Asthma

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Asthma in the US

- 7% of the population (18 million)
- Most common cause of hospitalization among children
- Higher prevalence in some areas
- Prevalence doubled 1980-1998, now stable
- 3,700 deaths in 2004, down from peak of 5,700 in 1996

Comparison of asthma hospitalization rates in children aged 0-14 in the US, NYS and NYC, 1999

Risk factors

- Family history (genetics)
- Sensitization to common allergens
- Maternal smoking
- Obesity
- Western lifestyle
- Diet?
- Pollution-assoc with exac vs new incidence?
Children who had ≥2 older siblings or attended day care during first 6 mo of life had increased risk of wheeze early in life but decreased risk later. 

**Asthma definition**

- Chronic inflammatory disorder of the airways
- Usually associated with atopy (extrinsic, intrinsic)
- Obstruction to airflow which is reversible (either spontaneously or with use of medications)
- Airway hyperresponsiveness and narrowing in response to a variety of stimuli

**Airway changes – Inflammation and bronchoconstriction**

**Effect of endotoxin exposure on wheeze**

- Effect of endotoxin exposure on wheeze

**Protective effect of day care in infancy and older siblings**

Children who had ≥2 older siblings or attended day care during first 6 mo of life had increased risk of wheeze early in life but decreased risk later.
Immunological mechanisms:
Allergic sensitization

IgE-dependent release of inflammatory mediators
- Immediate: Granule contents
  - Histamine
  - TNF-α
  - Proteases
  - Heparin
- Over minutes: Lipid mediators
  - Prostaglandins
  - Leukotrienes
- Over hours: Cytokine production
  - IL-4
  - IL-13

Diagnostic criteria for asthma
- CLINICAL DIAGNOSIS
- Cough, dyspnea, wheeze, chest tightness
- Waxing and waning symptoms
- Heightened airway reactivity—episodic airflow limitation in response to triggers.
- Airway hyperresponsiveness as measured by bronchoprovocation.

Methods for measuring airway caliber

FVC = TLC - RV
Physiologic features of asthma

- Reversible airflow limitation (obstructive defect)
  - >12% or 200ml change in FEV₁ in response to inhaled bronchodilator.

- Airway hyperresponsiveness
  - decrease in FEV₁ of 20% in response to bronchoprovocation testing (histamine, methacholine, cold air) in sensitive individuals. (Clinical trials, professional athletes)

Contributing factors to asthma exacerbation

- Poorly controlled airway inflammation
- Cold air
- Exercise
- Upper respiratory tract infection
- Sinusitis, rhinitis
- GERD
- First or second hand tobacco smoke
- Environmental allergens – indoor and outdoor
- Air pollution

Asthma environmental triggers
VRIs and asthma hospitalizations
Hospital admissions correlate with virus isolation peaks and school terms.

Asthma exacerbation
- Asthma trigger leads to bronchoconstriction and increase in airway inflammation—narrowing of airway lumen
- Increased resistance to airflow
- Reduction in FEV$_1$, peak flow
- Will reverse either spontaneously (eventually) or with use of medication (bronchodilators and anti-inflammatories)

Gas exchange abnormalities in acute asthma exacerbation
- Low V/Q leads to hypoxemia
- Increased ventilatory drive leads to reduction in pCO$_2$
- As severity of airflow obstruction increases, respiratory muscle fatigue develops and pCO$_2$ “pseudo-normalizes” then becomes elevated.

Physical Exam
- PE of chest may be normal
- Wheezing or prolonged expiration
  - May not correlate with clinical severity
- Hyperinflation of lungs
- Use of accessory muscles

Pathologic targets in asthma
- Bronchial smooth muscle
- Airway inflammatory cells
- Inflammatory cytokines
- Bronchial epithelium
- Bronchial blood vessels (anti-VLA-4)
Reliever vs. controller medications

Reliever medications
• Short acting bronchodilators

Controller medications
• Inhaled and oral corticosteroids
• Leukotriene modifiers
• Theophylline
• Cromolyn
• Long acting bronchodilators

β₂-agonists (Albuterol)
• Bind to β₂ receptors on airway smooth muscle cells
  – cause relaxation of muscle and bronchial dilatation
• Most effective bronchodilators
  – short term relief of bronchoconstriction
• Rapid onset of activity
• Duration of action 3-6 hours.
• “rescue” therapy for symptom relief
• no advantage to regularly scheduled use
• no effect on chronic inflammation

Side effects of β₂ agonists
• Due to non-airway β₂ activity: skeletal muscle tremor
• Due to overlap β₁ activity: tachycardia, arrhythmia, hypokalemia
• Excessive use related to higher mortality and morbidity
  – marker for more severe disease?
• Possible tachyphylaxis
  – mild downregulation of cell surface receptor number and desensitization of the receptor to drug
  – not clinically significant.

