Update on Pediatric Community-Acquired Pneumonia

K. Jane McClure
Leslie Herrmann
Cindi Mondesir
Introduction
Main Resource

The Management of Community-Acquired Pneumonia in Infants and Children Older Than 3 Months of Age: Clinical Practice Guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America

John S. Bradley,1,8 Carrie L. Byington,2,8 Samir S. Shah,3,8 Brian Alverson,4 Edward R. Carter,5 Christopher Harrison,6 Sheldon L. Kaplan,7 Sharon E. Mace,8 George H. McCracken Jr,9 Matthew R. Moore,10 Shawn D. St Peter,11 Jana A. Stockwell,12 and Jack T. Swanson13

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IDSA Guidelines

• 2011
• Children older than 3 months of age
• Issues addressed:
  – Who to hospitalize
  – What tests to order
  – Drugs of choice
  – Treatment failures
YK Guidelines

- Updated May 2015
- Based on IDSA Guidelines
- Input from ID experts, PICU, ANMC, and YOU!!
- Covers children >3 months old

**REMEMBER:**
If patient is <90 days and febrile, please see fever guidelines.
What’s changed?

• Inpatient IV therapy:
  – First-line: ampicillin
  – Second-line: Unasyn
  – Third-line: ceftriaxone

• New emphasis on supportive measures.

• Evaluating and treating based on severity of respiratory distress AFTER supportive measures.

• Formatting mirrors other pediatric respiratory guidelines.
Background
Epidemiology

• Pneumonia is the leading cause of death in children worldwide.

• In the developed world, the annual incidence of pneumonia is 3-4 cases per 100 children <5 years old.

• We have very high rates of pediatric pneumonia in the YK Delta.
  – Recurrent pneumonia leads to chronic lung disease and bronchiectasis.
  – Bronchiectasis has a high mortality rate, with patients dying in their 30’s in local study cohorts.
Etiology

• Difficult to determine true pathogen in most cases.
• Viruses more common in infants and toddlers.
  – RSV detected in 40% of children <2 years.
• Bacteria more common in older children.
Etiology - Common Trends

- *S. pneumoniae* is the most common bacterial cause of pneumonia in children.
- Viruses account for 14-35% of pneumonia cases, and as high as 50% of cases in young children.
- Viruses are more commonly identified in children <5 years.
- In children >5 years, *Mycoplasma pneumoniae* and *Chlamydia pneumoniae* are more common.

Source: UpToDate
Bacterial Causes in Children <5 Years

• *S. pneumoniae* is the single most common bacterial pathogen causing pneumonia in all patients beyond the first few weeks of life.

• *H. influenzae* type b is a rare cause of pneumonia in countries with universal childhood immunization.

• *S. aureus* (particularly CA-MRSA) and *S. pyogenes* are becoming increasingly frequent causes of CAP, particularly those complicated by necrosis and empyema.

• The prevalence of *M. pneumoniae* and *C. pneumoniae* may be increasing in preschool children with CAP.

Source: UpToDate
Bacterial Causes in Children >5 Years

- *S. pneumoniae* is the most common typical bacterial cause of pneumonia in children older than five years.
- *M. pneumoniae* is more common among children ≥ 5 years than among younger children.
- *C. pneumoniae* also is emerging as a frequent cause of pneumonia in older children and young adults.
So...

- Strep pneumo
- Strep pneumo
- Strep pneumo!!
Diagnosis
Pneumonia is a clinical diagnosis.

- CXR findings are not required to make the diagnosis of pneumonia. Consistent history and focal crackles on exam are sufficient.
- However, given the high incidence of chronic lung disease in our population, physical exam findings are not always reliable.
  - A child can have clear lungs with an infiltrate.
  - A child can have frank crackles with a clear CXR.
- Thus, we have a low threshold to order CXRs in our patients and interpret the results in light of the entire clinical picture.
Treatment decision should be based on severity of respiratory distress.

