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Common Pediatric Respiratory Infections

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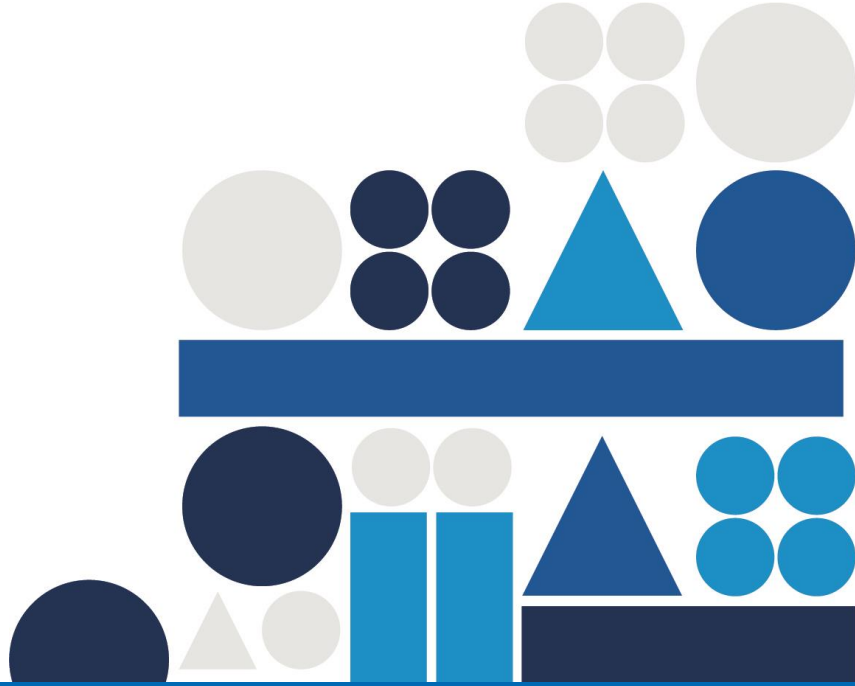

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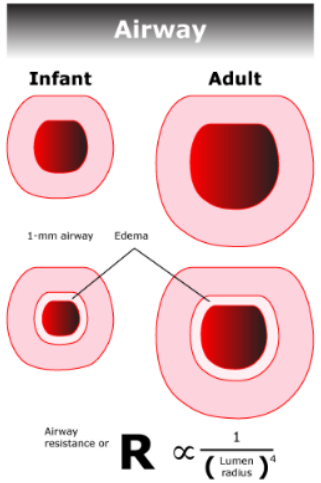
Objectives

1. Discuss unique features of the pediatric airway and impact to clinical presentation of respiratory infections
2. Identify clinical features of common pediatric respiratory infections
3. Describe management recommendations of common pediatric respiratory infections

Pediatric Airway Considerations[1]

- Infants obligate nasal breathers
- Increased chest wall compliance in infants
  - Increases risk of respiratory muscle fatigue, atelectasis and respiratory failure
- Larynx more anterior and superior in infants and children
- Smaller diameter airway
  - Small change in diameter results in significant increase in resistance
- Infant trachea and airway more compliant
- Small, fixed tidal volumes
  - Compensation to increase minute ventilation results in tachypnea
- Higher oxygen metabolism



	Infant	Adult
Airway diameter	4 mm	8 mm
Airway diameter with edema	3 mm	7 mm
Airway resistance	↑ 16 x	↑ 3 x
Cross-sectional area	↓ 75 percent	↓ 44 percent

King, C, Rappaport, LD. Emergent Endotracheal Intubation. In: Textbook of Pediatric Emergency Procedures, 2nd ed, King, C, Henretig, FM (Eds), Lippincott Williams & Wilkins, Philadelphia 2008. Copyright © 2008 Lippincott Williams & Wilkins. www.lww.com.[2]

