# Asthma

*Asthma is a chronic inflammatory disease characterized by episodic reversible airway obstruction, bronchial hyperreactivity, mucosal edema, and mucus hypersecretion. Status asthmaticus is an emergency situation characterized by life-threatening bronchospasm that persists despite treatment.*

**ANESTHETIC CONSIDERATIONS:**

- Obstructive Airway Disease due to airway inflammation and hyperreactivity:
  - Perioperative bronchodilator and corticosteroid therapy as indicated
  - Avoid stimulating airway reflexes (intubate deep, consider alternatives to ETT)
  - Avoid histamine release
- Appropriate ventilation strategy
  - slow respiratory rate
  - prolonged expiratory phase to allow adequate exhalation
  - prevent barotrauma and dynamic hyperinflation
- Risk of respiratory failure and status asthmaticus – emergency situation requiring simultaneous diagnosis and treatment
- Risk of pulmonary hypertension and RV failure
- Side effects of medications
  - B2 agonists (hypokalemia, arrhythmias)
  - corticosteroids (hyperglycemia, adrenal suppression – stress dose steroids, myopathy)

**ANESTHETIC GOALS:**

- Avoid precipitation of bronchospasm
- Appropriate intraoperative ventilatory strategy
- Continue inhaled beta agonists and corticosteroids in the perioperative period
- Stress dose steroids

**HISTORY**

- AMPLE Hx if status asthmaticus
- Symptoms
  - Wheeze
  - Dyspnea
  - Cough (dry vs productive)
  - Chest tightness
- Triggers
  - Nocturnal, allergens, irritants, exercise, cold air, emotional stress, infections
  - Pharmacologic agents – ASA, B-antagonists, NSAIDs, sulfites
- Severity
  - Frequency of exacerbations, ER visits, hospitalization, need for intubation/mechanical ventilation
- Effectiveness of current therapy
  - Prescribed regimen and compliance
  - Need for rescue bronchodilators
- Associated conditions
  - Recent URTI
  - Rhinitis, urticaria, eczema, nasal polyps
- Functional capacity

**PHYSICAL**

- ABCs and vital signs
  - Severe exacerbation: RR >30, HR >120, pulsus >15mmHg, SpO2 <90, diaphoresis, temperature, inability to lie supine
  - Imminent arrest: decreased LOC (hypercapnia), cyanosis (hypoxemia), bradycardia, loss of pulsus paradoxus, diminished respiratory effort (fatigue), silent chest, abdominal paradox
- CNS
  - Anxiety, altered LOC
- AW
  - Airway assessment for intubation, nasal polyps
- RESP
  - Work of breathing (tachypnea, inability to speak in full sentences, nasal flaring, tracheal tug, accessory muscle use, inspiratory indrawing, pulsus paradoxus)
    - Tachypnea and hyperventilation reflect neural reflexes in lungs (not hypoxemia)
  - Prolonged expiratory time, wheeze, crackles (pneumonia, pulmonary edema)
- CV
  - Tachycardia, volume status, pulmonary HTN (↑JVP, RV heave, loud P2)
  - Hypotension (hypovolemia, steroid-induced adrenal insufficiency)
- MSK
  - Proximal muscle weakness (steroid myopathy)

**INVESTIGATIONS**

- Purpose of preop testing is to predict respiratory complications and evaluate risk
- Labs
  - CBC/D – eosinophilia with asthma, neutrophilia with infection

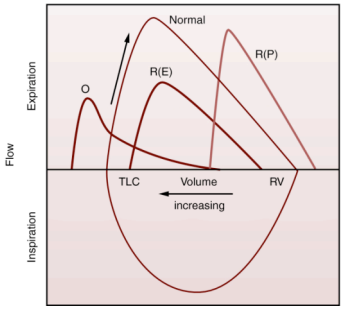
- Lytes – hypokalemia, hypomagnesemia with high-dose B-agonists
- Glucose – steroid-induced hyperglycemia
- ABG
  - Mild asthma: hypocapnia (hyperventilation)
  - Decompensation: normocapnia
  - Severe asthma: hypercapnia (respiratory muscle fatigue, high V/Q), hypoxemia with wide A-a gradient (low V/Q)