### Signs of Respiratory Distress

1. **Tachypnea**, respiratory rate, breaths/min
   - Age 0–2 months: >60
   - Age 2–12 months: >50
   - Age 1–5 Years: >40
   - Age >5 Years: >20
2. **Dyspnea**
3. **Retractions** (suprasternal, intercostals, or subcostal)
4. **Grunting**
5. **Nasal flaring**
6. **Apnea**
7. **Altered mental status**
8. **Pulse oximetry measurement** <90% on room air

*a* Adapted from World Health Organization criteria.

### Tachypnea
- 0-2 mo: >60
- 2-12 mo: >50
- 12-24 mo: >40

### Hypoxia
- <90% while awake
- <88% while asleep
- Sustained for >10 minutes

### Moderate to severe respiratory distress
- Sustained tachypnea, increased work of breathing, and/or hypoxia

### Mild or no respiratory distress
- Intermittent tachypnea, increased work of breathing, and/or hypoxia
To admit or not to admit?

• Children with moderate to severe respiratory distress after supportive measures should be admitted to YK or sent to Anchorage by medevac.

• Who stays? Who goes?
   – Stay tuned for exciting developments in this area!
   – A multidisciplinary team is working on this!
Labwork

• Moderate to severe respiratory distress (admission anticipated):
  – CBC
  – CRP
  – Blood culture
  – RSV and flu (if <3 years)
  – Sputum and culture (if >5 years)

• Mild or no respiratory distress (outpatient management): No labwork required
Cough ± fever

Institute SUPPORTIVE MEASURES
Then reassess respiratory distress

Moderate to severe respiratory distress
Sustained tachypnea, increased work of breathing, and/or hypoxia
- CXR (PA & lateral)
- CBC, CRP, and blood culture
- RSV and flu if <3 years
- Sputum culture if >5 years and able

Mild or no respiratory distress
Intermittent tachypnea, increased work of breathing, and/or hypoxia
- Consider CXR if <5 years old given high rates of pneumonia in Alaska Native population.
SUPPORTIVE MEASURES
- control fever, as it can be an independent cause of respiratory distress and tachycardia
- nasal suction with nasal bulb syringe and olive tip plus saline hydration
- gentle P&PD/CPT if helpful
- saline neb (0.9%)
- consider albuterol trial, especially in Alaska Native patients as they have high rates of RAD
Management
Now what?
Management/Treatment?
Some background...

Look what Leslie found in the Kasigluk clinic!
(That’s where she is right now.)
# 2003 Antibiotic Susceptibility Report

**Non-Urines 01/02/02 - 01/04/03**

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*Non urines – includes wounds, ears, positive blood cultures, anything EXCEPT urines*
Strep pneumo

• Historically, the YK Delta has had high resistance rates of *S pneumo* for penicillins.
• As a result, we used ceftriaxone as the first-line treatment for pneumonia.
• However, resistance rates are decreasing.
# 2014 Antibiogram

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<th>Isolates Tested</th>
<th>Interpretation</th>
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<th>Oxacillin</th>
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<tr>
<td>Organism</td>
<td># Isolates Tested</td>
<td>Interpretation</td>
<td>Penicillin</td>
<td>Ampicillin</td>
<td>Oxacillin</td>
<td>Cefuroxime</td>
<td>Cefotaxime</td>
<td>Ceftriaxone</td>
<td>Levofloxacin</td>
<td>Trimeth/sulfa</td>
<td>Clindamycin</td>
<td>Erythromycin</td>
<td>Nitrofurantoin</td>
<td>Vancomycin</td>
<td>Tetracycline</td>
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<td><em>Streptococcus pneumoniae</em></td>
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</tbody>
</table>
Low penicillin resistance for *S. pneumoniae*

- Ampicillin and amoxicillin are now the first-line drugs of choice for CAP.
- Dosing on guideline is based on local MIC:
  - Ampicillin 50 mg/kg/dose IV Q6h
  - Amoxicillin 45 mg/kg/dose PO Q12h
Pneumonia → No pneumonia → No pneumonia → Pneumonia

**Treatment**
1st line: ampicillin 50 mg/kg/dose IV Q6h
2nd line: Unasyn 50 mg/kg/dose IV Q6h
3rd line: ceftriaxone 75 mg/kg/dose IV Q24h

No pneumonia → Consider other diagnoses: RAD, bronchiolitis, TB, acidosis, toxins, etc.

