Pediatric Asthma
Common Things Happen Commonly

- Bottom line, asthma is common among kids
  - the most common chronic disease of childhood
    - Affects over 7 million children in the United States

- one of the most common reasons for pediatric ED visits
  - >750,000 ED visits annually

- the most reason for hospitalization among children
  - >200,000 hospital admissions
Common Things Happen Commonly

- And it is a disease whose numbers aren’t getting better
  - Prevalence has more than doubled in last 25 years

- One of few pediatric diseases with worsening prevalence, morbidity and mortality

- Racial disparities
  - Affects black and Asian children more than white children
  - As compared to white children, black children are:
    - 60% more likely to have asthma
    - 260% more likely to have to go to the ED for their asthma
    - 250% more likely to be admitted for an asthma exacerbation
Common Things Happen Commonly

- FDNY EMS and pediatric asthma
  - 534,403 pediatric calls from 2006-2012
  - 31,347 pediatric calls for asthma exacerbations (5.8%, or 1 out of every 17 peds patients)
    - 40% transported by FDNY ALS units
    - 84% of those transported by ALS units received nebulized albuterol
    - ~40% of those who receive albuterol receive >2 nebulizer treatments
The Problem

- Common definition of moderate to severe asthma exacerbation is the need for >2 nebulized albuterol treatments

- You treat ~1,500 of these children every year

- At present, the only thing you have to offer them besides albuterol is more albuterol... or epinephrine

- National standard of care for asthma management is to provide these kids with steroids (we do this for adults!)

- But <1% of pediatric patient transported by FDNY paramedics have an IV established
A Solution?

Hold that thought...
Let’s Review

- Pediatric pulmonary anatomy and physiology
- Pathophysiology of asthma
- Evaluation of the asthma patient
- Pharmacology of asthma management
- And then talk about the possible solution to our problem
Pediatric Pulmonary System - Anatomy

- The pediatric airway – three primary areas that differ from adults
  - Anatomic structure
  - Size
  - Respiratory muscles
Commonly listed differences as compared to adults

- Head
- Tongue
- Tonsils
- Larynx
- Epiglottis
- Cricoid ring
- Ribs
Pediatric Pulmonary System

- **Head**
  - Larger in size than adults
  - More prominent occiput

- Airway narrowing from poor position
  (particularly if consciousness is depressed or with severe respiratory distress)

  can narrow or close airway
Pediatric Pulmonary System - Anatomy

- Tongue
  - Proportionally larger in children, especially infants
  - Protrudes into the posterior pharynx
  - Combined with improper head positioning can represent a significant airway obstruction
Pediatric Pulmonary System - Anatomy

- Tonsils
  - Larger and more vascular
  - Implications for OP airway placement (anatomic position vs inversion)
Pediatric Pulmonary System - Anatomy

- Larynx
  - Positioned more anteriorly
  - Sits more superiorly than in adults

  - Adults – At the C4-5 vertebral level
  - Children – At the C3-4 vertebral level
  - Infants – At the C2-3 vertebral level
Pediatric Pulmonary System - Anatomy

- Epiglottis (greater potential for obstructing / obscuring airway)
  - Larger
  - Less cartilaginous support (“floppy”)
  - Omega-shaped (Ω)
Cricoid ring

- Narrowest part of airway (unlike adults, where it is the vocal cords)
- Forms a physiologic “cuff”
- Means that subglottic stenosis / obstruction is more common
Pediatric Pulmonary System - Anatomy

- Ribs
  - As compare to adults, more horizontally oriented
  - Lack of downward angle lessens ability of accessory muscles to aid in work of breathing
  - Less developed musculature between ribs makes chest wall more pliable (think about implications for exam - retractions)
Pediatric Pulmonary System - Size

- Airway size
  - Bronchioles in infants and children are obviously smaller than in adults
  - This multiplies the effects of airway swelling on airway resistance
Pediatric Pulmonary System - Size

- On a similar note – children (especially infants) are obligate nasal breathers

- Oral opening’s larger size = less resistance / work of breathing, but they do not recognize this

