**Definition**

Asthma is a chronic inflammatory disease of the airways associated with:

1. **airway hyper-responsiveness**
2. **airflow limitation** (at least partially reversible)
3. **respiratory symptoms** (cough, wheeze, etc.)
Pathophysiology

Two Main Issues:
1. Airway Inflammation
2. Smooth muscle constriction

Pathophysiology – best understood in allergic asthma

Antibodies
• Primarily IgE responding to an allergen

Inflammatory Cells
• Eosinophils
• Mast Cells
• Lymphocytes
• All release inflammatory mediators

Inflammatory Mediators
• Histamine
• Mast cell tryptase
• Prostaglandins
• Leukotrienes
• Cytokines
• Contribute to airway inflammation and bronchoconstriction

Pathophysiology

Airway inflammation contributes to:
- acute bronchoconstriction
- airway edema
- mucus plug formation
- lung hyperinflation
Changes in Airway Morphology

- Epithelial damage
- Inflammatory cell infiltration
- Vascular dilation
- Mucous gland hypertrophy and hyperplasia
- Airway smooth muscle hypertrophy, hyperplasia, and bronchoconstriction
- Inflammatory cell infiltration
- Thickening of basement membranes
- Airway lumen narrowing
- Goblet cell hyperplasia


Asthma Triggers

- Viral illnesses
- Stress
- Allergies
- Reflux
- Animals
- Cigarette smoke

- Air pollution
- Weather changes
- Exercise
- Cold Air
- Allergens
- Strong emotions

“Boy, son? Daddy’s company makes inhalers to help people with asthma.”
Risk Factors

- Allergen exposure – mold, cockroaches, dustmites, animals*
- Cigarette smoking – active or passive
- Irritant exposure – air pollution
- Gender - higher prevalence in males early in childhood, higher in females after age 13
- Atopy – personal or family history
- Family History of Asthma
- Obesity
- Prematurity

Incidence and Prevalence

Most common chronic disease of childhood
- 6.8 million (9.3%) of children with asthma in 2012
- 4.4 million missed school days / year
- 131 asthma deaths in 2006 in kids < 15 years
- Costs are approx. $20.7 billion / year (hospital, clinic visits, meds, missed work)
- Only 20% of kids with asthma are followed by a specialist

Incidence and Prevalence

- 16% of African American children
- 10.7% of American Indian and Alaskan Native children
- 7.9% of Hispanic children (16.5 among Puerto Rican children)
- 8.2% Caucasian children
- 6.8 of Asian children
Incidence and Prevalence

Racial Disparities

• African American children are twice as likely to have undiagnosed asthma compared to their white counterparts.
• Minority children with asthma are less likely to receive regular care and recommended treatment, and more likely to be hospitalized for their condition.
• Non-Hispanic black children are twice as likely to be hospitalized and four times more likely to die because of asthma than non-Hispanic white children.

Making the Diagnosis

History – most important

Spirometry – objective data, gold standard
Chest x-rays – nonspecific changes
Impulse oscillometry – measures airway resistance
Exhaled nitric oxide (NO) – inflammatory marker, not specific for asthma. Not widely used.
Exam

Making the Diagnosis

History

Typical symptoms – cough, wheeze, shortness of breath, chest pain, chest tightness
Nocturnal cough?
Symptoms with exercise?
Seasonality?
Long lasting URIs?
Typical Triggers – cold air, weather change, etc.
Making the Diagnosis

History
Previous Treatments – what's worked, what hasn't
Biggest clues come from quick(er) acting meds like:
- Bronchodilators – albuterol (Ventolin, Proventil, Proair), Xopenex
- Oral steroids – prednisone, Orapred

Making the Diagnosis

History - Other clues:
- History of "recurrent bronchitis" or even "recurrent pneumonia"
- History of allergies (or family history of asthma and/or allergies)
- Family report of inactivity in a child with some history of respiratory symptoms – likely not active because they can’t breathe

