Key questions and issues

What are the central tenants of an effective Antimicrobial Stewardship Program (ASP)?

What unique role might the hospitalist play in ASPs?

What other possible tools might there be to improve responsible use of antimicrobial medications?

Objectives

Develop an understanding of the imperatives for antibiotic stewardship.

Gain insights into the tenants of antibiotic stewardship.

Recognize the successes and challenges of ASP implementation and maintenance, as well as the opportunities for innovation.

Become familiar with the benefits and limitations of serum biomarkers for bacterial infection, namely procalcitonin.
Stewardship /st(y)ōərd,SHip/

The responsible overseeing and protection of something considered worth caring for and preserving.

60%

Of all hospitalized children receive at least one antibiotic

Gerber et al 2010
Variability in Prescribing Practices

50%

Of antibiotics in inpatient settings are prescribed inappropriately, including errors in antibiotic selection, dose, and duration.

Levy et al. 2012, Dellitt et al. 2007

Public information obtained from https://www.cdc.gov/getsmart/community/programs-measurement/measuring-antibiotic-prescribing.html
Estimated minimum number of illnesses and deaths caused annually by antibiotic resistance*:

At least 🌞 2,049,442 illnesses, 🖥 23,000 deaths

*bacteria and fungus included in this report

Estimated minimum number of illnesses and death due to *Clostridium difficile* (*C. difficile*), a unique bacterial infection that, although not significantly resistant to the drugs used to treat it, is directly related to antibiotic use and resistance:

At least 🌞 250,000 illnesses, ⚰ 14,000 deaths

Public information obtained from: https://www.cdc.gov/drugresistance/about.html
Antibiotics are responsible for nearly **1 in 5** ER visits for adverse drug events.

Antibiotics are the **most common** cause of ER visits for adverse drug events in patients less than 18 years of age.

It’s more than just rashes...

Public information obtained from: https://www.cdc.gov/drugresistance/protecting_yourself_family.html

Langdon et al. 2010
The Legislative Mandates

*California Senate Bill 739 - January 1, 2008*

California hospitals are required to develop process for monitoring judicious use of antibiotics, sharing results with quality improvement committees.

*California Senate Bill 1311 - July 1, 2015*

California hospitals are required to observe antimicrobial stewardship policies in accordance with federal guidelines including the creation and support of professional Antibiotic Stewardship Programs, accountable to quality improvement committees.
Federal Action

September 18, 2014

President Obama issued an executive order identifying antibiotic-resistant bacteria as a threat to national security and convened a task force with the directive to create an action plan to combat antibiotic resistance.
Federal Action

June 2, 2015

President Obama convened the 1st Antibiotic Summit bringing key stakeholders together to make commitments to stemming the tide of antibiotic resistance in the US.


CDC 7 Core Elements of ASP

Leadership Commitment
Accountability
Drug Expertise
Action
Tracking
Reporting
Education

CDC 2014.
Pillars of Antimicrobial Stewardship

Initiation: Only treat those truly infected

Optimization: Use as narrow spectrum as possible or de-escalate regimen as soon as safe