- Implications for nasal congestion / allergies / other triggers of asthma are obvious

- May compound work of breathing / distress
Pediatric Pulmonary System – Muscles of Respiration

- Ribs are more horizontally positioned (unlike adult ribs shown in diagram)

- Accessory muscles (i.e. intercostals, neck muscles) which normally assist in times of increased airway resistance are of little additional support

- Result is diaphragmatic breathing only even with distress

- Made even worse by air swallowing / distension (crying)
Pediatric Asthma

- Like adults, triad of pathologic changes in the airways
  - Bronchoconstriction
  - Airway inflammation
  - Mucosal edema
Pediatric Asthma

- Common triggers
  - Cold air
  - Allergies
  - Aspirin and other NSAIDs
  - Menstruation
  - Exercise
  - Psychological stress
Pediatric Asthma

- Regardless of “trigger,” inflammatory or allergic component / hyperreactivity is part of problem

- Evidence in increased numbers of immune cells in airways
  - Lymphocytes
  - Eosinophils
  - Mast cells
Pediatric Asthma

- Asthma in a child can be more complex
- Higher baseline oxygen consumption (up to double that of an adult at baseline)
- Respiratory distress → increased work of breathing → up to 15% of oxygen consumption just for breathing
- In an already hypoxic child, this can worsen hypoxemia
- Result can be a rapid decline from mild distress to bradycardia to arrest
Pediatric Asthma

- “Not all that wheezes is asthma”
  - Pneumonia
  - Bronchitis
  - Bronchiolitis
  - Obstruction (mass, foreign body, vocal cord dysfunction
  - Cystic fibrosis
  - Pulmonary edema
  - GERD
  - Aspiration
Pediatric Asthma - Assessment

- History for the asthmatic child
  - Confirm history of asthma (as well as prior admissions, ICU admits, ETIs)

- Comparison of this exacerbation to others; when was last “attack”

- Duration of symptoms

- Symptoms of more severe attack (difficulty sleeping, talking)

- Possible “triggers”
Pediatric Asthma - Assessment

- History for the asthmatic child
  - Chronic medications
    - Prescribed medications
    - Recent changes
    - Compliance (and reason, if not – lost med, ran out, can’t afford, etc)
  - Acute medication use
    - Number of MDI / neb uses for this exacerbation
    - Recent or current steroid use
Pediatric Asthma - Assessment

- Physical Examination (pediatric assessment triangle)
- Vital signs (including pulse oximetry)
- Signs of potential respiratory failure
  - Lethargy or anxiety / restlessness
  - Bradycardia
  - Cyanosis
  - Head bobbing
  - Severe retractions or see-saw breathing
  - Audible wheezing (without stethoscope) or silent chest
Pediatric Asthma - Assessment

- Retractions result from markedly negative intrathoracic pressure during an attempt to inhale against severe bronchoconstriction
  - Supraclavicular
  - Intercostal
  - Subcostal / infracostal
  - Substernal
Pediatric Asthma - Assessment

- Pulse oximetry
  - Ideal is a room air oxygen saturation before treatment
    - NEVER WITHHOLD OXYGEN JUST TO DO THIS
  - Initial room air saturation should always be documented
  - Initial room air saturation <93% is one indication of moderate to severe disease and likely will require hospital admission
  - Decline in saturation after nebulized beta agonist is normal ("afterdrop")
Pediatric Asthma - Assessment

- Peak expiratory flow rate (“peak flow”)
  - Provides an objective measurement of air movement in a very subjective disease

- Beginning May 1, 2014, FDNY paramedics will be required to obtain a “peak flow” for all pediatric asthma patients

- “Peak flow” should be measured prior to initial EMS treatment
Pediatric Asthma - Assessment