Making the Diagnosis

Spirometry
Objective measurement of lung function
Can be done in children 5 or 6 years and greater
Should be ordered pre and post bronchodilator if considering asthma
Making the Diagnosis

Spirometry – gives us a flow volume curve

Flow
(rate of air movement)

Volume
(amount of air)

Exhalation

Inhalation

Making the Diagnosis

Spirometry

Asthma is an obstructive airway disease – causes more difficulty exhaling than inhaling, resulting in air trapping. Therefore – when interpreting spirometry, we're more interested in the exhalation half of the curve.
Making the Diagnosis

Spirometry
FVC – forced vital capacity – total amount of air that can be exhaled forcefully
FEV1 – force expiratory volume in 1 second – total amount of air exhaled in 1 second
FEV1/FVC – ratio of FEV1/FVC – helps you decide if it’s obstructive disease
FEF 25-75 – forced expiratory flow during the mid portion of the exhalation
PEF – peak expiratory flow rate – max flow rate during exhalation

Making the Diagnosis

Spirometry:
To be interpreted - needs to be acceptable and reproducible
Acceptable: six second exhalation
3 attempts minimum
no cough / or obstruction
Reproducible: attempts need to be similar
Predicted values are based on height, gender, and race

Making the Diagnosis

Spirometry – normal values
FVC - >80% predicted
FEV1 - >80% predicted
FEV1/FVC ratio - >80% predicted (<12 yrs)
>70% predicted (>12 yrs)
FEF25-75 - > 70% predicted
PEF > 80% predicted
Making the Diagnosis

Spirometry
To diagnosis asthma – measure values before and after albuterol
Ideally should be off albuterol x 4-6 hours and LABAs 12 hours prior to test
Looking for 12-15% improvement in FEV1 and 25-30% improvement in FEF25-75
Making the Diagnosis

Chest x-rays – May show hyperinflation, peribronchial cuffing, possible atelectasis due to mucus plugging – non specific for asthma

Exam:

Acute asthma: tachypnea, increased WOB, anxiety / mental status changes, can’t find a comfortable position, speaking in short sentences, wheezing on exam, not wheezing on exam (silent chest – much more concerning), decreased O2 sats

Chronic asthma: likely normal exam, possibly prolonged exhalation, barrel chest (uncommon finding in children), possible signs of atopy (boggy turbinates, eczema)

Differential Diagnoses

Gastroesophageal reflux
Aspiration - 7 bottle in bed
Sinusitis / allergies with post nasal drip
Tracheo / bronchomalacia
Tracheal compression – vascular rings / slings
Foreign body aspiration
Cystic fibrosis
Heart failure
Viral bronchiolitis
Vocal cord dysfunction
Asthma Guidelines

New(ish) asthma guidelines – 2007

Broken up in age groups

Focus on severity, control, and assessment

Goals focused on

- reducing impairment (normal PFTs, symptom control, infrequent use of albuterol)
- reducing risk (minimizing ER visits, preventing loss of lung function)
- periodic assessment (every 1-6 months, determine if goals being met)

Recommendations for follow up care:

- Every 2-6 weeks for pts just starting therapy or who require step-up therapy
- Every 1-6 months once control is achieved
- Consider scheduling visits at 3 month intervals if step down therapy is anticipated

Classification of Asthma Severity

<table>
<thead>
<tr>
<th>Components of Severity</th>
<th>Classification of Asthma Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impairment</td>
<td>Moderate</td>
</tr>
<tr>
<td>Frequency of Exacerbations</td>
<td>Step 3</td>
</tr>
<tr>
<td>Lung function</td>
<td>Step 2</td>
</tr>
<tr>
<td>Symptom</td>
<td>Step 1</td>
</tr>
<tr>
<td>Impairment</td>
<td>Step 4 or 5</td>
</tr>
</tbody>
</table>

Recommended Step for Initiating Treatment (See figure 4-5 for treatment steps.)