- PEFR and PFTs
  - Note: since asthma is an episodic illness its diagnosis may be suspected even when PFTs are normal; may consider methacholine challenge
  - FEV1/FVC < 0.70

| Severity | FEV1 (% predicted) | $FEF_{25-75\%}$ (% predicted) | PEFR (L/min) | PaO2 (mmHg) | PaCO2 (mmHg) |
|---|---|---|---|---|---|
| Normal | | | | | |
| Mild (asymptomatic) | 65-80 | 60-75 | | > 60 | < 40 |
| Moderate | 50-64 | 45-59 | | > 60 | < 45 |
| Marked | 35-49 | 30-44 | < 200 | < 60 | > 50 |
| Severe (status asthmaticus) | < 35 | < 30 | | < 60 | > 50 |

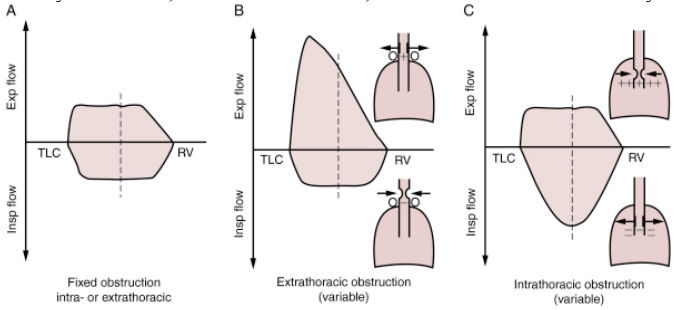
Anesthesia Coexisting Disease Table 9-2

- Flow-volume loops
  - Assess severity of obstructive disease




Anesthesia Coexisting Disease Fig 9-2

  - Differentiate fixed airway obstruction, variable extrathoracic, and variable intrathoracic airway obstruction




Anesthesia Coexisting Disease Fig 9-3

- EKG
  - Sinus tachycardia
  - Arrhythmias, myocardial ischemia in elderly (high-dose B-agonists)
  - Acute RV strain and PVCs with severe asthma exacerbation
- CXR
  - Hyperinflation
  - R/O PTX, pneumonia, CHF

**OPTIMIZATION**

- **Proceed vs cancel surgery**
  - Patients should be symptom-free, with no active respiratory infection and PEFR >80% predicted (or personal best) prior to elective surgery
    - Emergency surgery: conflict between airway protection with aspiration risk and risk of triggering bronchospasm, insufficient time to optimize bronchodilator therapy prior to surgery
- **Consults**
  - Pulmonary medicine if require optimization prior to surgery
- **Pharmacotherapy of asthma**
  - Continue/optimize controller medications
    - Corticosteroids
      - Inhaled
      - Systemic
    - Leukotriene antagonists
    - Theophylline
  - Continue/optimize reliever medications
    - B-adrenergic agonists
    - Anticholinergic drugs – caution; may ↑viscosity of airway secretions

