

Chapter 24

Respiratory Emergencies

Introduction

Breathing should be effortless, and individuals should exhibit respiratory rates and tidal volumes appropriate for their ages (normally 5 mL/kg in spontaneously ventilating infants and children; Table 24-1). A comprehensive equipment table inside the front cover contains weight-based recommendations for all respiratory equipment.

Table 24-1. Pediatric Respiratory Rates

Age (y)	Respiratory Rate (breaths per min)
< 1	30–60
1–3	24–40
4–5	22–34
6–12	18–30
> 12	12–16

Work of Breathing

- Evidence of increased work of breathing in a child may include the following:
 - Tachypnea
 - Retractions (intercostal, subcostal, or suprasternal)
 - Use of accessory muscles
 - Head bobbing
 - Open-mouth breathing
 - Nasal flaring
 - Grunting (**ominous sign!**)
- Appropriate tidal volume should be judged by thoughtful analysis during auscultation. Does the breath sound normal, small, or excessive?
 - Stridor is an abnormal breath sound that signifies upper-airway obstruction

- ▶ Causes: foreign body, infection, congenital airway anomalies, upper-airway edema, mass effect on airway
- Grunting is a short, low-pitched sound during exhalation and is a **late and ominous sign**
 - ▶ Child's attempt to create positive end-expiratory pressure (PEEP), which helps maintain airway and alveolar patency (functional residual capacity), thereby improving oxygenation and ventilation
 - ▶ May be present in a variety of conditions, including pneumonia, pulmonary contusion, and acute respiratory distress syndrome, and requires immediate intervention (possibly intubation)
- Wheezing is typically a musical expiratory sound associated with lower-airway obstructive disorders
 - Asthma and bronchiolitis typically manifest with polyphonic wheezing, signifying the closure of many airways at different times
 - Central airway collapse disorders, such as tracheomalacia or bronchomalacia, typically manifest with monophonic wheezing (the same noise can be heard throughout the chest)
- Crackles/rales are inspiratory sounds typically associated with airway or alveolar disease and collapse (pneumonia, atelectasis, pulmonary edema)
- Pulse oximetry
 - $\geq 94\%$ is normal for a child
 - $< 90\%$ despite 100% oxygen via a nonrebreather is **ominous**
 - Must be checked on warm, well-perfused extremity
 - Consider previously undiagnosed congenital cyanotic heart disease in infants and children who present with minimal respiratory distress and cyanosis that does not improve, despite oxygen

Status Asthmaticus

- Characterized by respiratory distress due to airway obstruction from bronchospasm, excess mucous production, and airway inflammation
- The following plan can be used for all acutely symptomatic asthma exacerbations (Tables 24-2–24-4):
 - Rapidly categorize severity based on presenting signs and

Table 24-2. Acute Asthma Severity

Signs and Symptoms	Category			
	Mild	Moderate	Severe	Imminent Respiratory Failure
Respiratory rate	30% above mean	30%–50% above mean	> 50% above mean	> 50% above mean, or very slow
Alertness	Normal	Usually agitated	Agitated	Drowsy, confused
Dyspnea	Mild	Moderate	Severe	Severe
Color	Good	Pale	May be cyanotic	Cyanotic
Accessory muscle use	Mild	Moderate	Severe	Paradoxical thoracoabdominal movements
Auscultation	End-expiratory wheeze	Inspiratory and expiratory wheezing	Inaudible wheezing	Inaudible wheezing, minimal breath sounds
PEFR (% of predicted)	70%–90%	50%–70%	< 50%	< 20%
Air movement	Good	Fair	Poor	Poor/absent
PaCO ₂	< 35 mmHg	< 40 mmHg	> 40 mmHg	> 40 mmHg

PEFR: peak expiratory flow rate

PaCO₂: partial pressure of carbon dioxide in arterial blood

Adapted from: National Institutes of Health, National Heart, Lung, and Blood Institute. *Guidelines for the Diagnosis and Management of Asthma*. Bethesda, Md: NIH; 1991.

symptoms

- Use time-based management, depending on severity
- Evaluate disposition based on response to prompt therapy
- Admit the patient to the hospital if the patient cannot take medications or fluids orally, cannot maintain saturation $\geq 94\%$ on room air, requires bronchodilators more often than every 3–4 hours, or if the patient is rapidly deteriorating (Table 24-5)
- Watch for toxicities and side effects of medications used (Table 24-6)
 - For example, extreme tachycardia can be seen when al-

