Therapeutic Strategies for Gram Negative Multi-drug resistant Bacterial Infections
Debra A. Goff, Pharm.D., FCCP

Clinical Associate Professor
Infectious Diseases Specialist
The Ohio State University Medical Center
Columbus, Ohio
Columbus, Ohio USA
The Ohio State University Medical Center

- **James Cancer Center**
  bone marrow transplants & oncology  
  165 beds

- **Ross Heart Hospital**
  Heart and lung transplants, cardiac  
  130 beds

- **The Ohio State University Hospital**
  solid organ transplant, General Medicine Surgery, SICU, MICU, NICU, Burn unit  
  850 beds
The Ohio State University Football Stadium
Capacity up to 105,000 people
Imagine the stadiums filled with people
Impact of Antibacterial Resistance

- Each year an estimated 1.7 million patients in U.S. hospitals acquire an infection resulting in **100,000 deaths** \(^1\)
- This results in an additional $6.5 billion in health care expenditures \(^2\)
- On October 1, 2008, Centers for Medicare Services in USA **limited reimbursement** for hospital-acquired conditions deemed preventable
  - catheter-associated urinary infections
  - vascular catheter-associated infections
  - mediastinitis after coronary artery bypass graft (CABG) surgery
  - surgical site infections

ESCAPE Pathogens

- **ESKAPE**: Describes the most critical drug resistant pathogens:
  - **E** = *Enterococcus faecium*
  - **S** = *Staphylococcus aureus*
  - **C** = *Clostridium difficile*
  - **C** = *Clostridium difficile*
  - **A** = *Acinetobacter baumannii*
  - **P** = *Pseudomonas aeruginosa*
  - **E** = *Enterobacteriaceae* (*E. coli* infection more numerous than *Klebsiella* and *Enterobacter* combined)
Colistin is only prescribed for MDR organisms when there are no other options.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-2004</td>
<td>$2,375</td>
</tr>
<tr>
<td>2007-2008</td>
<td>$23,309</td>
</tr>
<tr>
<td>2008-2009</td>
<td>$48,324</td>
</tr>
</tbody>
</table>
Multidrug resistant gram negative organisms
BAD BUGS We NEED DRUGS

Antibiotics are unique in that they become LESS effective the more they are used.

**Antibiotics are unlike any other drugs in that use of antibiotics in one patient can compromise efficacy in another.**

Resistant microorganisms can be spread to patients who have never received an antibiotic.

You can’t “catch cancer” from the patient next to you.

You CAN catch Acinetobacter or many other drug-resistant microorganisms!
### Hospital and Societal Costs of Antimicrobial-Resistant Infections

<table>
<thead>
<tr>
<th></th>
<th>All patients</th>
<th>Patients with ARI</th>
<th>Patients without ARI</th>
</tr>
</thead>
<tbody>
<tr>
<td>n (%)</td>
<td>1391</td>
<td>188 (13.5)</td>
<td>1203 (86.5)</td>
</tr>
<tr>
<td>APACHE III score</td>
<td>42.1</td>
<td>54.8</td>
<td>40.1</td>
</tr>
<tr>
<td>Duration of stay (days)</td>
<td>10.2</td>
<td>24.2</td>
<td>8.0</td>
</tr>
<tr>
<td>HAI (n)</td>
<td>260</td>
<td>135</td>
<td>125</td>
</tr>
<tr>
<td>Cost per day (US$)</td>
<td>1651</td>
<td>2098</td>
<td>1581</td>
</tr>
<tr>
<td>Total cost (US$)</td>
<td>19,267</td>
<td>58,029</td>
<td>13,210</td>
</tr>
<tr>
<td>Death [n (%)]</td>
<td>70</td>
<td>34 (18.1)</td>
<td>36 (3.0)</td>
</tr>
</tbody>
</table>