- Antibiotics if evidence of baterial pneumonia

- **Stress dose steroids**
  - Inhaled corticosteroid Rx – HPA suppression unlikely, stress-dose steroids not routinely indicated
  - Systemic corticosteroid Rx – stress-dose steroids if systemic corticosteroid Rx within 6mo
- **Status asthmaticus**
  - ABCs
  - Administer 100% O2 to keep SaO2 >90%
  - Inhaled B2-agonists
    - Salbutamol 2.5mg neb q10-20min (max 15mg/hr)
  - Inhaled anticholinergics
    - Disadvantages: ↑viscosity of secretions
    - Dosing:
      - Ipratropium 0.5 mg neb q20min
  - Corticosteroids
    - Advantages: anti-inflammatory effects target mechanism of disease
    - Disadvantages: delayed onset, hyperglycemia, HTN, myopathy, AVN
    - Dosing:
      - Prednisone 1mg/kg po daily
      - Hydrocortisone 200mg iv q6h
      - Methylprednisolone 60-125mg iv q6h
  - MgSO4
    - Advantages: bronchodilation (inhibits Ca influx into airway smooth muscle)
    - Disadvantages: hypotension, ↑risk toxicity (↓LOC, weakness, heart block) in renal insufficiency
    - Dosing: 2-3g over 20min
  - Theophylline
    - Disadvantages: ?effectiveness, tachycardia, arrhythmias, vomiting, seizures
    - Dose: 5mg/kg iv loading dose; subsequent doses to maintain target peak serum level 10-15 mg/L
  - IV B2-agonists
    - Advantages:
    - Disadvantages: ++ tachycardia, arrhythmias
    - Dosing:
      - Salbutamol:
      - Epinephrine (1:1000): 0.01 mg/kg divided in 3 doses, administer q20min x 3
      - Isoproterenol: 0.01 mcg/kg/min
  - Noninvasive ventilation (CPAP/BiPAP)
    - Controversial
      - Counteracts auto-PEEP → ↓WOB
    - Initial settings: inspiratory pressure 8-10, expiratory pressure 3-5 cm H2O
  - Ketamine
    - Advantage: direct bronchodilator and indirect bronchodilation (potentiates catecholamines)
    - Disadvantages: bronchial secretions, tachycardia
    - Dosing: 0.1-0.2 mg/kg bolus (0.5-1.5 mg/kg for intubation); 0.5 mg/kg/hr infusion
  - Heliox
    - Advantages: ↓density → ↑flow in regions of turbulent airflow (narrowed airways), ↓WOB
    - Disadvantages: limits FiO2
    - Dosing: 70:30 He:O2
  - Invasive mechanical ventilation
    - See "Management of Anesthesia" below
    - May require paralysis (+ sedation) to tolerate
  - Refractory status asthmaticus
    - Inhalational anesthetics – direct bronchodilation; isoflurane 0.5-1 MAC
    - NovaLung – CO2 removal
    - ECMO – oxygenation + CO2 removal
  - General
    - Fluids to target normovolemia
    - Treat precipitant
      - Discontinue culprit medications
      - Antibiotics for pneumonia (fevers, productive cough, ↑WBC, infiltrate on CXR)
    - No evidence for vigorous hydration, inhaled saline mist, mycolytics, chest physiotherapy
  - Weaning medications and supportive therapy
    - Wean mechanical ventilation and frequency of bronchodilator therapy once FEV1 or PEFR reach 50% of predicted

**ANESTHETIC OPTIONS**

- **Local**
- **Regional**
  - Ideal to allow avoidance of airway manipulation
- **General**

**ANESTHETIC SETUP**

- **Drugs**
  - See above under 'status asthmaticus'
  - Avoid histamine-releasing agents (morphine, atracurium)
- **Equipment**
  - Standard CAS monitors, 5 lead EKG
  - Consider artline for frequent ABGs, CVL/PAC if RV dysfunction
  - Ability to delivery in-line nebulized bronchodilators
  - Spirometry