Table 24-3. Acute Asthma Treatment for Mild to Moderate Attacks

Time Frame	Treatment
Presentation	Check vitals and pulse oximetry; take brief Hx and perform PE, administer supplemental oxygen for sat \leq 90%, preferably keeping sats \geq 94%
10–20 min	Administer an immediate β -agonist (eg, albuterol): <ul style="list-style-type: none"> • MDI with spacer 4–8 puffs <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • Albuterol (nebulized) 2.5–5 mg Reassess and repeat q10–20min; consider adding ipratropium to subsequent nebulizer 0.25–0.5 mg
30 min	Consider steroids: <ul style="list-style-type: none"> • Oral prednisone 2 mg/kg if tolerating PO <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • Methylprednisolone sodium succinate (IV or IM) 2 mg/kg if unable to tolerate PO
60 min	Consider MgSO ₄ : 40 mg/kg over 20 min and reassess (maximum single dose 2 g)
120–240 min	Patient may be discharged if clinically improved with sat \geq 94% and reliable follow-up established

Hx: history

IM: intramuscular

IV: intravenous

PE: physical examination

PO: per os (by mouth)

MDI: metered-dose inhaler

MgSO₄: magnesium sulfate

sat: saturation

SQ: subcutaneous

buterol, ipratropium inhalation, and terbutaline are used in combination

- An infant or toddler will tolerate a heart rate of 180 beats per minute, but an adolescent will not

Managing Chronic Asthma

- Optimal long-term management of asthma leads to fewer acute exacerbations, minimal use of medications (short-acting β -agonists and oral corticosteroids), fewer restrictions on activity, and preservation of lung function. The following steps provide a framework for long-term asthma management:
 - Classify asthma severity
 - ▶ Although spirometry provides an objective means for evaluating lung function, it is unlikely to be available
 - ▶ Classifying asthma severity using an age-based table

Table 24-4. Acute Asthma Treatment for Severe Attacks

Time Frame	Treatment
Presentation	Check vitals and pulse oximetry; take brief Hx and perform PE, administer supplemental oxygen for sat \leq 90%, preferably keeping sats \geq 94%
10–20 min	Administer an immediate β -agonist: <ul style="list-style-type: none"> • Albuterol (nebulized) 2.5–5 mg. Reassess and repeat q10–20min <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • Terbutaline or epinephrine (1:1,000) .01 mg/kg (SQ) if unresponsive to albuterol or not moving air; may repeat in 15 min; max dose 0.3 mg Add ipratropium to subsequent nebulizer 0.25–0.5 mg
30 min	Steroids: Methylprednisolone sodium succinate 2–4 mg/kg IV and reassess
60 min	MgSO ₄ 40 mg/kg over 20 min and reassess (max single dose 2 g) Continue nebulizer as necessary
120–240 min	Admit if not improved (ward or PICU)

Hx: history
 IV: intravenous
 PE: physical examination

PICU: pediatric intensive care unit
 MgSO₄: magnesium sulfate
 sat: saturation
 SQ: subcutaneous

can help guide initial management (Table 24-7)

- Control precipitating factors and comorbid conditions
 - ▶ Identification and avoidance of known triggers, along with aggressive use of rescue medications, can help minimize symptoms
 - ▷ Common triggers include upper respiratory infections, inhaled allergens (eg, pollen, dust mites), and irritants (eg, tobacco smoke)
 - ▶ Comorbid conditions, such as rhinitis, reflux, obesity, and stress, are known to worsen or attenuate asthma symptoms and should be treated
- Provide asthma education
 - ▶ Education should focus on appropriate use of medications (proper use of inhaler, chamber, and spacer), avoiding environmental exposures, recognizing worsening symptoms and adjusting medications, and seeking appropriate medical care when needed
 - ▶ A written asthma action plan is a validated