Termination: Only treat as long as needed

Antibiotic duration

<table>
<thead>
<tr>
<th>Study</th>
<th>$N$</th>
<th>Population</th>
<th>Short-course regimen$^*$</th>
<th>Long-course regimen$^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siegel et al. 1999</td>
<td>52</td>
<td>Adult inpatients</td>
<td>Cefuroxime 750 mg IV every 8 h for 3 d, then cefuroxime axetil 500 mg every 12 h PO for 5 d</td>
<td>Cefuroxime 750 mg IV every 8 h for 3 d, then cefuroxime axetil 500 mg every 12 h PO for 8 d</td>
</tr>
<tr>
<td>Leophonte et al. 2002</td>
<td>244</td>
<td>Adult inpatients</td>
<td>Ceftriaxone 1 g IV once daily for 5 d</td>
<td>Ceftriaxone 1 g IV once daily for 10 d</td>
</tr>
<tr>
<td>Tellier et al. 2004</td>
<td>385</td>
<td>Adult inpatients</td>
<td>Telithromycin 800 mg PO once daily for 5 d</td>
<td>Telithromycin 800 mg PO once daily for 7 d</td>
</tr>
<tr>
<td>El Moussaoui et al. 2006</td>
<td>119</td>
<td>Adult inpatients</td>
<td>Amoxicillin 1 g IV every 6 h for 3 d</td>
<td>Amoxicillin 1 g IV every 6 h for 3 d, then amoxicillin 750 mg PO every 8 h for 5 d</td>
</tr>
<tr>
<td>File Jr. et al. 2007</td>
<td>510</td>
<td>Adult outpatients</td>
<td>Gemifloxacin 320 mg PO once daily for 5 d</td>
<td>Gemifloxacin 320 mg PO once daily for 7 d</td>
</tr>
</tbody>
</table>

* No statistically significant differences in cure rates.

Open source study: Pinzone et al. 2014.
Hospitalists as Stewards

Choice of antibiotics in inpatient pediatric wards often falls to hospitalists or resident housestaff.

Hospitalists interface with ER physicians and can influence the initiation/choice of antibiotics.

Hospitalists can act as liaisons to Antimicrobial Stewardship Programs, increasing the effectiveness/reach of their message.

Hospitalists are responsible for housestaff education, which can include antimicrobial stewardship practices.

MOC- Part 2 Credit

Inappropriate use of antibiotics, including errors in selection, dose, and duration are present in up to what percentage of prescriptions?

A. 15%
B. 25%
C. 50%
D. 75%
Resident Education Program

Goals:

- To improve resident knowledge of infectious diseases, specifically antibiotic activity and use in common infections
- Promote antibiotic stewardship

Components:

- Noon conference curriculum
- “Tip of the month”
- Antibiotic stewardship rounds
- Advanced inpatient rotation
Curriculum:

- 5-10 minute quiz
- 30 minutes every other week
- Review of prior topic
- ID topic of the week
- Resident vs Attending jeopardy
- Future: Qualimetrics with pre- and post-surveys

Curriculum Breakdown

<table>
<thead>
<tr>
<th>Common Syndromes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-Acquired Pneumonia</td>
<td>Neonatal Sepsis</td>
</tr>
<tr>
<td>Appendicitis</td>
<td>Acute Otitis Media</td>
</tr>
<tr>
<td>Urinary Tract Infections</td>
<td>Meningitis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fundamentals of Antibiotics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Antistaph medications</td>
<td>Beta-lactams</td>
</tr>
<tr>
<td>Fluoroquinolones</td>
<td>Anti-fungals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Testing</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Procalcitonin</td>
<td>Clostridium Difficile Testing</td>
</tr>
<tr>
<td>MRSA Nasopharyngeal Swab</td>
<td>Antibiotic levels</td>
</tr>
</tbody>
</table>
Important Themes

IDSA guidelines
Evidence-based medicine
Local resistance patterns
Pharmacokinetics
Rates of infection

Clinical Practice Guideline for the Management of Candidiasis: 2016 Update by the Infectious Diseases Society of America


1University of Alabama at Birmingham; 2Veterans Affairs Ann Arbor Healthcare System and University of Michigan Medical School, Ann Arbor; 3University of Wisconsin, Madison; 4University of Pittsburgh, Pennsylvania; 5Johns Hopkins University School of Medicine, Baltimore, Maryland; 6University of Texas Health Science Center, Houston; 7Cooper Medical School of Rowan University, Camden, New Jersey; 8University of Pennsylvania, Philadelphia; 9Stanford-Nagano University, Augusta; 10Weill Cornell Medical College and Cornell University, New York, New York; 11Children’s Hospital of Philadelphia, Philadelphia; and 12Vanderbilt University Hospital and Vanderbilt University, Nashville, Tennessee

It is important to realize that guidelines cannot always account for individual variation among patients. They are not intended to supplant physician judgment with respect to particular patients or special clinical situations. IDSA considers adherence to these guidelines to be voluntary, with the ultimate determination regarding their application to be made by the physician in the light of each patient's individual circumstances.