**MANAGEMENT OF ANESTHESIA**

- **Induction**
  - RSI vs inhalational induction vs awake intubation
    - RSI – risk of paralysis with inadequate depth
    - Inhalational induction – require high MAC before intubation; risk of hemodynamic instability
    - Awake intubation – risk of inadequate topicalization
  - Suppress airway reflexes to avoid bronchospasm in response to mechanical stimulation during intubation
    - Ensure adequate depth of anesthesia prior to airway manipulation
  - Induction agents
    - Lidocaine 1-1.5mg/kg iv to suppress airway reflexes
    - Opioids
      - Suppress airway reflexes
      - Bolus may elicit brief cough (avoided with slower injection, pretreatment with lidocaine)
    - Propofol and ketamine preferred due to brochodilating properties
      - Thiopental does not affect bronchial smooth muscle, but may inadequately suppress airway reflexes → airway instrumentation may trigger bronchospasm
      - Etomidate may produce coughing, which could precipitate bronchospasm
    - Following loss of consciousness, ventilate with volatile anesthetic to further promote bronchodilation and suppress airway reflexes prior to intubation
      - Sevoflurane and halothane less pungent, do not trigger coughing which could precipitate bronchospasm
  - Minimize airway manipulation
    - LMA may produce less airway stimulation than ETT
    - Rapid intubation
  - Avoid excessive bag-mask ventilation; risk of dynamic hyperinflation and circulatory collapse
- **Maintenance**
  - Drugs
    - Avoid agents which release histamine (atracurium, morphine)
  - Ventilation
    - $FiO_2$ to maintain $SpO_2$ >92%
    - May require high peak airway pressures to deliver adequate Vt in severe bronchoconstriction
      - Keep Pplat < 30 $cmH_2O$
      - Permissive hypercapnia ($PaCO_2$ 70-90, pH >7.20) to prevent barotrauma
        - Contraindicated if ↑ICP; caution if arrhythmias, RV failure, hypotension
      - Hypocapnia promotes bronchoconstriction
    - Require prolonged expiratory phase to allow complete exhalation and prevent auto-PEEP with air-trapping
      - Slow respiratory rate (8-10/min) to allow longer expiratory time
      - Low I:E ratio (≥1:3)
      - Reduced tidal volumes (< 8mL/kg) generates smaller volume to exhale
      - High inspiratory flow (80-100L/min) allows shorter inspiratory time → longer expiratory time available
      - PEEP (set at < 80% of intrinsic PEEP) ↓s work required to trigger inspiration in *spontaneous* modes; risk of hyperinflation, avoid in controlled modes
    - Humidification and warming of inspired gases prevents drying of secretions/mucus plugging
  - Fluids
    - Maintain adequate hydration to avoid drying of secretions

- **Emergence**
  - Consider need for prolonged intubation with gradual weaning in ICU
  - Reversal of neuromuscular blockade
    - Anticholinesterase drugs could precipitate bronchospasm; does not commonly occur when co-administered with anticholinergic, which promotes bronchodilation
  - Extubation options
    - Deep
      - Avoids ETT stimulating bronchospasm, however high MAC can result in hemodynamic instability, and unprotected airway risks aspiration and secretions which can also stimulate airway reflexes
      - Suction airway and remove ETT while depth of anesthesia sufficient to suppress hyperactive airway reflexes
    - Awake
      - ↓Aspiration risk, however ETT may stimulate airway reflexes → bronchospasm

- Administer lidocaine, inhaled bronchodilators, or remifentanil prior to emergence
- Extubate once fully awake and able to protect airway

**DISPOSITION & MONITORING**

- ICU for severe exacerbations
- Monitor SpO2 if extubated

**COMPLICATIONS**

- Status asthmaticus
  - Hypoxemia, hypercarbia
- Arrhythmias
- Cardiovascular collapse
  - Dynamic hyperinflation → respiratory failure, RV failure
    - Hold ventilation x 1minute to allow autoPEEP to dissipate
  - Tension pneumothorax, pneumomediastinum
    - Needle decompression / chest tube
  - Myocardial ischemia (2° to Tx-induced tachycardia)
- Tracheoesophageal fistula

**OBSTETRICS**

- Asthma may improve, worsen, or remain the same

| Factors which may Improve asthma | Factors which may worsen asthma |
|---|---|
| - Progesterone-induced relaxation of airway smooth muscle<br>- Production bronchodilating prostaglandins<br>- Circulating cortisol | - Sensitivity to B-agonists<br>- Bronchoconstricting prostaglandins<br>- Sensitivity to cortisol (binding of progesterone to cortisol receptors) |