Respiratory Exam

- Airway divided into 3 parts
  - Extrathoracic: nasal passages to thoracic inlet
  - Intrathoracic-extrapulmonary: thoracic inlet to main stem bronchi
  - Intrapulmonary: Airway within lung parenchyma

- Classic exam findings[3]
  - Inspiratory stridor: Extrathoracic airway obstruction
  - Expiratory wheeze: Intrathoracic airway obstruction (either extrapulmonary or intrapulmonary)
  - Grunting - Expiration against partially closed glottis
    - Maintain positive airway pressure during expiration
    - Most beneficial in alveolar disease with reduced FRC
    - Can also help with small airway obstruction
  - Tachypnea: Parenchymal disease
    - Also with chest wall, suprasternal and intercostal retractions

Pediatric Respiratory Tract Infections

- Upper Respiratory Tract
  - Airways from nostrils to vocal cords
  - Infections include rhinitis, sinusitis, acute otitis media, pharyngitis, tonsillitis, epiglottitis
  - Vast majority are viral but can predispose to bacterial infection
- Lower Respiratory Tract
  - Airways from trachea, include bronchi, bronchioles and alveoli
  - Infections in bronchiolitis, pneumonia
- Acute most common cause of illness and mortality in children under 5
- Average 3-6 acute respiratory infections per year[4]

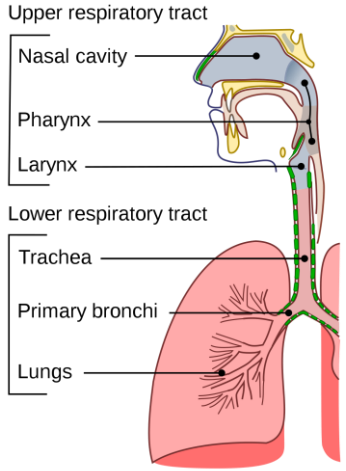


Image from Wikipedia "Pulmonary Aspiration"; image is in public domain[5]

Croup (laryngotracheitis)

- Inflammation and edema of the larynx and subglottic mucosa

- Most common 6 months to 3 years[4]
  - Accounts for 7% hospitalizations in children <5 years
  - Uncommon in children > 6 years

- Spectrum including laryngotracheobronchitis and laryngotracheobronchopneumonia
  - Lower airway signs including wheezing, crackles, tachypnea

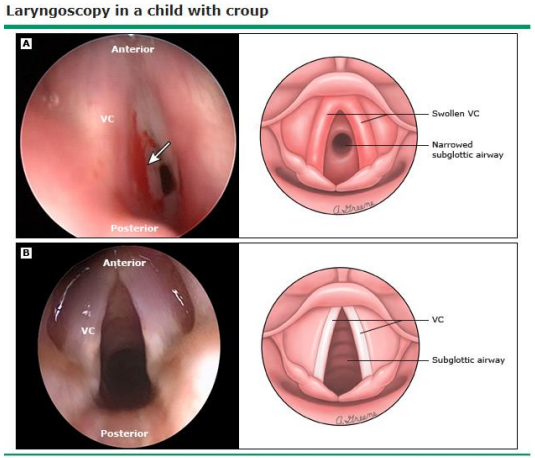


Image from: Woods CR. "Croup: Clinical features, evaluation and diagnosis" *Up To Date.* Feb 18, 2021[6]

Croup (laryngotracheitis)

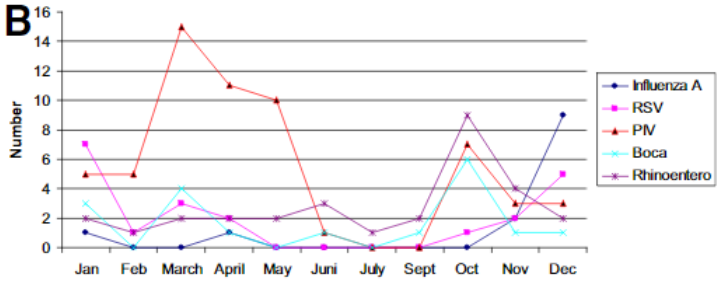


Figure. Number of patients with laryngeal croup and positive virus findings during 1-year study.