- Measuring peak expiratory flow rate (“peak flow”)
  - Indicated for all children with asthma exacerbations, age 5 and older
  - Ensure that the child’s mouth is empty
  - Ideally, have the child standing up
  - Reset the meter to “0” (manually or by shaking)
  - Have the child take a deep breath in
  - Place the mouthpiece between their teeth and have them seal their lips around the mouthpiece
  - Ask the child to exhale as hard and fast as possible (“like blowing out the candles on a birthday cake”)
  - Repeat the process three times and record the highest measurement
  - Record a second peak flow reading upon arrival in the emergency department

- If the child is too ill to perform the test, simply document that fact in the ePCR.
Pediatric Asthma - Assessment

- Measured peak flow is then compared to predicted values (based upon patient height)

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Pediatric Asthma - Treatment

- Current options
  - Albuterol
  - Ipratropium
  - Epinephrine
Pediatric Asthma - Treatment

- **Albuterol**
  - Inhaled beta\(_2\) agonist
  - Produces bronchodilation via beta agonism
  - Does not treat airway inflammation or mucosal edema
  - **Dose:** 2.5mg / 3cc (0.083% solution)
  - **Adverse effects:** tremor, tachycardia
Pediatric Asthma - Treatment

- What about levalbuterol (Xopenex)??
  - “Albuterol” is a mix of R-albuterol and S-albuterol (two isomers of the albuterol molecule)
  - R-albuterol provides the clinical benefits
  - S-albuterol (long thought inert) may have pro-inflammatory and constricting properties
  - Levalbuterol is purely the R isomer, so in theory, only the desired albuterol effects
Pediatric Asthma - Treatment

- What about levalbuterol (Xopenex)??
  - Often said to cause less tachycardia / tremor and to be more effective than “regular” albuterol
  - Heart rate – Clinical study among critically ill patients found a difference of only 4 beats per minute less (vs. albuterol)
  - Tremor – caused by the R-albuterol, so no expected difference
  - More effective – no supporting data; no difference in pulmonary function, admission, discharge rates
What about levalbuterol (Xopenex)?

- Only “increase” with this drug is cost (10x more than albuterol)

- Standard of care remains “regular” albuterol

- Parents may say that “the pediatrician said that (the child) should only be given Xopenex,” but other than a known allergy, there is no contraindication
Pediatric Asthma - Treatment

- **Ipratropium**
  - Anticholinergic agent
  - Decreases reflex bronchoconstriction
  - Does not treat airway inflammation or mucosal edema
  - Shown to decrease hospitalization rates and improve pulmonary function testing when administered along with albuterol

- Dose (given each of the first three albuterol nebs): >6 years = 2.5ml of a 0.02% solution, <6 years = 1.25ml of a 0.02% solution

- Because <1% systemic absorption, there are essentially no adverse effects
Pediatric Asthma - Treatment

- **Epinephrine**
  - Parental medication with beta$_2$-agonist activity (~25% beta$_1$-, 25% beta$_2$- and 50% alpha-adrenergic)
  - Potential adverse effects (tremor, vomiting, tachycardia, hypertension) limit use to severely ill patients
  - Limited clinical data for efficacy (though our internal data demonstrates safety)
  - **Dose:** 0.01mg/kg (=0.01ml/kg) IM to a max of 0.3mg (0.3ml)
Back to our problem
Common definition of moderate to severe asthma exacerbation is the need for >2 nebulized albuterol treatments

You treat ~1,500 of these children every year

At present, the only thing you have to offer them besides albuterol is more albuterol... or epinephrine

National standard of care for asthma management is to provide these kids with steroids (we do this for adults!)

But <1% of pediatric patient transported by FDNY paramedics have an IV established
The Solution?

- Corticosteroids
  - Treat both airway inflammation and mucosal edema
  - Dose = 1mg/kg
  - Most initial studies done with intravenous administration, as we currently do for adults
The Solution?

- Corticosteroids
  - Oral vs. intravenous / intramuscular
    - Found to be equally effective at reducing hospital admission
    - Because it is less painful, oral administration is now recommended in NHLBI national guidelines
  - Prednisolone vs dexamethasone
    - No clinical difference
    - One version of prednisolone has better taste and, for that reason, tolerance among pediatric patients
The Solution?

