate tissue oxygenation, ventilation, carbon dioxide removal, and acid–base balance. Respiratory care in the ICU is

BOX 2-11

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.

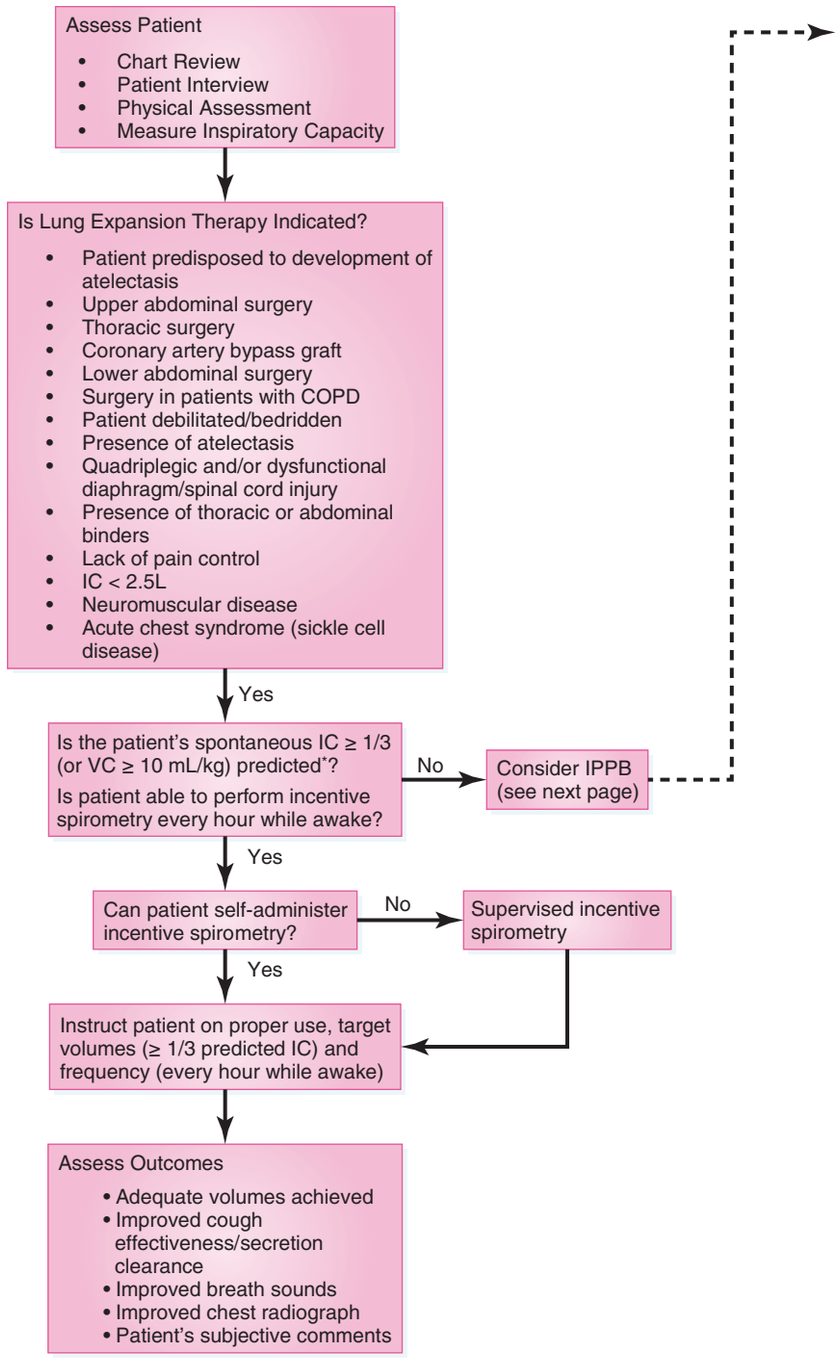

FIGURE 2-6 Protocol for lung expansion therapy.

Modified from: the American Association for Respiratory Care. Clinical Practice Guideline: Intermittent positive pressure breathing—2003 revision and update. *Respir Care*.2003; 48(5):540–546.