- Presentation
  - Preceding rhinorrhea, congestion, mild cough (typically day 1-3)
  - Progresses to barking cough, hoarseness, inspiratory stridor (day 3-7)
  - Most commonly worse at night
  - Tachypnea develops as airway obstruction worsens
  - Retractions signify more severe disease
  - Hypoxia is sign of life-threatening illness in laryngotracheitis
    - Laryngotracheitis can progress to laryngotracheobronchitis or laryngotracheobronchopneumonia in which case lower respiratory findings, including hypoxia may be present
- Etiology
  - *Rihkanen, et al:* 80% of children presenting with hoarseness and stridor had virus identified[7]
  - Parainfluenza 1 remains most common

Image from: Rihkanen H, Rönkkö E, Nieminen T, Komsi KL, Räty R, Saxen H, Ziegler T, Roivainen M, Söderlund-Venermo M, Beng AL, Hovi T, Pitkäranta A. Respiratory viruses in laryngeal croup of young children. J Pediatr. 2008 May;152(5):661-5[7].

Croup (laryngotracheitis)

- Diagnosis
  - Croup is a clinical diagnosis
  - Viral testing not routinely indicated
  - Imaging and laryngoscopy should be reserved for patient with concern for alternative diagnosis[8]
    - Steeple sign not sensitive nor specific for croup

- Ddx
  - Infectious: Bacterial tracheitis, epiglottis, retropharyngeal/parapharyngeal abscess
  - Anatomic: Foreign body, malacia, airway anomaly
  - Allergic: Spasmodic, anaphylaxis, asthma
  - Reflux

- Special Considerations for recurrent croup
  - Age less than 36 months
  - Prior history of intubation
  - Prematurity

Croup (laryngotracheitis) - Management

- Assessment of severity
  - Identify severe croup
    - Biphasic stridor at rest or absent stridor, cyanosis, marked tachycardia or bradycardia, bradypnea, altered consciousness
- Minimize agitation
- Humidified air not indicated[9]
- Oxygen as needed for hypoxemia or severe respiratory distress
- Oral glucocorticoids[10]
  - Dexamethasone 0.6 mg/kg/dose po x 1; max 16 mg
    - Improved croup symptoms at 2 hours post po dose (peak effect of IV dex in 10 minutes)
    - Effect lasted 24 hours
    - Reduced length of stay and rates of return visits, admissions and readmissions
  - Decreased efficacy with IM dose
  - Repeat dosing not routinely indicated but may be warranted if persistent symptoms
    - Thought to increase side effects

Croup (laryngotracheitis) - Management

- Racemic epinephrine[8]
  - Decreases severity scores in moderate to severe croup at 30 minutes
  - Dose 0.25-0.5 mL of 2.25% solution via nebulizer over 15 minutes
  - Effects wane after 2 hours
  - Monitor for side effects with repeat dosing
- Nebulized budesonide
  - Not for routine care
  - Consider for severe respiratory distress, emesis without IV access
  - Dose 2 mg inhaled over 30 minutes
- Heliox[8]
  - Not routinely indicated
  - Mixture helium (70-80%) and oxygen (20-30%) improve work of breathing by decreasing turbulent airflow
  - Low FiO2 may not be appropriate for hypoxic patients
- Intubation rarely required
  - Needs skilled provider

Croup (laryngotracheitis)

- Outpatient/ED Disposition
  - Admission if requiring multiple doses of RE, dehydration, hypoxemia
    - PICU for impending respiratory failure
  - If symptoms remain absent/minimal after observation, consider discharge home
    - Increased treatment failure if observed 2.1-3 hours vs 3.1-4[11]
    - ~5% 72 hour re-visit rate after ED treatment[12]