Keywords. candidemia; invasive candidiasis; fungal diagnostics; azoles; echinocandins.
Evidence-Based Medicine


Safety profile of quinolone antibiotics in the pediatric population.
Gracy H1.

Author information

Abstract
Fluoroquinolone-induced joint/cartilage toxicity has been observed in juvenile animal studies and is species- and dose-specific with canines exhibiting the highest rate of arthralgias. These early observations led to the contraindication of fluoroquinolones in the pediatric population. Despite these recommendations fluoroquinolones continue to be prescribed for select children with difficult-to-treat infections for whom the benefit of quinolone therapy may outweigh the risk of cartilage toxicity. A review of retrospective and prospective safety data of ciprofloxacin-treated children showed that the rates of arthralgia and quinolone-induced cartilage toxicity were low. Episodes of arthralgia were mostly reversible based on published surveillance data in children. Recent data from Bayer's ciprofloxacin clinical trials database found that the incidence of arthralgia in children did not differ between the ciprofloxacin and nonquinolone antimicrobial control groups. The role of fluoroquinolones in the treatment of certain serious infections in children does not appear to be compromised by safety concerns when used appropriately.

PMID: 14698568 DOI: 10.1097/01.inf.0000101994.26947.12

Local Resistance Patterns

Antimicrobial Susceptibility Profile Report - NCAL Kaiser Regional Laboratory 2016

URINE ISOLATES: GRAM NEGATIVE BACTERIA

PEDIATRICS <18

<table>
<thead>
<tr>
<th>Organism</th>
<th>(#iso)</th>
<th>Amoxicillin</th>
<th>Ampicillin</th>
<th>Amp/Resolactam</th>
<th>Cefazolin</th>
<th>Cefepime</th>
<th>Cefazidime</th>
<th>Ceftriaxone</th>
<th>Ciprofloxacin</th>
<th>Eradiphen</th>
<th>Gentamicin</th>
<th>Metronidazole</th>
<th>Nitrofurantoin</th>
<th>Piperacillin</th>
<th>Tobramycin</th>
<th>Trimeth/Clav</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citrobacter freundii (a)</td>
<td>46</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>100</td>
<td>83</td>
<td>87</td>
<td>96</td>
<td>100</td>
<td>98</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Citrobacter koseri (dversus)</td>
<td>59</td>
<td>100</td>
<td>R</td>
<td>R</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>95</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Enterobacter aerogenes (a)</td>
<td>53</td>
<td>100</td>
<td>R</td>
<td>R</td>
<td>100</td>
<td>98</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>98</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Enterobacter cloacae (a)</td>
<td>69</td>
<td>100</td>
<td>R</td>
<td>R</td>
<td>98</td>
<td>95</td>
<td>96</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>97</td>
<td>100</td>
<td>96</td>
<td>96</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>6541</td>
<td>100</td>
<td>89</td>
<td>66</td>
<td>66</td>
<td>100</td>
<td>98</td>
<td>97</td>
<td>94</td>
<td>100</td>
<td>99</td>
<td>98</td>
<td>96</td>
<td>96</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Klesbiella oxytoca</td>
<td>64</td>
<td>100</td>
<td>R</td>
<td>69</td>
<td>66</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>98</td>
<td>100</td>
<td>96</td>
<td>96</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Klesbiella pneumoniae</td>
<td>318</td>
<td>100</td>
<td>R</td>
<td>88</td>
<td>96</td>
<td>100</td>
<td>100</td>
<td>99</td>
<td>100</td>
<td>100</td>
<td>97</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Proteus mirabilis</td>
<td>518</td>
<td>100</td>
<td>89</td>
<td>94</td>
<td>97</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>98</td>
<td>98</td>
<td>96</td>
<td>96</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>126</td>
<td>100</td>
<td>R</td>
<td>98</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>R</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>