Table 24-5. Asthma Inpatient Management Plan

Ward	Pediatric Intensive Care Unit
If O ₂ sat ≥ 94% on ≤ 50% FiO ₂ , requires ≤ q2–3h albuterol prn (MDI with spacer or nebulized)	If patient remains in distress, use albuterol continuously (.5 mg/kg/h, range 10–40 mg/h) with O ₂ to keep O ₂ sat ≥ 94% (always use humidified O ₂)
Use prednisone 2 mg/kg/day or methylprednisolone sodium succinate 2–4 mg/kg/day ÷ q6h	Use terbutaline drip as adjunct, bolus with 10 µg/kg over 10 min, then run drip .1 µg/kg/min, titrating q15–30min, up to max of 4 µg/kg/min
Consider ipratropium neb 0.25–0.5 mg q4–6h	Use methylprednisolone sodium succinate 4 mg/kg/day ÷ q6h
Consider MgSO₄ 40 mg/kg IV q6h (if not already given)	Ipratropium neb 0.25–0.5 mg q4–6h
Consider temporary NPO status with maintenance IVFs if in distress	Consider repeating MgSO₄ 25–50 mg/kg IV q6h
Discharge patient to home if clinically improved with O ₂ sat ≥ 94%, and reliable follow-up established	Consider temporary NPO status with maintenance IVFs if in distress, especially if intubation a possibility
	Other options include: Heliox 70:30 Consider theophylline 6–7mg/kg bolus, followed by drip Must follow levels 30 min after bolus and 12–24 h after initiation of drip Ketamine sedation 0.5–1 mg/kg/dose for agitation out of proportion to respiratory distress. CAUTION: may cause respiratory depression
	Inhaled anesthetics
FiO ₂ : fraction of inspired oxygen IV: intravenous IVF: intravenous fluid MDI: metered dose inhaler	MgSO ₄ : magnesium sulfate neb: nebulized NPO: nil per os (nothing by mouth) prn: pro re nata (as needed) sat: saturation

educational tool

Other Common Respiratory Emergencies

- Anaphylaxis
 - Generalized, potentially fatal allergic reaction
 - ▶ Symptoms usually develop seconds to minutes after contact with the offending agent

Table 24-6. Asthma Medication Toxicity Profile

Medication	Toxicity
Albuterol	Tachycardia, hypokalemia, tremors
Ipratropium	Dry mouth, tachycardia, dry secretions
Terbutaline	Tachycardia, arrhythmias, hypokalemia, muscle twitching, increased muscle CPK
Steroids	Hyperglycemia, gastritis, CNS stimulation, hypertension, immune suppression
Magnesium	Hypotension, weakness, nausea, flushing
Theophylline	Tachycardia, nausea, ventricular dysrhythmias, tremors, seizures
Ketamine	Potent sialogogue, respiratory depression, emergence phenomena, tachyphylaxis
Heliox	Theoretical risk of atelectasis
Inhaled anesthetics	Hypotension, apnea, myocardial depression

CNS: central nervous system

CPK: creatine phosphokinase

Table 24-7. Chronic Asthma Severity and Suggested Treatment

Severity	Intermittent	Mild	Moderate	Severe
Frequency of symptoms	< 2/wk	> 2/wk (not daily)	Daily	Throughout day
Nighttime awakenings	None	1–2/mo	3–4/mo	> 1/wk
Impairment	None	Minor limitation	Some limitation	Extremely limited
Treatment (alternate)	Albuterol (as needed) corticosteroid	Low-dose inhaled corticosteroid or leukotriene receptor antagonist	Low- or medium-dose and albuterol or leukotriene receptor antagonist	Medium- or high-dose corticosteroid and albuterol; consider oral corticosteroids

- ▶ Several organ systems may be involved, including the skin, respiratory tract, cardiovascular system, and gas-

trointestinal tract

- ▶ If not recognized and promptly treated, anaphylaxis may lead to death from respiratory or cardiovascular collapse
- Causes can include foods, drugs, and hymenoptera venom
 - ▶ **Foods:** peanuts, tree nuts, milk, eggs, fish, shellfish, fruits, grains
 - ▶ **Drugs:** penicillins, cephalosporins, sulfonamides, non-steroidal antiinflammatory medicines, opiates, insulin, local anesthetics
 - ▶ **Hymenoptera venom:** honeybee, yellow jacket, wasp, hornet, and fire ant venom
 - ▶ **Other:** latex, exercise, vaccinations
- Evaluation
 - ▶ History should include investigations into interaction with anaphylaxis-associated allergens via contact, ingestion, inhalation, or medication administration; inquiries into previous history of anaphylaxis; and past medical history
 - ▶ Review of symptoms and physical examination should check for the following:
 - ▷ Dermatologic: urticaria, angioedema, pruritus, flushing, or warmth
 - ▷ Oropharynx: swelling of the lips, tongue, or mouth
 - ▷ Throat: hoarseness, cough
 - ▷ Pulmonary: dyspnea, wheeze
 - ▷ Gastrointestinal: nausea, vomiting, diarrhea, or abdominal pain
 - ▷ Cardiovascular: hypotension, dizziness, syncope, or cardiovascular collapse
- Treatment
 - ▶ **Immediate**
 - ▷ Check airway, breathing, and circulation (ABCs)
 - ▷ Administer epinephrine 0.01 mg/kg (1:1,000) intramuscular (IM)
 - Maximum single dose: 0.3 mg
 - Repeat every 15 minutes as needed
 - ▷ Auto injectors: epinephrine 0.15 mg (0–25 kg) or epinephrine 0.3 mg (> 25 kg)