- Inpatient Disposition
  - Minimal stridor at rest, adequate hydration, >3 hours since last RE
  - Prolonged observation after repeated doses of steroids not routinely recommended
    - Single center retrospective cohort study at CHCO found clinically significant rate of critically ill patients rebounded, however cumulative dexamethasone dose did not predict timing or odds of rebound[13]
  - CLOSE OUTPATIENT FOLLOW UP KEY!
    - Phone f/u 12-24 hours and in-person visit within 2 days

Bronchiolitis

- Lower respiratory tract infection
- Acute inflammation, edema and necrosis of epithelial cells of small airways and increased mucus production
  - -> obstruction, atelectasis and air trapping
- ~100,000 admissions annually
  - Average RSV hospitalization rate 5.2/1000 <24 months

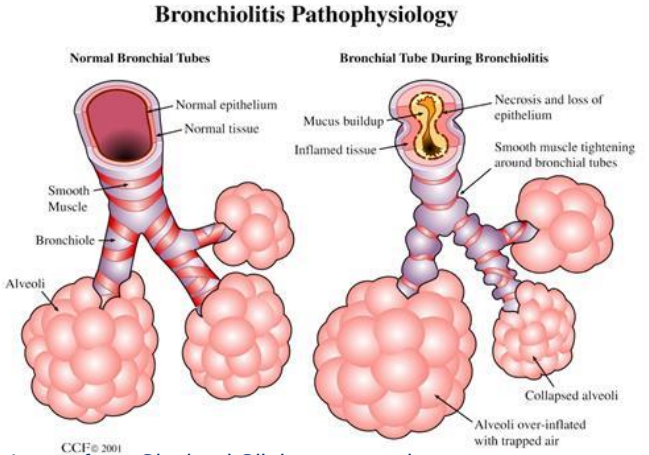
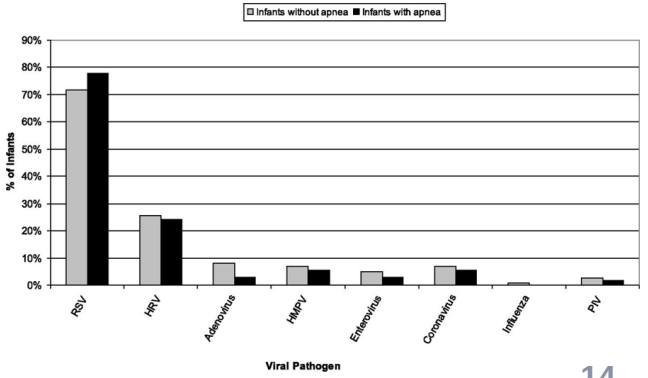


Image from Clevland Clinic, accessed at: https://my.clevelandclinic.org/health/diseases/8272-bronchiolitis

Bronchiolitis

- Presentation
  - < 2 years of age
  - URI progresses to lower respiratory tract involvement
    - Cough, tachypnea, accessory muscle use, abnormal breath sounds with changing exam, wheeze, prolonged expiratory phase, typically fever, +/- hypoxia
  - Peak day 3-5, symptoms generally resolve 2-3 weeks
- Potential Complications
  - Dehydration
  - Apnea[14]
    - Increased risk if <8 wks corrected for GA <37 weeks, reported prior apnea, hypoxia and high or low RR at presentation
  - Hypercapnic respiratory failure[15]
  - LOW risk of secondary bacterial[16]
- Risk factors
  - Age and chronic disease
  - Smoke exposure, daycare attendance, older siblings, high altitude[17,18]