R Indicates organism is intrinsically resistant to this antibiotic even if it tests susceptible. See Enterobacteriaceae Intrinsic Resistance Table for more details.

a Citrobacter spp, Enterobacter spp, Hafnia spp, Morganella spp, Providencia spp, Indole-positive Proteus spp, and Serratia spp have inducible beta-lactamases
“Antibiotic Stewardship Jeopardy”: Residents vs. Staff

<table>
<thead>
<tr>
<th>What’s bugging you?</th>
<th>β-lactams</th>
<th>Other antibiotics</th>
<th>Staphing ratios</th>
<th>Testing 1, 2, 3</th>
<th>It’s NOS</th>
<th>Things not to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>$200</td>
<td>$200</td>
<td>$200</td>
<td>$200</td>
<td>$200</td>
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<td>$1000</td>
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<td>$1000</td>
<td>$1000</td>
</tr>
</tbody>
</table>

“Tip of the Month”

CLOSTRIDIA DIFFICILE

THINK BEFORE YOU TEST

Over diagnosis of Clostridia difficile in the Molecular Test Era

Pediatric Antimicrobial Stewardship
Tip of the Month

Not everyone needs vancomycin
Stewardship Rounds  
(adapted from “Handshake Stewardship”/Colorado Children’s’)

Physician reviews ASP Dashboard then meets with each team (NICU, PICU, ward teams) to discuss each patient on antibiotics including choice of antibiotic, planned duration, potential interventions:

- Discontinue antibiotics
- De-escalate antibiotics
- Broaden antibiotics
- Plan for shorter/different duration than team originally
- IV to PO
- Laboratory advice/intervention
- Recommend formal ID consult
- Teaching opportunity, emphasizing on ASP lecture topics

Additionally, Pediatric pharmacist rounds with all teams; effective ASP practice

Weekly Reports

<table>
<thead>
<tr>
<th>Handshake ASP Rounds, Weekdates: May 1-May 5, 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PICU</strong></td>
</tr>
<tr>
<td><strong>Monday</strong></td>
</tr>
<tr>
<td><strong>Tuesday</strong></td>
</tr>
<tr>
<td><strong>Wednesday</strong></td>
</tr>
<tr>
<td><strong>Thursday</strong></td>
</tr>
<tr>
<td><strong>Friday</strong></td>
</tr>
</tbody>
</table>

Handshake rounds – Type of intervention:
- A. Discontinue antibiotics
- B. De-escalate antibiotics
- C. Plan for shorter/different duration than team originally
- D. Broaden antibiotics
- E. Laboratory advice/intervention
- F. IV to PO
- G. Recommend formal ID consult

7 patients on antibiotics/2 of those patients currently being followed by ID
1 intervention: de-escalate antibiotics
Important themes addressed throughout the ASP educational curriculum at our institution included which of the following:

A. IDSA guidelines
B. Local antibiotic resistance patterns
C. Pharmacokinetics
D. Evidence-based medicine
E. All of the above
Goal: Responsible Antibiotic Use at Kaiser Oakland

2015: Antibiotic Stewardship launch
Goal: Narrow Antibiotic Use

Decrease piperacillin-tazobactam
Increase ceftriaxone / metronidazole
2015: Pediatric Surgery transition

Appendicitis

Lee JY, et al.