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

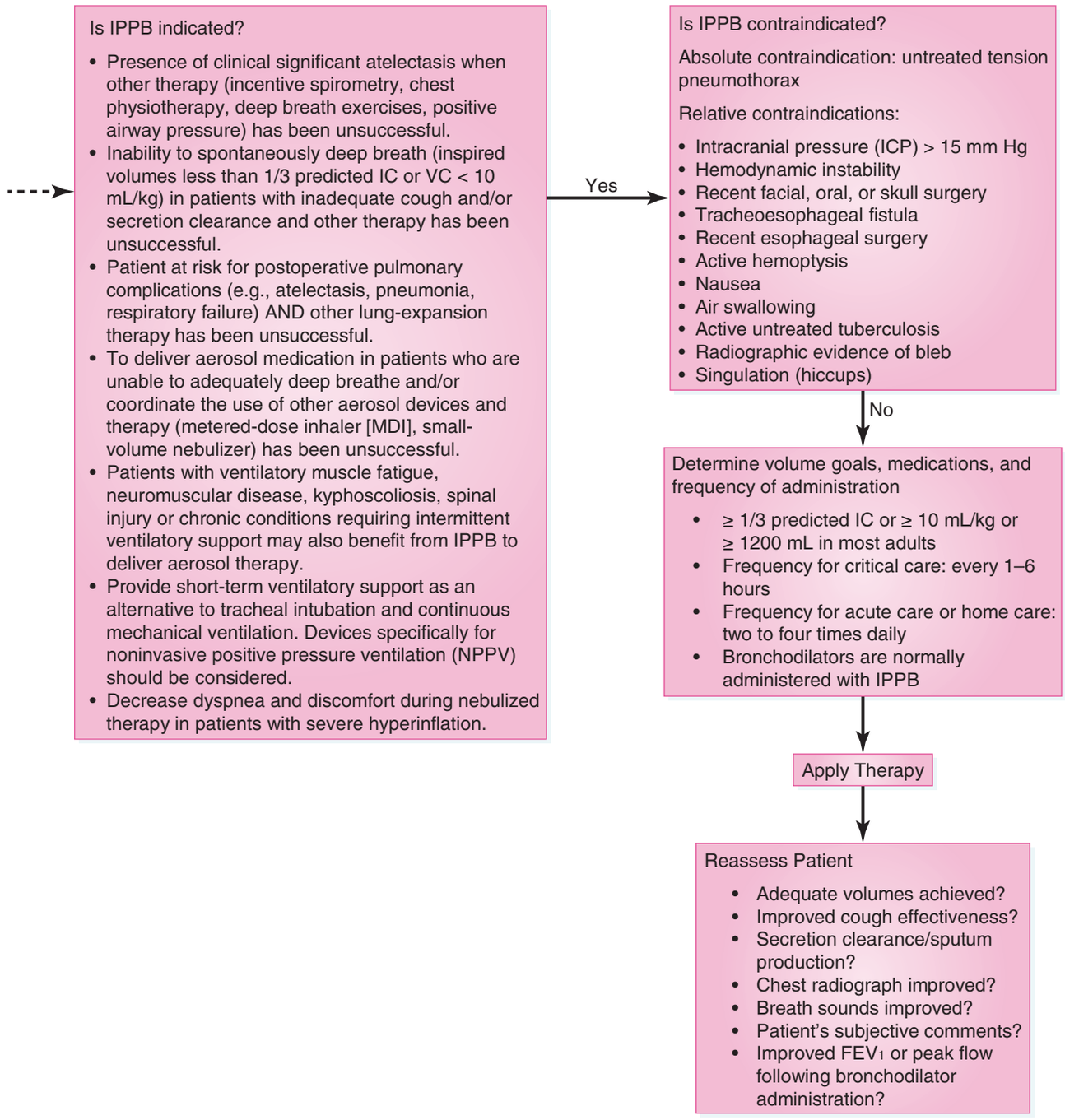

FIGURE 2-6 (*continued*)

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.

S: The patient's **subjective** expression of the symptoms that have brought him or her before the clinician.
- The chief complaint is the leading statement reported by the patient.
- The history of present illness and past medical history are also subjective.