- Oral corticosteroids
  - Included in the latest NHLBI guidelines
  - Included in the NAEMSP / EMS-C National Model Protocols
  - Already in use in one upstate region in New York
  - Shown to reduce hospitalization rate if given during ED triage as opposed to after ED physician evaluation
  - Although recommended for use in prehospital setting, use has not been proven to improve outcomes
Prehospital Oral Steroids for the Treatment of Status Asthmaticus in Children (POSTSAC) Study
Question to be answered: Does the prehospital administration of oral steroids to pediatric patients with moderate to severe asthma exacerbations improve outcomes?

Three-year study funded by federal government (US Health Services and Resources Administration, or HRSA)

One of six grants awarded nationally

Study to be conducted among patients treated by FDNY paramedics
Who will be included in the study?

- Pediatric patient treated for asthma / wheezing by FDNY paramedics
- Age 2-14
- History of asthma
- No other underlying lung disease (i.e. cystic fibrosis)
- Not already taking oral steroids (prednisone, prednisolone, dexamethasone)
- Moderate to severe asthma exacerbation (defined as needing >2 nebulized albuterol treatments)
Prehospital Oral Steroids for the Treatment of Status Asthmaticus in Children (POSTSAC) Study

- New protocol (written for this study)
- Only one change / addition (#5):

“If available, administer Prednisolone 1mg/kg (0.33ml/kg of a 3mg/ml solution), orally, for patients who meet the ALL of the following criteria:

a. More than one Albuterol Sulfate dose administered, via nebulizer, for on-going respiratory distress and/or wheezing.
b. Patient has a known history of asthma
c. Patient is not actively taking prednisolone, prednisone, or other oral steroid medication.
Prehospital Oral Steroids for the Treatment of Status Asthmaticus in Children (POSTSAC) Study

- What “if available” means for you...
- Randomized study
  - Beginning May 1, 2014, FDNY ALS ambulances will be randomized to carry oral prednisolone
  - Initial randomization will be by station
    - Half of FDNY stations will have med inserts that contain oral prednisolone plus medication cup for dosing
    - Other half will have current med inserts without prednisolone
  - Medication inserts with oral prednisolone will be labeled as such
  - Treat according to protocol, including the administration of prednisolone, if available
What the study means for you as an FDNY paramedic:

- Required documentation of peak flow for all pediatric asthmatic patients
- Required documentation of estimated patient height for all pediatric asthma patients
- Administration of oral prednisolone, if available, to pediatric asthma patients who meet criteria
- Need to communicate to ED staff whether steroids were administered
- Contact with OLMC at the conclusion of the assignment for a brief phone interview
- Opportunity to take part in a study that could define / validate a new standard for care for prehospital pediatric asthma care
Prehospital Oral Steroids for the Treatment of Status Asthmaticus in Children (POSTSAC) Study

- Study partnership:
  - Fire Department of New York
  - North Shore Long Island Jewish Medical Center Department of Emergency Medicine
  - Hofstra School of Medicine
  - Maimonides Medical Center
  - Cohen’s Children’s Medical Center

- Study Investigators
  - Dr. Robert Silverman (Co-Principal Investigator, Research Director, NSLIJ Emergency Medicine)
  - Dr. John Freese (Co-Principal Investigator, Director of Prehospital Research, FDNY)
  - Dr. Doug Isaacs (Site Investigator, Deputy Medical Director, FDNY Office of Medical Affairs)

- Study approvals:
  - Institutional Review Board
  - New York City Regional Emergency Medical Advisory Committee (REMAC)
  - New York State Emergency Medical Advisory Committee (SEMAC)
Prehospital Oral Steroids for the Treatment of Status Asthmaticus in Children (POSTSAC) Study

- Study protocol expected to be in effect from 5/1/14 – 3/31/16

- Will be one of the largest prehospital asthma studies ever conducted

- Results to be announced in the fall of 2016

- Potential for results to do more than simply alter the NYC protocols
Questions?