**Treatment for 10 days**
1st line: amoxicillin 45 mg/kg/dose PO BID
2nd line: Augmentin 45 mg/kg/dose PO BID
3rd line: cefdinir 7 mg/kg/dose PO BID
This is in line with national guidelines.

### Table 5. Selection of Antimicrobial Therapy for Specific Pathogens

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Parenteral therapy</th>
<th>Oral therapy (step-down therapy or mild infection)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Streptococcus pneumoniae</em> with MICs for penicillin ≤2.0 μg/mL</td>
<td>Preferred: ampicillin (150–200 mg/kg/day every 6 hours) or penicillin (200 000–250 000 U/kg/day every 4–6 h); Alternatives: ceftriaxone (50–100 mg/kg/day every 12–24 hours) (preferred for parenteral outpatient therapy) or cefotaxime (150 mg/kg/day every 8 hours); may also be effective: clindamycin (40 mg/kg/day every 6–8 hours) or vancomycin (40–60 mg/kg/day every 6–8 hours)</td>
<td>Preferred: amoxicillin (90 mg/kg/day in 2 doses or 45 mg/kg/day in 3 doses); Alternatives: second- or third-generation cephalosporin (cefepime, cefuroxime, cefprozil); oral levofloxacin, if susceptible (16–20 mg/kg/day in 2 doses for children 6 months to 5 years old and 8–10 mg/kg/day once daily for children 5 to 16 years old; maximum daily dose, 750 mg) or oral linezolid (30 mg/kg/day in 3 doses for children &lt;12 years old and 20 mg/kg/day in 2 doses for children ≥12 years old)</td>
</tr>
</tbody>
</table>
Caveats

**For PCN allergy:** If reaction was non-anaphylactic, may trial amoxicillin with monitoring. If reaction was anaphylaxis, treat with a cephalosporin. If any questions, please obtain a pediatrics consult.

**Azithromycin:** Do not prescribe azithromycin unless there is evidence of an atypical pathogen and child is >5 years.

**RUL infiltrate:** consider starting with Augmentin/Unasyn to cover for oral anaerobes.
Exceptions

• RUL infiltrate ➔ consider antibiotic with oral anaerobe coverage
  – Augmentin/Unasyn
  – Clindamycin
• Child received amoxicillin/ampicillin in last 30 days ➔ go to second-line: Augmentin/Unasyn.
• Child is incompletely immunized: consider broader-spectrum coverage.
• Effusion in patient with possible sepsis, consider Vanco
When is ceftriaxone indicated as first-line therapy?

- Hospitalized patients who are not appropriately immunized.
- In regions where pneumococcus has high-level penicillin resistance.
- Patients with life-threatening infection, including empyema. (also consider adding Vanco)
Translation:
“Are your shots up-to-date?”

<table>
<thead>
<tr>
<th>Age</th>
<th>No. doses of vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4 months</td>
<td>1 dose</td>
</tr>
<tr>
<td>&lt;6 months</td>
<td>2 doses</td>
</tr>
<tr>
<td>6-12 months</td>
<td>3 doses</td>
</tr>
<tr>
<td>≥12 months</td>
<td>2 total doses of vaccine, the first of which was at 12-14 months of age</td>
</tr>
<tr>
<td>≥12 months</td>
<td>3 total doses of vaccine, the first at &lt;12 months of age, the second at &lt;15 months of age, the third at ≥12 months of age</td>
</tr>
<tr>
<td>≥15 months</td>
<td>first dose of vaccine was at or after 15 months of age</td>
</tr>
</tbody>
</table>