O: The **objective** signs that are exhibited by the patient.
- Includes physical assessment, vital signs, inspection, palpation, percussion, and auscultation.
- Diagnostic data such as the results of arterial blood gas analysis, chest radiography, pulmonary function, and other laboratory tests may also be recorded.

A: The clinician's **assessment** of the findings noted in the S & O sections of the clinical note.
- Commonly an assessment of the clinical signs and symptoms followed by the disease or disorder that is suggested by the findings.
- For example, the symptoms, physical findings, and diagnostic data noted during examination of the asthmatic patient present a very characteristic disease pattern.

P: Describes the care **plan** that has been formulated based on the assessment findings.
- The plan should address the treatment and/or monitoring of the patient's disease state, conditions, or compliant.

SOAP Note Format

Patient Name: _____ Age: _____
Physician(s): _____ Height: _____
Hospital ID No.: _____ Weight: _____
Sex: _____

Admitting Diagnosis: _____

Problems or Complaints:
1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

Subjective Findings: _____
_____
_____
_____

Objective Findings: _____
_____
_____

Assessment: _____
_____

Plan: _____
_____
_____
_____

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 SpO_2: _____
_____
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: _____ FEV_1: _____

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)

Yes	No	
☐	☐	asthma
☐	☐	COPD
☐	☐	upper airway edema

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

Yes	No	
☐	☐	asthma

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

Yes	No	
☐	☐	retained secretions, excess secretion production
☐	☐	following bronchial hygiene therapy
☐	☐	at risk for atelectasis/post-op pulmonary complications
☐	☐	to obtain sputum specimen

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

Yes	No	
☐	☐	inability to clear secretions with cough
☐	☐	need to remove secretions with artificial airway
☐	☐	need to stimulate cough
☐	☐	to obtain sputum specimen

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

Yes	No	
☐	☐	evidence of viscous/retained secretions which are not easily removed via other therapy
☐	☐	chronic bronchitis, cystic fibrosis, bronchiectasis

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

Postural Drainage and Percussion

Yes	No	
☐	☐	suggestion/evidence of problems with secretion clearance
☐	☐	difficulty clearing secretions with volume >25–30 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

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

Cool Mist Bland Solution

Yes	No	
☐	☐	post extubation
☐	☐	deliver precise FIO_2 via air-entrainment nebulizer
☐	☐	upper airway edema
☐	☐	to obtain sputum specimen

Heated Large-Volume Nebulizer

Yes	No	
☐	☐	evidence/potential for secretion clearance problem
☐	☐	deliver precise FIO_2 with high humidity
☐	☐	mobilize secretions

Hypertonic Saline Administration

Yes	No	
☐	☐	induce sputum

FIGURE 2-8 (*continued*)

Assessment for Lung Expansion Therapy (see Box 2-11)

Incentive Spirometry (check all of the indications present for this patient)

Yes	No	
☐	☐	Patient is able to perform the maneuver q1–2 hours while awake and is able to achieve adequate inspired volume.

AND:
Check as many as apply:

Yes	No	
☐	☐	Patient is predisposed to development of atelectasis (surgery, debilitated, bedridden, ventilatory impairment/restrictive/ neuromuscular defect).
☐	☐	Presence of atelectasis.
☐	☐	Preoperative screening/education of patients at risk.
☐	☐	Patient has reduced inspiratory capacity (<2.5 L).

IPPB (check all the indications present for this patient)

Yes	No	
☐	☐	Presence of clinically important atelectasis AND other therapy has been unsuccessful.
☐	☐	Patient cannot or will not spontaneously deep breathe and is at risk for atelectasis.
☐	☐	To deliver aerosol medication with coordination or cooperation issues.
☐	☐	NPPV to provide short-term ventilatory support in an attempt to avoid intubation and continuous mechanical ventilation.

IS, incentive spirometry; CPT, chest physiotherapy.

FIGURE 2-8 (***continued***)

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 FEV_1, improvement in oxygenation or 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 **S**ubjective, **O**bjective, **A**ssessment, and **P**lan.
- 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 $Paco_2$ with a corresponding decrease in pH.
- Chronic ventilatory failure is defined as a chronically elevated $Paco_2$ 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 cardiopulmonary function.

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