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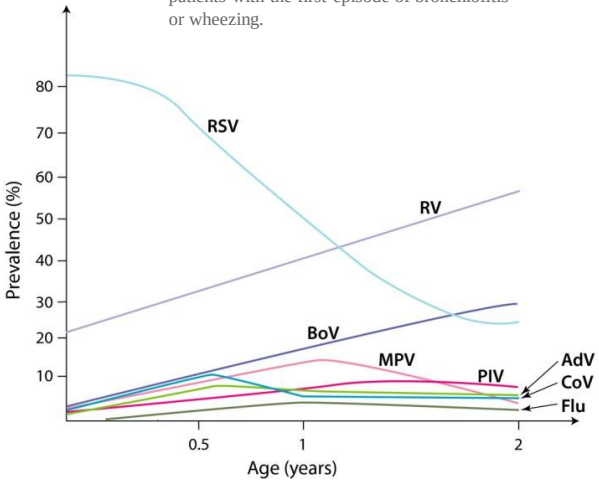
Bronchiolitis

- Etiology
  - RSV most common
  - Co-infection with multiple viruses 10-30% in hospitalized patients[19]
- Diagnosis is clinical
- Not routinely indicated
  - Routine viral pathogen testing
    - Consider influenza and SARS-CoV-2.
  - Chest x-ray[20]
  - Universal testing for SBI unless ill-appearing[16,21]
- Differential Diagnosis
  - Myocarditis, FB, anatomic abnormality, mass, pertussis, pneumonia, croup, malacia, asthma

The frequency of viral etiologic agents according to the age of the hospitalized patients with the first episode of bronchiolitis or wheezing.



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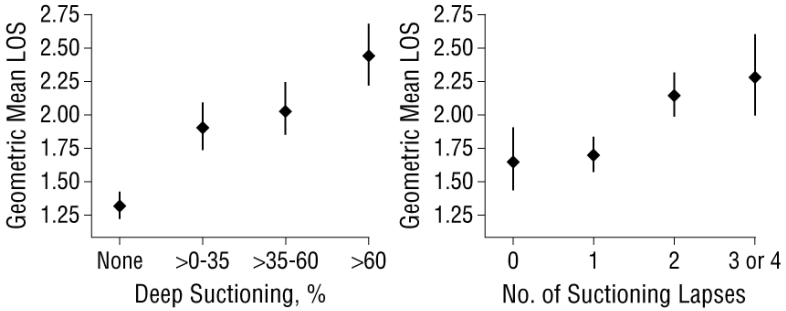
Bronchiolitis – Management

- Assess severity
  - Consider mental status, work of breathing, RR and feeding status
- Indications for hospitalization
  - Moderate-severe respiratory distress
  - Dehydration, poor feeding
  - Ill appearance, lethargy
  - Apnea
  - Hypoxemia[23]
- Supportive treatment
  - Suctioning[24]
  - Supplemental oxygen: LFNC>HFNC>NIVPP>intubation
    - HHFNC
  - Maintain hydration (IVF vs NG)[25,26]
  - Serial exams



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Bronchiolitis – Management

- Not routinely recommended interventions
  - Chest physiotherapy
  - Nebulized medication including albuterol, epinephrine and hypertonic saline
    - Bronchodilators do not reduce admission, shorten LOS or reduce time to resolution of illness[27]
  - Steroids[28]
    - No change in admission rate, resp status 4 hours post or LOS
    - May prolong viral shedding[29]
  - Antibiotics

- Disposition
  - Home management
    - Adequate hydration
    - Manageable secretions
    - RA or low flow nasal cannula <1/2LPM
      - Retrospective study demonstrating safety and reduction in admissions in select patients[30]

Bronchiolitis

- Prevention[31]
  - Hand hygiene
  - Synagis
  - Breastfeeding

- Recurrent wheeze
  - Consider early pulmonary evaluation when
    - previous hospitalization for wheeze
    - 2 prior PCP/UC/ED evaluation for wheeze
  - Additional considerations
    - Parental history of asthma
    - Personal history of eczema or inhalant allergy