[LOE: ★★★★☆ Moderate quality] (ASA, 2011)
<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Parenteral therapy</th>
<th>Oral therapy (step-down therapy or mild infection)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Streptococcus pneumoniae</em> with MICs for penicillin ≥2.0 μg/mL</td>
<td>Preferred: amoxicillin (110-200 mg/kg/day every 6 hour) or penicillin 200,000-250,000 UI/kg/day every 4-6 h; Alternatives: ceftriaxone (150 mg/kg/day every 6 hours), may also be effective; clindamycin (40 mg/kg/day every 6-8 hours) or vancomycin (40-60 mg/kg/day every 6-8 hours)</td>
<td>Preferred: amoxicillin (80 mg/kg/day in 2 doses or 45 mg/kg/day in 3 doses); Alternatives: second or third-generation cephalosporins for penicillin, clindamycin, or linezolid (30 mg/kg/day in 3 doses for children &lt;12 years old and 20 mg/kg/day in 2 doses for children ≥12 years old)</td>
</tr>
<tr>
<td><em>S. pneumoniae</em> resistant to penicillin, with MICs &gt;4.0 μg/mL</td>
<td>Preferred: ceftriaxone (100 mg/kg/day every 12-24 hours); Alternatives: ampicillin (200-400 mg/kg/day every 6 hours), levofloxacin (16-20 mg/kg/day every 12 hours for children 6 months to 5 years old and 8-10 mg/kg/day once daily for children 5-16 years old); maximum daily dose, 750 mg), or linezolid (30 mg/kg/day every 6 hours for children &lt;2 years old and 20 mg/kg/day every 12 hours for children ≥12 years old); may also be effective; clindamycin* (40 mg/kg/day every 6-8 hours) or vancomycin (40-60 mg/kg/day every 6-8 hours)</td>
<td>Preferred: oral levofloxacin (16-20 mg/kg/day in 2 doses for children 6 months to 5 years old and 8-10 mg/kg/day once daily for children 5-16 years old); maximum daily dose, 750 mg), or oral linezolid (30 mg/kg/day in 3 doses for children &lt;12 years old and 20 mg/kg/day in 2 doses for children ≥12 years old)</td>
</tr>
<tr>
<td><em>Group A Streptococcus</em></td>
<td>Preferred: intravenous penicillin (150,000-250,000 UI/kg/day every 6-8 hour) or ampicillin (200 mg/kg/day every 6 hour); Alternatives: ceftriaxone (80-100 mg/kg/day every 12-24 hours) or cefotaxime (150 mg/kg/day every 8 hours); may also be effective; clindamycin, if susceptible (40 mg/kg/day in 2 doses for children 5-16 years old); maximum daily dose, 750 mg), or oral linezolid (30 mg/kg/day in 3 doses for children &lt;12 years old and 20 mg/kg/day in 2 doses for children ≥12 years old)</td>
<td>Preferred: amoxicillin 80-75 mg/kg/day in 2 doses, or penicillin V (80-75 mg/kg/day in 3 or 4 doses)</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em>, methicillin susceptible (combination therapy not well studied)</td>
<td>Preferred: cefazolin (150 mg/kg/day every 8 hours) or semisynthetic penicillin, eg oxacillin (150-300 mg/kg/day every 6-8 hours); Alternatives: clindamycin* (40 mg/kg/day every 6-8 hours) or vancomycin (40-60 mg/kg/day every 6-8 hours)</td>
<td>Preferred: oral cephalaxin (75-100 mg/kg/day in 3 or 4 doses)</td>
</tr>
<tr>
<td><em>S. aureus</em>, methicillin resistant, susceptible to clindamycin (combination therapy not well studied)</td>
<td>Preferred: vancomycin 40-60 mg/kg/day every 6-8 hours or dosing to achieve an AUC/MIC ratio of &gt;400 or clindamycin (40 mg/kg/day every 6-8 hours); Alternatives: linezolid (30 mg/kg/day every 8 hours for children &lt;12 years old and 20 mg/kg/day every 12 hours for children ≥12 years old)</td>
<td>Preferred: oral clindamycin (30-40 mg/kg/day in 3 or 4 doses)</td>
</tr>
<tr>
<td><em>S. aureus</em>, methicillin resistant, resistant to clindamycin (combination therapy not well studied)</td>
<td>Preferred: linezolid (30 mg/kg/day every 8 hours for children &lt;12 years old and 20 mg/kg/day every 12 hours for children ≥12 years old)</td>
<td>Alternatives: none; entire treatment course with vancomycin therapy may be required</td>
</tr>
</tbody>
</table>