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>CTX, Metronidazole (n=66)</th>
<th>Other Regimens (n=57)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-op LOS</td>
<td>5.7 +/- 2.96</td>
<td>5.8 +/- 2.46</td>
<td>0.83</td>
</tr>
<tr>
<td>Post-op Abscess Rate</td>
<td>5 (8%)</td>
<td>2 (4%)</td>
<td>0.57</td>
</tr>
<tr>
<td>Post-op Wound Infx Rate</td>
<td>3 (5%)</td>
<td>1 (2%)</td>
<td>0.73</td>
</tr>
<tr>
<td>Readmission</td>
<td>2 (3%)</td>
<td>6 (11%)</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Lee et al. 2012
Using less piperacillin-tazobactam
Using more ceftriaxone/metronidazole

Readmission for complications did not increase from 2014-2016
Appendicitis

Summary

Less piperacillin-tazobactam
More ceftriaxone / metronidazole
Readmission rate did not increase

Community Acquired Pneumonia

Significant worldwide morbidity and mortality
Almost always treat with antibiotics
Challenges of targeted therapy
  Difficult to identify source
  Empiric therapy guided by clinical judgement
CDC Checklist

Checklist for hospitals to implement Antibiotic Stewardship Programs

Core conditions to target optimal use of antibiotics

CDC. Core Elements of Hospital Antibiotic Stewardship Programs. Atlanta, GA: US Department of Health and Human Services, CDC; 2014.

Diagnosis and infections specific interventions

<table>
<thead>
<tr>
<th>Does your facility have specific interventions in place to ensure optimal use of antibiotics to treat the following common infections?</th>
<th>Action performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-acquired pneumonia</td>
<td>Yes</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>Yes</td>
</tr>
<tr>
<td>Skin and soft tissue infections</td>
<td>Yes</td>
</tr>
<tr>
<td>Surgical prophylaxis</td>
<td>Yes</td>
</tr>
<tr>
<td>Empiric treatment of Methicillin-resistant <em>Staphylococcus aureus</em> (MRSA)</td>
<td>Yes</td>
</tr>
<tr>
<td>Non-<em>C. Difficile</em> infection (CDI) antibiotics in new cases of CDI</td>
<td>Yes</td>
</tr>
<tr>
<td>Culture-proven invasive (e.g., blood stream) infections</td>
<td>Yes</td>
</tr>
</tbody>
</table>

CDC. Core Elements of Hospital Antibiotic Stewardship Programs. Atlanta, GA: US Department of Health and Human Services, CDC; 2014.
Goal: Narrow Antibiotic Use

Targeted use of azithromycin

Narrow beta-lactam use

Ampicillin / amoxicillin rather than ceftriaxone

Goal: Targeted Use of Azithromycin

“Atypical” pneumonia

Uncommon < 5 yo

IDSA – 2011

For the older child: “Macrolide antibiotics should be prescribed for treatment of children (primarily school-aged children and adolescents)”

Bradley et al. 2011
Goal: Targeted Use of Azithromycin

Cochrane Review

12 studies, ~2000 children

Outcome: Sx Improvement

“Almost all showed no benefit”

“Insufficient evidence” regarding benefit of macrolide use

Community Acquired Pneumonia

Mulholland et al. 2010

13.2%

Of Mycoplasma pneumoniae strains resistant to macrolides when tested across 6 US medical centers

Zheng et al. 2015
Fewer 0-5 year olds receiving azithromycin
Goal: Reduce Ceftriaxone Use

Community Acquired Pneumonia

Ampicillin or amoxicillin rather than ceftriaxone as first line

<table>
<thead>
<tr>
<th>Fully Immunized</th>
<th>Ampicillin or PCN G *Unless high S. pneumo resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Fully Immunized or infant/child with 'life threatening' illness</td>
<td>Ceftriaxone</td>
</tr>
</tbody>
</table>

Bradley et al. 2011

Increased ampicillin/amoxicillin use
Decreased ceftriaxone use

Readmission rate not significantly different from 2014-2016

Kaiser Oakland Data
Summary

Less “inappropriate” azithromycin
Fewer patients receiving ceftriaxone
Stable readmissions trend

Limitations

Preliminary data
Short term
Illness severity / patient complexity
Antibiotic duration
MOC- Part 2 Credit

Which antibiotic demonstrates “insufficient evidence” of benefit in community acquired pneumonia according to a Cochrane Database meta-analysis, and is therefore a target for Antimicrobial Stewardship Programs?