Uncomplicated Community Acquired Pneumonia

- Acute infection of pulmonary parenchyma acquired outside of the hospital setting
  - Typically follows URI->invasion of LRT by pathogens triggers immune response and create inflammation
    - Decreased compliance, increased resistance, collapse of distal air space, and V/Q mismatch
  - Complicated pneumonia includes pleural effusion, empyema, lung abscess, necrotizing pneumonia, bronchopleural fistula or pneumothorax
- Clinical presentation varies by etiology and age
  - Classically fever, cough, respiratory distress
- ~1.2 million outpatient visits and >150,000 hospitalizations annually[32,33]
- Overall incidence of 15.7-22.5/10,000 children < 18 years of age[34]
  - Highest for <2 years 62.2/10,000 and decreases with age

Image from: Neuman MI, Lee EY, Bixby S, Diperna S, Hellinger J, Markowitz R, Servaes S, Monuteaux MC, Shah SS, Reliability of CXR for Pneumonia. *J. Hosp. Med* 2012;4;294-298[35]

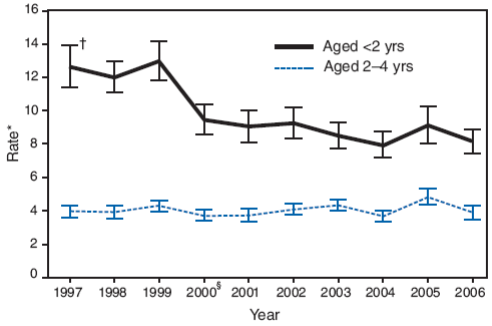
Uncomplicated CAP- Etiology

- Viral, bacterial, atypical bacterial
- Impact of routine childhood vaccination
- Advances in molecular diagnostics have highlighted the role of viruses in CAP, however bacterial diagnostics remain suboptimal[36]
- Pre-PCV study by Michelow, et al
  - 60% infection with typical respiratory bacteria (73% s.pneumo)
  - 43% with virus identified

Impact of PCV 6[37]

- Introduced in 2000
- By 2006 hospitalization rates for CAP among young children decreased by 39%[36]

FIGURE. Annual all-cause pneumonia hospitalizations rates* among children aged <2 years and 2–4 years — Nationwide Inpatient Sample, United States, 1997–2006



* Per 1,000 population.
† 95% confidence interval.
§ 7-valent pneumococcal conjugate vaccine licensed in February 2000.

Image from: Centers for Disease Control and Prevention (CDC). Pneumonia hospitalizations among young children before and after introduction of pneumococcal conjugate vaccine--United States, 1997-2006. MMWR Morb Mortal Wkly Rep. 2009 Jan 16;58(1):1-4.[37]

Impact of PCV 13[38]

- After introduction of PCV 7 a surge of serotype 19A emerged and increase in complicated pneumonia
- PCV 13 introduced 2010
- Hospitalization rate decreased by >50%

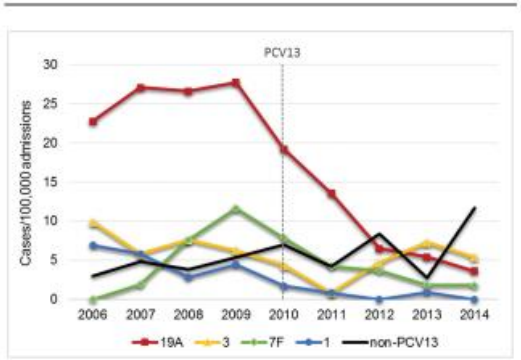


Figure 2. Annual hospitalization rates of serotype-specific pneumonia cases per 100 000 admissions from 2006 to 2014.