*Note: *Clindamycin* may be effective for methicillin-resistant *S. aureus* infections. However, the use of clindamycin in combination therapy may not be appropriate due to the potential for resistance. Consult local guidelines for specific recommendations.*
# Hideous Table of Antimicrobial Therapy Choices

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Parenteral therapy</th>
<th>Oral therapy (step-down therapy or mild infection)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemophilus influenza, typeable</td>
<td>Preferred: intravenous ampicillin (150-200 mg/kg/day every 6 hours) if β-lactamase negative, ceftriaxone (50–100 mg/kg/day every 12-24 hours) if β-lactamase producing, or cefotaxime (150 mg/kg/day every 8 hours); Alternatives: intravenous ciprofloxacin (300 mg/kg/day every 12 hours) or intravenous levofloxacin (16-20 mg/kg/day every 12 hours for children 6 months to 5 years old and 8-10 mg/kg/day once daily for children 5 to 16 years old; maximum daily dose, 750 mg)</td>
<td>Preferred: amoxicillin (75-100 mg/kg/day in 3 doses) if β-lactamase negative) or amoxicillin clavulanate (amoxicillin component, 45 mg/kg/day in 3 doses or 90 mg/kg/day in 2 doses) if β-lactamase producing; Alternatives: cefdinir, cefixime, cefpodoxime, or cefditoren</td>
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<tr>
<td>(A/F) or nontypeable</td>
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<tr>
<td>Mycoplasma pneumoniae</td>
<td>Preferred: intravenous azithromycin (10 mg/kg on days 1 and 2 of therapy; transition to oral therapy if possible); Alternatives: intravenous erythromycin lactobionate (20-20 mg/kg/day every 8 hours) or levofloxacin (16-20 mg/kg/day every 12 hours; maximum daily dose, 750 mg)</td>
<td>Preferred: azithromycin (10 mg/kg on day 1, followed by 5 mg/kg/day once daily on days 2–5); Alternatives: clarithromycin (15 mg/kg/day in 2 doses) or oral erythromycin (40 mg/kg/day in 4 doses); for children &gt;7 years old, doxycycline (2–4 mg/kg/day in 2 doses; for adolescents with skeletal maturity, levofloxacin (500 mg once daily) or moxifloxacin (400 mg once daily)</td>
</tr>
<tr>
<td>Chlamydia trachomatis or Chlamydia pneumoniae</td>
<td>Preferred: intravenous azithromycin (10 mg/kg on days 1 and 2 of therapy; transition to oral therapy if possible); Alternatives: intravenous erythromycin lactobionate (20 mg/kg/day every 8 hours) or levofloxacin (16-20 mg/kg/day in 2 doses for children 6 months to 5 years old and 8-10 mg/kg/day once daily for children 5 to 16 years old; maximum daily dose, 750 mg)</td>
<td>Preferred: azithromycin (10 mg/kg on day 1, followed by 5 mg/kg/day once daily on days 2–5); Alternatives: clarithromycin (15 mg/kg/day in 2 doses) or oral erythromycin (40 mg/kg/day in 4 doses); for children &gt;7 years old, doxycycline (2–4 mg/kg/day in 2 doses; for adolescents with skeletal maturity, levofloxacin (500 mg once daily) or moxifloxacin (400 mg once daily)</td>
</tr>
<tr>
<td>Site of care</td>
<td>Presumed bacterial pneumonia</td>
<td>Presumed atypical pneumonia</td>
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<tr>
<td>&lt;5 years old (preschool)</td>
<td>Amoxicillin, oral (90 mg/kg/day in 2 doses)*</td>
<td>Azithromycin oral (10 mg/kg on day 1, followed by 5 mg/kg/day once daily on days 2-5)</td>
</tr>
<tr>
<td></td>
<td>Alternatives: oral amoxicillin clavulanate (amoxicillin component, 90 mg/kg/day in 2 doses)*</td>
<td>Alternatives: oral clarithromycin (15 mg/kg/day in 2 doses for 7-14 days) or oral erythromycin (40 mg/kg/day in 4 doses)</td>
</tr>
<tr>
<td>≥5 years old</td>
<td>Oral amoxicillin (90 mg/kg/day in 2 doses)* to a maximum of 4 g/day; for children with presumed bacterial CAP who do not have clinical, laboratory, or radiographic evidence that distinguishes bacterial CAP from atypical CAP, a macrolide can be added to a β-lactam antibiotic for empiric therapy; alternative: oral amoxicillin clavulanate (amoxicillin component, 90 mg/kg/day in 2 doses)* to a maximum of 4 g/day, eg, one 2000 mg tablet twice daily*</td>
<td>Oral azithromycin (10 mg/kg on day 1), followed by 5 mg/kg/day once daily on days 2–5 to a maximum of 500 mg on day 1, followed by 250 mg on days 2–5; alternatives: oral clarithromycin (15 mg/kg/day in 2 doses to a maximum of 1 g/day); erythromycin, dicyclomine for children &gt;7 years old</td>
</tr>
</tbody>
</table>