In 2-6 weeks, evaluate level of asthma control that is achieved and adjust therapy accordingly.
Asthma Guidelines

Components of Control

- Symptom control (not prevention of EIB)
- Lung function
- Nighttime awakenings
- Interference with normal activity

Severity Category

- Very Poorly Controlled
- Not Well Controlled
- Well Controlled

Recommended Action for Treatment (see figure 4 for treatment steps)

- Step 1: Low-dose ICS, low-dose SABA, or nedocromil
- Step 2: Medium-dose ICS or low-dose ICS + LABA
- Step 3: High-dose ICS, LABA, or nedocromil
- Step 4: ICS + LABA + oral corticosteroids
- Step 5: ICS + LABA + oral corticosteroids + systemic theophylline
- Step 6: ICS + LABA + oral corticosteroids + systemic theophylline + subcutaneous allergen immunotherapy

Classification of Asthma Control

- Well Controlled
- Not Well Controlled
- Very Poorly Controlled

Thresholds for FEV₁

- ≥80% predicted/FVC >80%
- ≥60% predicted/FVC ≥60%
- ≤40% predicted/FVC ≤40%
Asthma Guidelines

Classification of Asthma Control (5-11 years of age):

**Step 1**
- Regular days/week or Reevaluate in 2 weeks.
- SABA as needed for symptoms. Intensity of treatment depends on severity of symptoms.
- Caution: Increasing use of SABA or use >2 days a week for symptoms. Consider step down if exacerbations requiring oral systemic corticosteroids.
- Exacerbations requiring oral systemic corticosteroids.
- Consult with asthma specialist if step 4 care or higher is needed.

**Step 2**
- Patient education, environmental control, and management of comorbid conditions.
- Low dose ICS + either LTRA or Theophylline.
- Frequency and severity may fluctuate over time.
- Theophylline for symptom relief (not prevention of EIB) generally indicates inadequate control and the need to step up treatment.

**Step 3**
- Preferred:
  - LABA
  - Medium dose ICS + either LTRA or Theophylline
  - Reduction in lung growth interference with activity considered in the overall assessment of risk.
- Medication side effects can vary in intensity from none to very troublesome and worrisome.

**Step 4**
- Recommended Step for Initiating Therapy
- Consult with asthma specialist if step 4 care or higher is needed.
- Exacerbations requiring oral systemic corticosteroids, or followup 6 months.

**Symptoms**
- Severe
- Moderate
- Mild

**Intermittent Asthma**
- Daily Medication
- Treatment options.

**Persistent Asthma: Daily Medication**
- Consult with asthma specialist if step 4 care or higher is needed.
- Step 1 and consider short course of oral systemic corticosteroids.
- Consider severity and interval since last exacerbation:
  - Very Poorly Controlled
  - Not Well Controlled
  - Well Controlled

**Classification of Asthma Severity**

<table>
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<th>Classification</th>
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<tbody>
<tr>
<td>Symptom Frequency</td>
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</tr>
<tr>
<td>Mild</td>
<td>Up to 2 episodes/month</td>
</tr>
<tr>
<td>Moderate</td>
<td>3-5 episodes/month</td>
</tr>
<tr>
<td>Severe</td>
<td>More than 5 episodes/month</td>
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**Classification of Asthma Control (0-4 years of age)**

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**Components of Control**

- Education
- Environmental control
- Medication adherence
- Early symptom recognition
- Inhaler technique

**Asthma Guidelines**

- 0-6 years of age
- 7-11 years of age
- 11 years of age and older
Asthma Guidelines

Quick-Relief Medication for All Patients
- SABA as needed for symptoms. Intensity of treatment depends on severity of symptoms.
- With viral respiratory infection: SABA q 4–6 hours up to 24 hours (longer with physician consult). Consider short course of oral systemic corticosteroids if exacerbation is severe or patient has history of previous severe exacerbations.
- Caution: Frequent use of SABA may indicate the need to step up treatment. See text for recommendations on initiating daily long-term control therapy.