Mean values shown in table.
HAI: health care–acquired infection
<table>
<thead>
<tr>
<th>organism</th>
<th>Mean cost (USD) per patients N=1391</th>
<th>Mean cost (USD) per patients Health-care acquired</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>E</strong> VRE</td>
<td>$66,416</td>
<td>$73,481</td>
</tr>
<tr>
<td><strong>S</strong> MRSA</td>
<td>$46,236</td>
<td>$60,984</td>
</tr>
<tr>
<td><strong>A</strong> Acinetobacter</td>
<td>$97,444</td>
<td>$111,062</td>
</tr>
<tr>
<td>resistant to amikacin or imipenem</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E</strong> Klebsiella or Ecoli</td>
<td>$26,549</td>
<td>$39,403</td>
</tr>
<tr>
<td>resistant to quinolones or 3GC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple ARIs</td>
<td>$157,835</td>
<td></td>
</tr>
</tbody>
</table>

Hospital and Societal Costs of Antimicrobial-Resistant Infections

Hospital and Societal Costs of Antimicrobial-Resistant Infections

Figure 2
Projected cost savings if antimicrobial-resistant infection (ARI) rates were reduced from 13.5% to 10%.

Current ARI rate: 13.5%  
Reduced ARI rate: 10%

Savings for 1391 patients: $2.7 million total  
$1,948 per patient

Hospital and Societal Costs of Antimicrobial-Resistant Infections

• The attributable medical and societal costs of ARIs are considerable.
• The lowest estimate using sensitivity analysis resulted in a cost of $13.35 million in 2008 dollars in this patient cohort.
• This detailed analysis of the cost of antibiotic resistance in a single large teaching hospital gives an indication of the magnitude of the burden imposed by resistance.
• Efforts must be increased to control antibiotic resistance.

Strategy #1
Antimicrobial Stewardship Team

Clinical Pharmacist
ID Physician
Infection Information System Specialist
Hospital Epidemiologist
Clinical Microbiologist

Patient

Optimal Team Members (A-III)

“ASP: there’s no such thing as too much”
Dr Pagani Bolzano Italy

OSU Antimicrobial Stewardship Program

ASP is a corporate commitment!
Are Guidelines Focused and Easy to Follow?
Strategy #2
Develop Specific Antibiograms
Consensus Guideline from Clinical and Laboratory Standards Institute (CLSI)

- Monitoring of drug resistance at the local level is crucial to support clinical decision making.
- Algorithms for handling repeat isolates
  - patient-based
  - episode-based
  - resistance phenotype-based
- Combination Antibiograms useful in ICU with high gram-negative resistance

Do MD’s Use Hospital Antibiograms?
Online survey of 545 residents at a University Teaching Hospital

- How data is communicated to the medical staff is critical

Antibiograms

• Should be produced annually
• ICU specific is necessary in era of escalating resistance
• ED specific skin/skin structure antibiogram
  Developed in response to escalating prevalence of CA-MRSA
• Combination Antibiograms
  Useful in ICU with high gram-negative resistance
• Use this data to guide/change prescribing
  It’s based on evidence/data from your own hospital

CA-MRSA = community-acquired methicillin-resistant *Staph. aureus*
Example: Hospital-wide Antibiogram

<table>
<thead>
<tr>
<th></th>
<th>Pip/tazo</th>
<th>Cefepime</th>
<th>Imipenem</th>
<th>Cipro</th>
<th>Tobramycin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>K. pneumoniae</strong> (954)</td>
<td>91</td>
<td>95</td>
<td>99</td>
<td>88</td>
<td>92</td>
</tr>
<tr>
<td><strong>E. cloacae</strong> (287)</td>
<td>79</td>
<td>95</td>
<td>95</td>
<td>92</td>
<td>91</td>
</tr>
<tr>
<td><strong>E. coli</strong> (1971)</td>
<td>96</td>
<td>99</td>
<td>99</td>
<td>89</td>
<td>98</td>
</tr>
<tr>
<td><strong>P. aeruginosa</strong> (1039)</td>
<td>87</td>
<td>70</td>
<td>81</td>
<td>70</td>
<td>89</td>
</tr>
<tr>
<td><strong>A. baumannii</strong> (121)</td>
<td>91</td>
<td>80</td>
<td>100</td>
<td>70</td>
<td>85</td>
</tr>
</tbody>
</table>
Example: ICU Antibiogram
First isolates only