| Inpatient (all ages)* | Ampicillin or penicillin G; alternatives: ceftriaxone or ceftazidime; addition of vancomycin or clindamycin for suspected CA-MRSA | Azithromycin (in addition to β-lactam, if diagnosis of atypical pneumonia is in doubt); alternatives: clarithromycin or erythromycin; dicyclomine for children >7 years old; levofloxacin for children who have reached growth maturity or who cannot tolerate macrolides | Oseltamivir or zanamivir (for children ≥7 years old); alternatives: paromomycin, oseltamivir and zanamivir (all intravenous) are under clinical investigation in children; intravenous zanamivir available for compassionate use |

| Fully immunized with conjugate vaccines for Haemophilus influenzae type b and Streptococcus pneumoniae; local penicillin resistance in invasive strains of pneumococcus is minimal | Ceftriaxone or ceftazidime; addition of vancomycin or clindamycin for suspected CA-MRSA, alternative: levofloxacin; addition of vancomycin or clindamycin for suspected CA-MRSA |  |  |

| Not fully immunized for H. influenzae type b and S. pneumoniae; local penicillin resistance in invasive strains of pneumococcus is significant |  |  |  |
Change is scary.
What if it doesn’t work?
Follow-up Studies

• Dinur-Scheiter et al (2013): 319 children aged 3 months to 2 years admitted with non-complicated pneumonia between 2003-2008 treated with either penicillin/ampicillin or cefuroxime.
  – No difference in number of days of IV treatment, days of supplemental oxygen requirement, or length of hospitalization.
  – No significant difference in treatment failures.
  – One week after admission, no difference between the groups.
Follow-up Studies

• Amarilvo *et al* (2014): prospective, randomized study with 58 children aged 3 months to 15 years with community-acquired pneumonia. Children were randomly assigned to receive low-dose penicillin G, high-dose penicillin G, or cefuroxime IV for 4-7 days.
  – No significant difference in time to defervescence or duration of hospitalization.
  – There were differences in leukocyte counts and C-reactive protein at discharge, but these “were of questionable clinical significance.”
Case Scenarios
Treatment for CAP

• **Outpatient**
  – Amoxicillin 45mg/kg PO BID X 10d
  – Augmentin 45mg/kg PO BID X 10d
  – Cefdinir 14mg/kg/d div BID