Glucocorticoids (Steroids)
• Most effective anti-inflammatory agent for treatment of persistent asthma
• Reduce influx of inflammatory cells into the airways (eosinophils, lymphs)
• Reduce production of pro-inflammatory cytokines by airway epithelial cells
• Reduce airway edema and mucus production
• May reduce airway remodeling

Effect of polymorphisms at the amino acid residue 16 locus of the β₂ adrenergic receptor

Inhaled glucocorticoids
• First line therapy for all but very mild asthma
• Early initiation of therapy may preserve lung function over long term
Side effects of inhaled steroids

- Thrush and dysphonia are local effects
- Potential systemic effects: growth retardation, adrenal suppression, osteoporosis, cataracts, acne, skin fragility with high doses.

Bone density vs daily puffs of ICS

Leukotrienes

- Chemoattractant for eosinophils
- Smooth muscle contraction
- Vascular permeability
- Enhanced mucus production
- Can block by leukotriene synthesis inhibitors or receptor antagonists (oral agents)
Long acting beta agonists

- Inhaled salmeterol (component of Advair®), formoterol
- Duration of action 12 hours, bid drug
- Delayed onset of action (30 minutes)
- Efficacious in moderate to severe asthma
- Allow reduction of inhaled steroid dose
- Not monotherapy; ie use only as add on therapy to anti-inflammatory agents – avoid masking of inflammation
- Available as combination therapy in a single inhaler
- New black box warning: Increased mortality and serious events in some patients taking long acting beta agonists, particularly African Americans

Biologics in treatment of asthma

- Targeted toward specific mediators
- Monoclonal Ab-IgE is first compound commercially available.
- Expensive

Monoclonal Ab – IgE (omalizumab, xolair®)

- Approved for treatment of moderate and severe asthma only in atopic (IgE mediated) asthma
- Effective in reducing asthma exacerbation rate and reducing required corticosteroid dose
- Subcutaneous injections 1-2x/month
Asthma treatment

- NIH Guidelines, updated in 2007
- Assessment of asthma severity in initiating therapy
- Assessment of asthma impairment and asthma risk in adjusting therapy.

Assessment of asthma severity during office visits

- Nocturnal awakenings from asthma symptoms
- Days per week with symptoms
- Need for rescue bronchodilators
- Activity limitation because of asthma
- Frequency of exacerbations and side effects from medications (assess risk which is a component of severity)

Assessment of asthma risk

- Frequency of exacerbations
- Side effects from medications
- Decline in lung function

NAEPP (2007) Guidelines for Asthma Severity classification

- **Mild intermittent**: symptoms < 2x/week, nocturnal symptoms < 2x/month, normal FEV₁
- **Mild persistent**: symptoms 3-6x/week, 3-4 awakenings/month, normal FEV₁
- **Moderate persistent**: daily symptoms, >5 nocturnal awakenings/month, FEV₁ 60-80%
- **Severe persistent**: continual symptoms, FEV₁ < 60%

NIH Guidelines

- Patients with asthma symptoms more than twice per week should be on daily anti-inflammatory therapy.

- Inhaled steroids (rather than leukotriene modifiers) are the preferred first line therapy.

Long term control

- Immediate acting bronchodilators for acute symptom relief
- Step up anti-inflammatory therapy based on need for bronchodilators and frequency of symptoms
- Add second agent in suboptimally controlled asthma (LABA or leukotriene modifiers)
- Leukotriene modifiers and long acting β-agonist as steroid sparing agents.
- Frequent follow up to reassess symptoms and need to tailor therapy.
Treatment of acute asthma exacerbation

- High dose β₂ agonist (inhaled, SQ, IV)
- Nebulized anticholinergics
- Epinephrine
- Corticosteroids
- Oxygen
- Mechanical ventilation

Asthma that is difficult to control

- Observe inhaler technique
- Other diagnoses
- Adherence to regimen
- Reflux or sinusitis present
- Sensitivity to medication (NSAIDS, food additives)
- Abuse of OTC inhalers
- Environmental stimulus – mold, smoking

Future Goals

- Pharmacogenetics
- Use of biomarkers to assist with management (exhaled NO, PC20, sputum eosinophils)
- Identification of genes responsible for disease
- Better side effect profiles of drugs
- Biologics (monoclonal blocking antibodies)
- Th2/Th1 balance - vaccines
- Reduce racial disparities in asthma morbidity and mortality