Step 1
Preferred: SABA PRN

Step 2
Preferred: Low-dose ICS
Alternative: Cromolyn or Montelukast

Step 3
Preferred: Medium-dose ICS

Step 5
Preferred: High-dose ICS + either LABA or Montelukast

Step 6
Preferred: High-dose ICS + either LABA or Montelukast

Oral systemic corticosteroids: Step up if needed (first, check adherence, inhaler technique, and environmental control). Step down if possible (and asthma is well controlled at least 3 months).

Patient Education and Environmental Control at Each Step
- Step 4
Preferred: Medium-dose ICS + either LABA or Montelukast
Assess control

Recommended Action for Treatment (See figure 4–1a for treatment steps.)

>3/year 2–3/year 0–1/year
Exacerbations requiring oral systemic corticosteroids

Risk
- Several times per day >2 days/week ≤2 days/week
- Short-acting beta_2-agonist use for symptom control (not prevention of EIB)

Interference with normal activity
- Extremely limited
- Some limitation
- None

Medication side effects can vary in intensity from none to very troublesome and worrisome. The level of intensity does not correlate to specific levels of control but should be considered in the overall assessment of risk.

Classification of Asthma Control (0–4 years of age)

Impairment

Components of Control
- Treatment-related adverse effects

Nighttime awakenings
- Throughout the day >2 days/week ≤2 days/week

Symptoms
- Very Poorly Controlled
- Not Well Controlled
- Well Controlled

Medication side effects can vary in intensity from none to very troublesome and worrisome. The level of intensity does not correlate to specific levels of control but should be considered in the overall assessment of risk.

Recommended Action for Treatment (See figure 4–1a for treatment steps.)

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Classification of Asthma Control (0–4 years of age)

Impairment

Components of Control
- Treatment-related adverse effects

Nighttime awakenings
- Throughout the day >2 days/week ≤2 days/week

Symptoms
- Very Poorly Controlled
- Not Well Controlled
- Well Controlled
Asthma Management

Short acting beta agonists (SABAs)
- quick relief
- relieves acute bronchospasm
- fast onset 5-15 minutes
Examples: Albuterol (Proventil, Ventolin, ProAir), Levalbuterol (Xopenex), Pirbuterol (Maxair)

Asthma Management

Inhaled Corticosteroids
Gold standard in chronic asthma management
Inhibits late phase response
Treats inflammatory component of asthma
Low systemic bioavailability
Most common side effects – thrush, hoarseness – can be avoided by rinsing mouth
Examples: Flovent, Pulmicort, Asmanex, QVAR, Aerospan, Alvesco

Asthma Management

Long acting beta agonists (LABAs)
Intended for use in pts with moderate to severe asthma uncontrolled on a medium dose ICS
Caution is recommended in prescribed these products and use in children (as a single agent) is strongly discouraged
Examples: Serevent, Foradil
Asthma Management

Combination Products – ICS + LABA
Useful in moderate to severe asthma
Useful in those with exercise intolerance
Helpful in kids who need both products – convenient for pt, providers don’t need to worry that child is only taking the LABA
Examples – Advair, Symbicort, Dulera

Asthma Management

Leukotriene Modifiers:
Stops inflammatory cascade
ICS still first line treatment, though can consider monotherapy in those with mild symptoms
May be helpful in those with associated allergy symptoms
Examples – Singulair, Zyflo

Asthma Management

Methylxanthines
Long acting bronchodilators
Requires close monitoring of drug levels
Can cause toxicity with permanent CNS damage
Recheck levels if symptoms of toxicity, continued asthma symptoms, or with viral illnesses
Rarely used in pediatrics because of these issues
Examples: Theophylline
Asthma Management

Mast cell stabilizers:
- Anti-inflammatories
- Not as effective as ICS
- Often require TID – QID dosing
- Rarely used in because of the above
- Examples: Cromolyn, Nedocromil (Tilade)