- ▷ Obtain intravenous (IV) access, administer 100% oxygen, observe cardiac monitor and pulse oximetry
 - ▷ Bolus normal saline (NS) 20 cc/kg, repeat as needed for hypotension
 - ▶ **Therapy after epinephrine**
 - ▷ H1 antagonist (diphenhydramine 1–2 mg/kg PO/IM/IV)
 - ▷ Corticosteroids (prednisone 1 mg/kg PO or methylprednisolone 2 mg/kg IV)
 - ▷ Consider nebulized albuterol 1.25–2.5 mg every 20 minutes for bronchospasm
 - ▷ Consider H2 antagonist (ranitidine 2 mg/kg PO or IV)
 - ▶ **Disposition**
 - ▷ Following initial stabilization, observe at least 4 hours (may have biphasic response)
 - ▷ Discharge with 72 hours of antihistamine and corticosteroids (albuterol if bronchospasm present)
 - ▷ Prescribe epinephrine auto injector (use age-based dosing)
 - ▷ Educate on anaphylaxis trigger avoidance and proper use of epinephrine auto injector
- **Bronchiolitis**
 - Acute, infectious, inflammatory disease of the upper and lower respiratory tracts; major cause of respiratory disease worldwide
 - ▶ Obstruction of bronchioles from inflammation, edema, and debris leads to hyperinflation (evident on chest radiograph), increased airway resistance, and atelectasis
 - ▶ Although wheezing is common, bronchoconstriction is not
 - ▶ Most cases are mild and self-limiting; however, inpatient mortality can be as high as 5%
 - Causes
 - ▶ Bronchiolitis is most often caused by respiratory syncytial virus (RSV), but parainfluenza, adenovirus, human metapneumovirus and *Mycoplasma* have been implicated
 - ▶ Common in infants and during the winter or rainy season (may be year-round near the equator)

- ▶ Infants are affected most often because of their small airways
 - ▷ Premature, chronically ill, or malnourished infants are at higher risk for severe disease
- Evaluation
 - ▶ A clinical diagnosis is based on age, season (winter), and presentation with a low-grade fever, nasal congestion that can progress to lower tract symptoms with cough, dyspnea, wheezing, and feeding difficulties
 - ▶ Severe cases can manifest with respiratory distress, tachypnea, nasal flaring, retractions, irritability, and cyanosis
 - ▶ Common auscultatory findings include biphasic wheezing and crackles
 - ▶ Hypoxemia on pulse oximetry is the best predictor of severe illness and correlates with a respiratory rate > 50 breaths per minute
 - ▶ Consider hospitalization for respiratory distress, room air saturation values < 92%, dehydration, apnea, or hypothermia
 - ▶ Bronchiolitis, particularly RSV, can present with otitis media, myocarditis, dysrhythmias, and syndrome of inappropriate antidiuretic hormone (SIADH)
 - ▶ A significant number of young or premature infants will have apnea
 - ▶ Radiograph, if available, will show hyperexpansion, diffuse bilateral perihilar peribronchial cuffing
- Treatment
 - ▶ Therapy is supportive, using oxygen and IV fluids in infants who are hypoxemic and cannot take oral liquids
 - ▶ Excess fluid administration may exacerbate pulmonary edema
 - ▶ Although studies do not support the routine use of nebulized albuterol or racemic epinephrine, some infants may experience short-term symptom relief with these agents
 - ▶ Mild nasal decongestants or bulb suctioning are more likely to be of symptomatic benefit
 - ▶ If mechanical ventilation becomes necessary, use syn-

chronized intermittent mechanical ventilation with pressure support and PEEP, ventilating at relatively slow rates to allow adequate exhalation time