A. Ceftriaxone  
B. Amoxicillin  
C. Azithromycin  
D. Ampicillin-sulbactam

Procalcitonin Biomarker:  
Uses and Limitations
Procalcitonin (PCT) Background

- Pre-hormone of calcitonin
- Produced by C-cells of the thyroid, but also all cells in response to inflammation

PCT Kinetics

- Normal range: undetectable
- Rises 4 hours after stimulation
- Peaks around 6-24 hours
- ½ life: 22-26 hours
Proposed PCT Uses

1. Rapid Diagnostics
   - Bacterial vs. non-bacterial infection

2. Antibiotic Stewardship
   - Initiation of antibiotics
   - Response to antibiotics
   - Duration of antibiotics therapy

Sepsis data (Hatherill et al. 1999)

Prospective study

175 PICU children → 77 septic shock

0 - 16 years old (median: 16 months)

ROC curve: >20 ng/mL threshold
   - sensitivity 83%, specificity 92%

PCT > CRP > WBC
Meningitis data
(Dubos et al. 2006, 2008)

Retrospective cohort studies in European hospitals

- PCT higher in bacterial meningitis vs. aseptic meningitis
- PCT threshold: >0.5 ng/mL
  - sensitivity 99%, specificity 83%
- PCT > CSF protein, CSF neutrophil

<table>
<thead>
<tr>
<th>AUC of the ROC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.98</td>
</tr>
<tr>
<td>0.89</td>
</tr>
<tr>
<td>0.88</td>
</tr>
<tr>
<td>0.87</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case Description</th>
<th>PCT (ng/mL)</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1: 5 year old male with 1 week of fever presenting with facial swelling and diffuse rash that progressed to uncompensated shock.</td>
<td>2.6</td>
<td>Streptococcus pyogenes bacteremia Toxic Shock Syndrome</td>
</tr>
<tr>
<td>Case Description</td>
<td>PCT (ng/mL)</td>
<td>Diagnosis</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
<td>-------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td><strong>Case 1:</strong> 5 year old male with 1 week of fever presenting with facial swelling</td>
<td>2.6</td>
<td><em>Streptococcus pyogenes</em> bacteremia</td>
</tr>
<tr>
<td>and diffuse rash that progressed to uncompensated shock.</td>
<td></td>
<td><em>Toxic Shock Syndrome</em></td>
</tr>
<tr>
<td><strong>Case 2:</strong> 20 day old term female infant with fever.</td>
<td>4.6</td>
<td><em>Group B Strep bacteremia</em></td>
</tr>
<tr>
<td><strong>Case 3:</strong> 2 year old male with B cell ALL and a central line presenting with</td>
<td>22</td>
<td><em>central line infection,</em></td>
</tr>
<tr>
<td>neutropenic fever.</td>
<td></td>
<td><em>bacteremia</em></td>
</tr>
</tbody>
</table>
Pneumonia data
(Baer et al. 2013: ProPAED Study)

Switzerland ED
n = 337 (1 month to 18 years)
Threshold:
- 0.25 - 0.5 ng/mL: likely bacterial, treat
- >0.5 ng/mL: probable bacterial, treat