Asthma Management

Acute asthma management – beyond albuterol
- Oral corticosteroids – potent anti-inflammatories
- Anticholinergics – (Atrovent) – another type of bronchodilator
- Magnesium Sulfate – smooth muscle relaxant
- Heliox – mixture of helium and oxygen used to drive albuterol treatment. Its lower gas density results in decreased flow resistance and increased lung penetration

Asthma Management

Medications are available in several delivery forms:
- Metered dose inhalers – should be used with a spacer in most populations
- Dry powder inhalers
- Nebulized medications
- Oral – tablet / liquid

Goal is to pick the best route of delivery for each patient
Asthma Management

Special Considerations
Nebulized medications – especially budesonide must be delivered with a face mask in young children – no blow by!
Flovent, QVAR, Symbicort, Dulera, Advair – must be BID dosing – when weaning, wean dose, not frequency
Pulmicort and Asmanex may be given once daily
Spacers are recommended in all age groups. Most kids need one with a mask until 5-6 years of age.

Asthma Management

Age considerations
Flovent - 44mcg – approved ages 4+ 110 & 220 – approved 11+
QVAR – approved for 5+
Pulmicort Respules – approved 12 months +
Singulair approved 6 months +
Symbicort & Dulera – 12+
Advair diskus – 4+
Advair HFA – 12+

Asthma Management

Education is key
Critical families know asthma triggers, symptoms, acute management, and difference between controller and rescue meds
Stress that controller medications need to be refilled every month
Show patient and family how to use the device chosen – check technique at every visit
Give written asthma action plans
Asthma Management

Peak flow meters
Home device where patients blow as hard as they can into device to get reading
Norms are based on height
Usually results divided into green zone (>80% predicted), yellow zone (60-80% predicted) or red zone (<60% predicted)

Asthma Management

Peak flow meters
Choose candidates wisely – adds “one more thing”
Helpful in those who are poor perceivers or for parents who are unsure “if this is asthma”
Can be done daily, or prn after establishing child’s “norm”
Asthma Management

Trouble shooting and adherence issues

Trouble shooting
Considerations if not getting better
- They aren’t taking their medication (check refill history)
- They aren’t taking their medication correctly (check technique)
- Not the right medication for that patient
- Not the right delivery method for that patient
- Co-morbid condition – GERD, allergies, sinusitis
- Environmental factors – smoke, allergens
- It’s not asthma – VCD, CF, airway anomaly
Asthma Management

Adherence - A HUGE ISSUE with asthma
A 2005 study showed that:
- An ICS is filled an average of 2.29 x / yr.
- Advair diskus filled an average of 3.98 x / yr.
- Singulair is filled an average of 4.33 x / yr.

Another study showed that:
- Parental report of adherence is 85%
- Actual adherence was 25% (using an electrically monitored device)

Assessing adherence:
- Ask how many doses they think they miss a week
- Ask where the controller inhaler is located
- Ask who is responsible for remembering the medication
- Ask parent if they personally observe each dose
- Ask parent if they check the dose counter
Asthma Management

**Improving adherence**

- Acknowledge that it’s a difficult thing
- Assess barriers – finances, transportation, etc. - consider options such as mail order pharmacies, auto-refills w/ text reminders
- Suggest the inhaler not be kept in the child’s bedroom or even bathroom
- Ask parents not just to remind the child, but to personally observe each dose – good time to bring up developmental considerations
- Remind patients that most inhalers do have counters, and if they don’t most inhalers have exactly enough for 30 days – then the medicine is gone, even if the inhaler doesn’t feel empty

Have parents or teens set a reminder on their phone

- Use sticker calendars to help remember doses
- Consider med choices carefully – do they really need every they’re on, can something be QD vs. BID, etc
- Get the school involved
- Encourage positive reinforcement
- Frequent follow up – monthly if needed

**School and Daycare issues**

- Educate caregivers on s/s of asthma and how to relieve symptoms
- Every child should have a rescue medication available at school and staff should be trained to administer it – check expiration dates
- Provide school with written asthma action plan and emergency phone numbers
- Encourage participation in physical activity – recess, PE, sports activities