Chestnut Box 52-2

- Effects of asthma on perinatal outcome
  - Incidence preeclampsia, c-section, low birth weight infants, PTL, antepartum and postopartum hemorrhage, perinatal mortality
  - DM more common with corticosteroids in pregnant asthma patients
  - Mechanisms: hypoxemia, hypocapnia, inflammation, altered placental function from asthma-associated mediator release
- B2-agonists, theophylline, cromolyn corticosteroids, and Mg safe in pregnancy; minimal data for anticholinergics and leukotriene antagonists (appear safe)
  - Theophylline clearance s in 3rd trimester, monitor carefully
  - No need for stress-dosing in labor, low potential for adrenal insufficiency in fetus
- Obstetric management
  - B2-agonists inhibit uterine contractions
  - Preeclampsia – avoid B-blockers
- Induction of labor – avoid PGF2; PGE2 unpredictable (b/d or b/c; safest to avoid)
  - PPH – avoid PGF2α and ergot alkaloids; oxytocin preferred
- Anesthesia management for labor
  - Effective analgesia ↓s maternal stress (bronchospasm) and stimulus for hyperpnea
  - Avoid high thoracic motor block → respiratory insufficiency
- Anesthesia management for c-section
  - Neuraxial techniques
    - Advantage: avoid airway instrumentation
    - Disadvantage: unstable asthmatics require use of accessory respiratory muscles; high thoracic motor block will impair ventilatory capacity → avoid neuraxial techniques
  - GA
    - Conflict between avoiding aspiration (requires ETT) and preventing bronchospasm (which ETT stimulates)
    - Propofol, ketamine, and volatile anesthetics inhibit airway reflexes and relax airway smooth muscle
    - High concentrations of volatile agents ↑risk of PPH
    - B2-agonists relax bronchial smooth muscle but also uterine smooth muscle → ↑risk PPH?

**PATHOPHYSIOLOGY**

- Epidemiology
  - Onset prior to 10y.o. in 50% of cases
  - M:F = 2:1 in childhood (vs 1:1 in adults)
- Pathogenesis
  - Genetic factors
    - Immunologic imbalance
    - Neural imbalance
      - Imbalance b/w excitatory (b/c) and inhibitory (b/d) neural input
      - Chemical mediators released from mast cells stimulate airway receptors (b/c) while other mediators sensitize airway smooth muscle to effects of ACh
      - Muscarinic receptors facilitate mast cell degranulation → positive feedback loop
  - Environmental factors
    - Viruses, allergens, occupational exposures
- Pathophysiology
  - Triad of bronchospasm, mucosal edema, mucus hypersecretion/plugging → airway obstruction

- Airway obstruction → low V/Q mismatch → hypoxemia → hyperventilation
  → high V/Q mismatch → ↑dead space →hyperventilation
  - Hyperventilation → hypocarbia, respiratory alkalosis
    → eventual fatigue → hypoventilation → hypercarbia, respiratory acidosis
- Status asthmaticus
  - Airflow obstruction due to airway edema and intraluminal secretions/mucus plugging, in addition to bronchospasm
- Dynamic hyperinflation
  - Definition – when a new breath begins before the lung has reached the static equilibrium volume during exhalation (auto PEEP – end expiratory flow)
  - Mechanism – airflow obstruction during expiration slows lung emptying → inspiration initiated before exhalation complete → progressive hyperinflation (air trapping, auto-PEEP)
  - Benefits – Hyperinflation acts as a compensatory mechanism; ↑lung volume ↑s airway caliber → ↓resistive work of breathing
  - Disadvantages – high lung volumes have negative consequences:
  - In severe asthma hyperinflation is maladaptive:
    - ↑WOB due to ↓lung compliance, ↑dead space
    - Patient difficulty in triggering ventilator
    - Barotrauma
    - Hypotension (↓preload, ↑afterload)

- Differential diagnosis of intraoperative wheezing
  - ETT obstruction
    - Kinking, secretions, overinflated cuff
  - ETT endobronchial
  - Inadequate depth of anesthesia
    - Active expiratory efforts, reduced FRC
  - Parasympathetic stimulation
  - Drugs administered during anesthesia
  - Anaphylaxis
  - Aspiration
  - Asthma
  - Pulmonary edema
  - Pneumonia
  - PE

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