- Croup
 - Laryngotracheobronchitis is an infection of the upper airway characterized by inspiratory stridor, cough, wheezing and hoarseness
 - Causes
 - ▶ The etiology is predominately viral infection (parainfluenza, RSV, adenovirus)
 - ▶ Often occurs during winter or cooler months
 - ▶ Measles can be a cause in unimmunized populations
 - Evaluation
 - ▶ Children ages 3–36 months typically present with gradual symptoms, including barking cough, hoarse voice, inspiratory stridor, tachypnea, and retractions (usually worse at night)
 - ▶ Significant hypoxia, biphasic stridor, change in mental status, poor air movement, or apparent fatigue may suggest impending respiratory failure and require urgent management
 - ▶ Chest radiograph will demonstrate laryngeal narrowing or “steep sign”
 - Treatment
 - ▶ Urgent treatment includes rapid-acting nebulized racemic epinephrine (0.05 mL/kg, maximum dose of 0.5 mL) of 2.25% solution diluted to 3.0 cc with NS, repeated as needed
 - ▷ Rapid onset, short duration (about 2 h)
 - ▷ Patients should be monitored closely for rebound symptoms 2 hours after nebulized treatment, and may tachyphylax with repeated dosing
 - ▷ If racemic epinephrine is unavailable, use L-epinephrine (0.5 mg/kg, maximum dose 5 mL of 1:1,000 solution)
 - ▶ Corticosteroids are the mainstay of treatment to decrease airway edema
 - ▷ Onset of action is around 6 hours
 - ▷ Dexamethasone: 0.6 mg/kg IV/IM/PO (IV formula-

tions can be given orally)

- ▷ Prednisolone: 2 mg/kg/day IV divided bid for 2 days
- ▷ Prednisone: 4 mg/kg PO (equivalent to 0.6 mg/kg dexamethasone)

- ▶ Management includes supplemental oxygen and supportive measures, including IV fluids and humidified air

- Epiglottitis

- Epiglottitis is a rapidly progressive bacterial infection of the epiglottis, aryepiglottic folds, and surrounding tissues that leads to edema, airway compromise, and respiratory failure

- Causes

- ▶ More common in unimmunized populations due to *Haemophilus influenzae* type b
- ▶ Rare causes in immunized populations include: *Pneumococcus*, *Staphylococcus aureus*, group A β -hemolytic streptococci (GABHS), and nontypeable *H influenzae*

- Evaluation

- ▶ Children ages 1–5 years old can present with a rapid progression from minimal symptoms to fever, sore throat/dysphagia, inability to manage secretions, and toxic appearance
- ▶ Airway compromise appears rapidly with respiratory distress and a muffled “hot-potato” voice, and patient may exhibit abnormal positioning (tripoding or leaning forward with mouth open) to maintain maximum airway patency
- ▶ Hoarseness and stridor are typically absent or mild
- ▶ Work of breathing is normal to minimally elevated
- ▶ Clinical diagnosis is based on high index of suspicion; cherry-red epiglottitis may be seen on passive visualization
- ▶ Aggressive attempts to visualize the airway should be avoided until skilled personnel are present (ie, an anesthesia professional and a surgeon capable of emergent pediatric tracheostomy) and prepared to intervene
- ▶ Lateral neck radiographs should be obtained with caution in children with airway concerns; however, the enlarged epiglottis can be visualized (it appears as the so-called “thumb sign” on the lateral neck)

- Treatment
 - ▶ Total airway obstruction may occur due to massively enlarged epiglottitis
 - ▶ Management includes intubation by the most experienced provider, with an endotracheal (ET) tube 0.5–1.0 size smaller than that routinely used for a child of that age and size
 - ▶ Simple bag-valve mask ventilation may be successful if absolutely necessary
 - ▶ Once the child is intubated, it is critical to secure the ET tube and sedate the child sufficiently to avoid a potentially catastrophic self-extubation
 - ▶ Treatment includes broad-spectrum IV antibiotics
 - ▷ Oxacillin or nafcillin (150–200 mg/kg/day divided qid),
OR
 - ▷ Cefazolin (75–100 mg/kg/day divided tid),
OR
 - ▷ Clindamycin (30–40 mg/kg/day divided tid)
PLUS
 - ▷ Third-generation cephalosporin (ceftriaxone 75–100 mg/kg/day divided bid)
 - ▷ Cover for methicillin-resistant *S aureus* in endemic area
- **Bacterial Tracheitis**
 - Symptoms: similar to epiglottitis but with copious purulent tracheal secretions
 - ▶ Often complicates viral croup
 - Etiology: usually *S aureus*, also GABHS, Hib, or *S pneumoniae*
 - Diagnosis: clinical; trachea may appear “shaggy” on radiograph
 - Treatment
 - ▶ Intubate for 5–7 days (usually needed for pulmonary toilet)
 - ▶ Nafcillin, cefazolin, cefuroxime or ampicillin/sulbactam, all IV
 - ▶ Cover for methicillin-resistant *S aureus* in endemic area