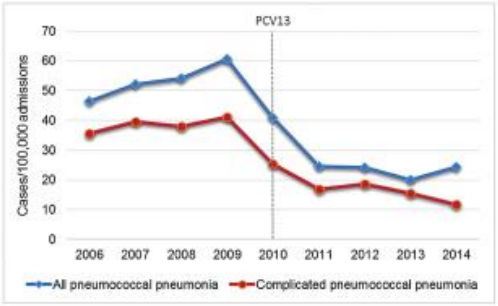
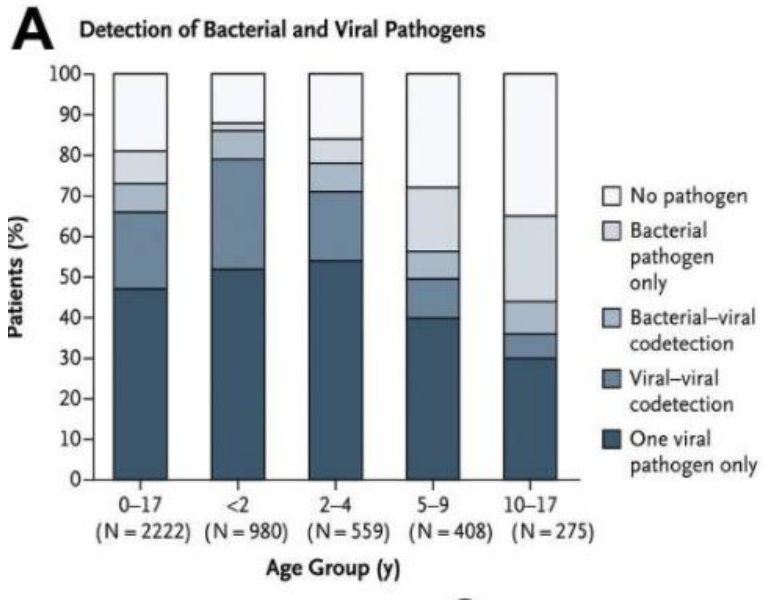
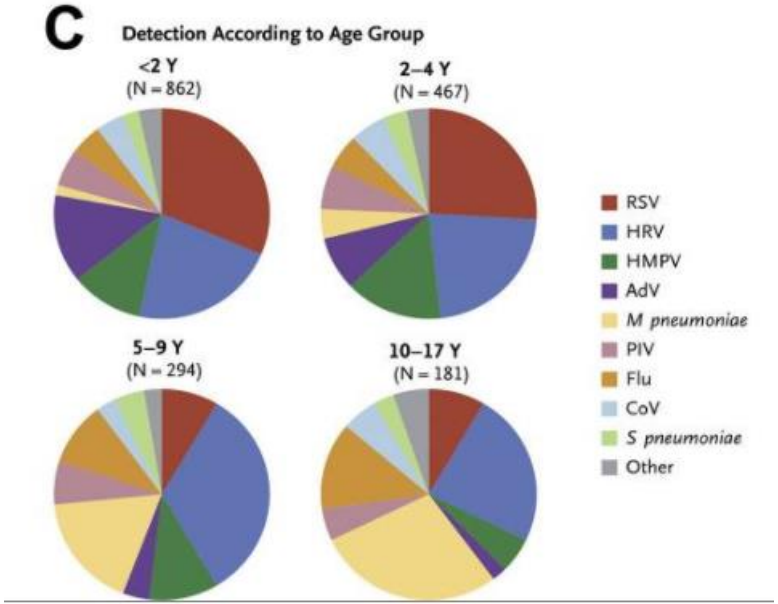


Figure 1. Annual hospitalization rates of all pneumococcal pneumonia and complicated pneumococcal pneumonia per 100 000 admissions from 2006 to 2014. The annual admissions among the 8 children's hospitals were 2006 = 101 116; 2007 = 103 524; 2008 = 105 367; 2009 = 111 969; 2010 = 114 615; 2011 = 118 077; 2012 = 107 737; 2013 = 110 241; and 2014 = 111 089.