For all LRTI, there was no increase in complications

Case Description  PCT (ng/mL)  Diagnosis
---  ----  
Case 1: 4 year old male with recent RLL pneumonia s/p antibiotics, presenting with fevers and respiratory distress.  5.4  Empyema
<table>
<thead>
<tr>
<th>Case Description</th>
<th>PCT (ng/mL)</th>
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</tr>
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<td><strong>Case 1:</strong> 4 year old male with recent RLL pneumonia s/p antibiotics, presenting with fevers and respiratory distress.</td>
<td>5.4</td>
<td>Empyema</td>
</tr>
<tr>
<td><strong>Case 2:</strong> 2 year old female with failure to thrive and chronic lung disease presenting with fevers and respiratory distress.</td>
<td>0.5</td>
<td><em>E. coli</em> pyelonephritis</td>
</tr>
<tr>
<td><strong>Case 3:</strong> 17 year old female with polyarticular JIA and psoriasis presenting with left arm erythema and edema.</td>
<td>&lt;0.1</td>
<td>MSSA cellulitis</td>
</tr>
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<td>PCT (ng/mL)</td>
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</tr>
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<td>&lt;0.1</td>
<td>MSSA cellulitis</td>
</tr>
<tr>
<td><strong>Case 4:</strong> 1 year old female s/p lumbar lipoma resection with wound dehiscence and ongoing fevers.</td>
<td>0.1</td>
<td>Localized <strong>E. coli</strong> wound infection. Not meningitis.</td>
</tr>
</tbody>
</table>

**Pneumonia data**  
*(Baer et al. 2013: ProPAED Study)*

Switzerland ED  
*n = 337 (1 month to 18 years)*  
Threshold:  
- 0.25 - 0.5 ng/mL: likely bacterial, treat  
- >0.5 ng/mL: probable bacterial, treat

For all LRTI:  
- Initiation rate of antibiotics similar  
- Decreased average duration 6 → 4 days

Baer et al. 2013
<table>
<thead>
<tr>
<th>Case Description</th>
<th>PCT (ng/mL)</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Case 1:</strong> 2 year old with expressive language delay, presenting in status epilepticus.</td>
<td>22</td>
<td>Refractory status epilepticus.</td>
</tr>
</tbody>
</table>
| **Case 2:** 3 year old female presenting with fever x 7 days, conjunctivitis, strawberry tongue, rash. | 1.2         | Refractory Kawasaki disease.  
|                                                                                   |             | S/p IVIG x 2, then steroids.                  |
**Other Confounders:**

<table>
<thead>
<tr>
<th>Status Epilepticus</th>
<th>Inhalational Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refractory Kawasaki</td>
<td>Appendicitis / Pancreatitis</td>
</tr>
<tr>
<td>Extensive Trauma / Surgery</td>
<td>Burns / Heat Stroke</td>
</tr>
<tr>
<td>Hypothermia after Cardiac Arrest</td>
<td>Fungal Infections</td>
</tr>
<tr>
<td>Normal Newborn Physiology</td>
<td>Systemic Viral Infections</td>
</tr>
<tr>
<td>Obstructive Ileus</td>
<td>Vasculitis</td>
</tr>
</tbody>
</table>

**Proposed PCT Uses**

1. **Rapid Diagnostics**
   - Bacterial vs. non-bacterial infection

2. **Antibiotic Stewardship**
   - Initiation of antibiotics
   - Response to antibiotics
   - Duration of antibiotics therapy
Procalcitonin is reported as a diagnostic biomarker for bacterial infections, but clinical context must be taken into consideration.

MOC- Part 2 Credit

Elevation in serum procalcitonin levels is most sensitive in which of the following infections?

A. Urinary tract infection
B. Aseptic meningitis
C. Bacteremia/sepsis
D. Cellulitis
Take Home Points

Drug resistance among bacteria is a present and rapidly growing threat to public health.

Antimicrobial Stewardship Programs effectively reduce the use of unnecessary antimicrobial agents among inpatients when implemented well and with clear leadership.

Hospitalists can be effective members of Antimicrobial Stewardship Programs, as both prescribers and educators.

Further research as it relates to antimicrobial stewardship is needed, including (but not limited to) ideal antibiotic duration and the performance of serum biomarkers of infection.

Special Thanks

Carol Glaser, MD, DVM, MPH
Shital Kelshikar, PharmD
Zapora Zangwill
References

- Center for Disease Control and Prevention. Resistance in the United States: https://www.cdc.gov/drugresistance/about.html
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