• **Inpatient/Transfer**
  – Ampicillin 50mg/kg/dose IV q6h
  – Unasyn 50mg/kg/dose IV q6
  – Ceftriaxone 75mg/kg dose IV q12
Case Scenario

- 14 month old female with h/o previous RUL PNA 1/2015 presents to ED with 1 wk cough and runny nose, fever
- v/s: T 102.8 HR 185 RR 52 SpO2 98 % RA
- PE: lungs clear
- TX: Amoxicillin 45mg/kg PO bid X 10d
Follow Up Exam

- 14 month old presents for f/u evaluation with increased lethargy, decreased oral intake, decreased number of wet diapers, moaning at times
- v/s T 98.9 HR 154 RR 34 SpO2 98% on RA
- PE: pale, child laying on mother, course breath sounds, dry mucous membranes, cap refill < 4 sec
- What do we do now?
Case Scenario 2

• 12 month old female presents to health aide at 3PM with cough X 4 days, fever X 2 days Tm 101 and pulling at ears. Diffuse wheezing course crackles.

• V/S: T101.4 HR 170 RR 64 sats 95% RA

• Albuterol nebs given in village clinic

• V/S: 100.7 HR 174 RR 72 sats 95% RA

• Arrives in ED commercial flight 6PM
<table>
<thead>
<tr>
<th>Age group</th>
<th>Heart rate (beats/minute)</th>
<th>Respiratory rate (breaths/minute)</th>
<th>Leukocyte count (leukocytes x 10³/mm³)</th>
<th>Systolic blood pressure (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn (0 days to 1 week)</td>
<td>&gt;180, &lt;100</td>
<td>&gt;50</td>
<td>&gt;34</td>
<td>&lt;59</td>
</tr>
<tr>
<td>Neonate (1 week to 1 month)</td>
<td>&gt;180, &lt;100</td>
<td>&gt;40</td>
<td>&gt;19.5 or &lt;5</td>
<td>&lt;79</td>
</tr>
<tr>
<td>Infant (1 month to 1 year)</td>
<td>&gt;180, &lt;90</td>
<td>&gt;34</td>
<td>&gt;17.5 or &lt;5</td>
<td>&lt;75</td>
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<tr>
<td>Toddler and preschool (≥1 to 5 years)</td>
<td>&gt;140, NA</td>
<td>&gt;22</td>
<td>&gt;15.5 or &lt;6</td>
<td>&lt;74</td>
</tr>
<tr>
<td>School age (≥5 to 12 years)</td>
<td>&gt;130, NA</td>
<td>&gt;18</td>
<td>&gt;13.5 or &lt;4.5</td>
<td>&lt;83</td>
</tr>
<tr>
<td>Adolescent (≥12 to &lt;18 years)</td>
<td>&gt;110, NA</td>
<td>&gt;14</td>
<td>&gt;11 or &lt;4.5</td>
<td>&lt;90</td>
</tr>
</tbody>
</table>

NA: not applicable.

Initial management of shock in children

0 minutes
- Recognition of shock:
  - Diminished peripheral pulses
  - Cool, pale, or mottled skin
  - Prolonged capillary refill time
  - Altered mental status
  - Tachycardia or bradycardia

5-15 minutes
- Identify and treat life-threatening conditions:
  - Administer high flow oxygen
  - Perform endotracheal intubation in patients with airway compromise or impending respiratory failure
  - Establish vascular access

- Infuse isotonic crystalloid 20 mL/kg over 5 to 10 minutes in patients with uncompensated shock.
  - Give patients with compensated shock 20 mL/kg over 5 to 20 minutes
  - For possible anaphylaxis, give epinephrine, diphenhydramine, and hydrocortisone
  - Institute continuous monitoring of heart rate, blood pressure, and pulse oximetry
  - Obtain diagnostic studies (including bedside glucose)