Olarte L, Barson WJ, Barson RM, Romero JR, Bradley JS, Tan TQ, Givner LB, Hoffman JA, Lin PL, Hultén KG, Mason EO, Kaplan SL. Pneumococcal Pneumonia Requiring Hospitalization in US Children in the 13-Valent Pneumococcal Conjugate Vaccine Era. Clin Infect Dis. 2017 Jun 15;64(12):1699-1704.

Post-Pneumococcal Conjugate Vaccine[34]





Images from: Jain S, Williams DJ, Arnold SR, et al. Community-acquired pneumonia requiring hospitalization among U.S. children. *N Engl J Med.* 2015;372(9):835-845.

Uncomplicated CAP – Diagnosis

- Diagnosis remains primarily clinical
  - Assess respiratory status, pulse ox in all patients
  - Test for flu and SARS-CoV 2 when indicated
- Outpatient
  - Not routinely indicated: CXR, inflammatory markers, blood culture
- Inpatient
  - National guidelines recommendations for CXR for hypoxemia, *severe respiratory distress, failed initial antibiotic therapy*[39]
    - US being used with increasing frequency
    - Neither CXR or US can reliably differentiate between viral and bacterial etiology[40]
  - National guidelines recommendations for blood cultures
    - 2017 *Pediatrics* demonstrated low rate of bacteremia for hospitalized children in a non-ICU setting[41]
  - Inflammatory markers should not be used in isolation to make a diagnosis
    - Can be used to trend treatment response but typically not indicated in uncomplicated pneumonia
- Indications for hospitalization
  - Hypoxemia, dehydration, moderate/severe respiratory distress, young age, outpt tx failure, concern for complicated PNA

Uncomplicated CAP – Treatment

- Address hypoxemia, dehydration
- Antibiotics not indicated for viral etiology
  - Majority CAP <5 years is VIRAL
  - Well-appearing child with influenza does not need treatment for staph aureus
  - Consider viral treatment for influenza, management of acute COVID if meeting criteria
- Antimicrobial selection
  - FIRST LINE= Amoxicillin high dose
  - For PCN allergy: Cefpodoxime, cefuroxime, cefprozil
    - If unable to obtain consider clindamycin or doxycycline
    - Cefdinir does not have adequate oral adequate absorption[42] and should not be used
  - If unable to take oral medications Ampicillin -> ceftriaxone if PCN allergy
  - Do not provide macrolide monotherapy[43]
    - 40-50% resistance to s.pneumoniae
- Treatment duration
  - Treatment courses of 10 days[39] best studied but evidence emerging that shorter duration adequate
  - Same, et all found a short course of antibiotic therapy does not increase odds of 30-day treatment failure compared with longer courses for hospitalized children with uncomplicated CAP[44]

Mycoplasma Pneumoniae – To treat or not?

- Most common between 5-15 years of age
- Generally, symptoms last several weeks but are self limited[45]
- Cannot be reliably diagnosed based on clinical signs and symptoms[46]
  - Radiographic findings also variable and non-diagnostic[45]
- Carriage rate in healthy children without respiratory symptoms ranges 21-56%[47,48]
- Azithromycin
  - Review of 17 articles majority did not show significant clinical benefit to treatment with macrolide, concluded there is insufficient evidence of support or refute treatment
    - 2 articles demonstrated decreased LOS when combined with beta lactam
  - 10-20% resistance to M.pneumoniae in US
  - Long serum half life
    - Has been associated with significant alteration of microbiome and selection of resistant organisms
  - Association with obesity after 1st exposure
- Consider if treatment for mycoplasma is indicated. If concern for ANY bacterial CAP do not use macrolide monotherapy

Conclusion

- Acute respiratory infections significant cause of disease in pediatric patients
  - Assess respiratory status
  - Level of care depends on respiratory distress, hydration
- Unique features of pediatric airway contribute to clinical findings
- Large overlap of symptoms
  - Mainly clinical diagnosis
- Primarily viral etiology
  - Judicious use of antibiotics

QUESTIONS?

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