<table>
<thead>
<tr>
<th></th>
<th>Pip/tazo</th>
<th>Cefepime</th>
<th>Imipenem</th>
<th>Cipro</th>
<th>Tobramycin</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>K. pneumoniae</em></td>
<td>66</td>
<td>71</td>
<td>100</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td>(32)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. cloacae</em></td>
<td>77</td>
<td>77</td>
<td>92</td>
<td>77</td>
<td>69</td>
</tr>
<tr>
<td>(13)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>94</td>
<td>94</td>
<td>94</td>
<td>89</td>
<td>94</td>
</tr>
<tr>
<td>(16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td>81</td>
<td>59</td>
<td>70</td>
<td>78</td>
<td>95</td>
</tr>
<tr>
<td>(37)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>A. baumannii</em></td>
<td>86</td>
<td>14</td>
<td>86</td>
<td>52</td>
<td>19</td>
</tr>
<tr>
<td>(21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Targeted Empiric Coverage

- Ertapenem
- Ampicillin/sulbactam
- Piperacillin/tazobactam
- Imipenem

Targeted Empiric Coverage

- Anaerobes
- Gram-positives
- Non-Pseudomonas gram-negatives

Resistant ESBL’s

Pseudomonas aeruginosa

Collateral Damage
### ASP initiative in the Management of complicated intra-abdominal Infection

**Example: Surgical ICU and Hospital Antibiogram**

<table>
<thead>
<tr>
<th>Organism</th>
<th>Ampicillin/sulbactam</th>
<th>Ertapenem</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SICU</td>
<td>hospital</td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>42%</td>
<td>45%</td>
</tr>
<tr>
<td><em>E. coli</em> ESBL-producing</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>75%</td>
<td>78%</td>
</tr>
<tr>
<td><em>K. pneumoniae</em> ESBL-producing</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Anaerobes</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><em>Enterococcus</em></td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Neither ampicillin-sulbactam nor ertapenem covers *P. aeruginosa*.
# Antibiotic By Site of Infection

## Computer order entry

<table>
<thead>
<tr>
<th>Pathway-Enter Orders</th>
<th>Pharmacy Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name:</strong> MOUSE, MINNIE</td>
<td><strong>MR#: 300010872</strong></td>
</tr>
</tbody>
</table>

### Lung Non-ICU:
- CAP
- HCAP

### Skin/Soft Tissue Non-ICU:
- Cellulitis
- Diabetic Foot Ulcer/Chr Wound
- Septic Arthritis
- Necrotizing Fasciitis

### Catheter Related Non-ICU:
- Catheter Related

### Meningitis/Encephalitis Non-ICU:
- Community Acquired
- Community Acquired Listeria Rsk
- Nosocomial, involving hardware

### Abdomen Non-ICU:
- Upper GI - Esoph to Prox Small Bowel
- Lower GI - Mid Small Bowel to Rectum
- Biliary Tract
- Necrotizing Pancreatitis
- C Difficile

### GU Non-ICU:
- Cystitis, Uncomplicated Pyelo
- Complicated Pyelo
- GYN
- PID

### Unknown Source Non-ICU:
- Normal Host-Severe Sepsis
- Immunocompromised - Severe Sepsis
- Febrile Neutropenia-No Organ Failure

---

**F1 Exit System**  **F4 Skip Selection**  **F2 Census**
Strategy # 3 Evaluate the impact of your recommendations
Ertapenem: No Effect on Imipenem Susceptibility to Gram-Negative Pathogens 5

Years after Formulary Addition
Carbapenem Use and P. aeruginosa Susceptibility

Goff D, Mangino J. 2008 J. Infection 57(2);123-127
Consensus Guideline from Clinical and Laboratory Standards Institute: Antibiograms