Evaluate target endpoints:
- Blood pressure (5th percentile minimum)
- Quality of pulses (strong, central + distal)
- Skin perfusion: warm, cap refill <2 seconds
- Mental status (alert)
- Urine output (>1 mL/kg per hour, once effective circulating volume is restored)

Inadequate response: 
- Targets achieved
- Continue monitoring and treatment
- Admit to hospital

15-30 minutes
- Begin treatment of glucose, electrolyte, and calcium abnormalities
  - For possible cardiogenic shock, begin vasoactive drug therapy
  - For possible sepsis, give antibiotics
  - Repeat isotonic crystalloid infusion in 20 mL/kg boluses as needed for persistence of decreased perfusion to a total of 60 mL/kg
  - Evaluate target endpoints after each bolus

Inadequate response: 
- Targets achieved

30-60 minutes
- Re-evaluate presumed cause of shock:
  - For possible hypovolemic shock, re-evaluate estimate of fluid losses, continue fluid replacement, consider colloid
  - For possible sepsis, unresponsive to fluid, begin vasoactive drug therapy
  - For hemodynamic shock, give blood products

* For possible cardiogenic shock with hypovolemia, give 5 to 10 mL/kg of isotonic fluids (eg, normal saline or Ringers lactate), infused over 10 to 20 minutes. Evaluate target and points and slowly give another 5 to 10 cc/kg if there has been improvement or no change. For patients with diabetic ketoacidosis, give 10 mL/kg of isotonic fluids over one hour.

• Such as inotropes or vasodilators. For newborns, prostaglandin E1.
• For patients with DKA who do not improve with 20 mL/kg, look for another cause of shock before administering additional crystalloid. For possible cardiogenic shock, slowly give another 5 to 10 mL/kg if there has been improvement or no change.
• Dopamine if normotensive, norepinephrine if hypotensive and vasodilated, and epinephrine if hypotensive and vasoconstricted.

Pediatric Advance Lifes Support septic shock algorithm

First hour:
- Recognize altered mental status and perfusion
- Give oxygen and support ventilation, establish vascular access and begin resuscitation according to PALS guidelines
- Consider VBG or ABG, lactate, glucose, ionized calcium, cultures, CBC

First hour: Push repeated 20 mL/kg boluses of isotonic fluid up to 3, 4, or more boluses based on patient response
Additional therapies:
- Correct hypoglycemia and hypocalcemia
- Administer first-dose antibiotics STAT
- Consider ordering STAT vasopressor drip and stress-dose hydrocortisone*

Consider ICU monitoring

Fluid responsive (i.e., normalization of blood pressure and/or perfusion?)

Begin vasoactive drug therapy and titrate to correct hypotension/poor perfusion; consider establishing arterial and central venous access
- Normotensive: Begin dopamine
- Hypotensive vasodilated (warm) shock: Begin norepinephrine
- Hypotensive vasoconstricted (cold) shock: Begin epinephrine rather than norepinephrine

Evaluate ScvO2 goal ScvO2 sat > 70 percent?

ScvO2 > 70 percent
Low BP
"Warm shock"

Additional fluid boluses
Norepinephrine +/- vasopressin

ScvO2 < 70 percent
Normal BP/poor perfusion

Transfuse to Hgb > 10 g/dL
Optimize arterial oxygen saturation
Additional fluid boluses
Consider milrinone or nitroprusside
Consider dobutamine

ScvO2 < 70 percent
Low BP/poor perfusion
"Cold shock"

Transfuse to Hgb > 10 g/dL
Optimize arterial oxygen saturation
Additional fluid boluses
Consider epinephrine or dobutamine + norepinephrine

* NOTE: Fluid refractory and dopamine- or norepinephrine-dependent shock defines patient at risk for adrenal insufficiency. Draw baseline cortisol; consider ACTH stimulation test if unsure of need for steroids. If adrenal insufficiency is suspected give hydrocortisone ≥2 mg/kg bolus IV; maximum 100 mg.

References


• UpToDate

• Seattle Children’s Hospital Community-Acquired Pneumonia clinical pathway.