- Monitoring of drug resistance at the local level is crucial to support clinical decision making.
- Algorithms for handling repeat isolates
  - patient-based
  - episode-based
  - resistance phenotype-based

Examples of How Different Methods Yield Different % Susceptibility

### Table 3
Isolates chosen from the sample patient that would be included in the analysis according to various algorithms for harding repeat isolates.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Isolates included in the analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolate based (all isolates)</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Patient based (first isolate per patient)</td>
<td>1</td>
</tr>
<tr>
<td>Episode based (first isolate per episode)</td>
<td></td>
</tr>
<tr>
<td>7-Day interval from initial isolate</td>
<td>1, 3, 4</td>
</tr>
<tr>
<td>7-Day interval from previous isolate</td>
<td>1, 3, 4</td>
</tr>
<tr>
<td>30-Day interval from initial isolate</td>
<td>1, 4</td>
</tr>
<tr>
<td>30-Day interval from previous isolate</td>
<td>1</td>
</tr>
<tr>
<td>Resistance phenotype based (first isolate per phenotype)</td>
<td></td>
</tr>
<tr>
<td>Major difference in any antimicrobial result</td>
<td></td>
</tr>
<tr>
<td>Consecutive isolates</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Nonconsecutive isolates</td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>Major difference in oxacillin result</td>
<td></td>
</tr>
<tr>
<td>Consecutive isolates</td>
<td>1, 2</td>
</tr>
<tr>
<td>Nonconsecutive isolates</td>
<td>1, 2</td>
</tr>
</tbody>
</table>

### Table 4
Estimates of the percentage susceptible for *Staphylococcus aureus* (oxacillin) and *Pseudomonas aeruginosa* (ciprofloxacin) using 5 different calculation algorithms to analyze data in a single dataset.

<table>
<thead>
<tr>
<th>Pathogen, algorithm</th>
<th>No. of isolates</th>
<th>Susceptible isolates, %</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S. aureus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient based (first isolate per patient)</td>
<td>1439</td>
<td>55</td>
</tr>
<tr>
<td>Episode based (30-day interval)</td>
<td>1615</td>
<td>53</td>
</tr>
<tr>
<td>Phenotype based</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major difference in oxacillin result</td>
<td>1467</td>
<td>55</td>
</tr>
<tr>
<td>Major difference in any antimicrobial result</td>
<td>1536</td>
<td>54</td>
</tr>
<tr>
<td>Isolate-based (all isolates)</td>
<td>2192</td>
<td>49</td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient based (first isolate per patient)</td>
<td>742</td>
<td>70</td>
</tr>
<tr>
<td>Episode based (30-day interval)</td>
<td>864</td>
<td>69</td>
</tr>
<tr>
<td>Phenotype based</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major difference in ciprofloxacin result</td>
<td>767</td>
<td>69</td>
</tr>
<tr>
<td>Major difference in any antimicrobial result</td>
<td>919</td>
<td>66</td>
</tr>
<tr>
<td>Isolate-based (all isolates)</td>
<td>1445</td>
<td>62</td>
</tr>
</tbody>
</table>

**Combination Antibiogram: SICU**

Empiric antibiotics: pip/tazo + amikacin

<table>
<thead>
<tr>
<th>Antibiotics</th>
<th>Pip/tazo</th>
<th>Cefepime</th>
<th>Imipenem</th>
<th>Cipro</th>
<th>Amikacin</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. aeruginosa</em></td>
<td>84%</td>
<td>67%</td>
<td>69%</td>
<td>65%</td>
<td>89%</td>
</tr>
<tr>
<td>(116)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For all pip/tazo resistant *P. aeruginosa* what is the most effective 2\textsuperscript{nd} agent?

| *P. aeruginosa*    | 0        | 9        | 39       | 33    | 89       |
| (19) pip/tazo R    |          |          |          |       |          |

17/19 pip/tazo resistant isolates are covered (susceptible) by amikacin

The additional of empiric amikacin benefits only 14.6% (17/116) of all patients.
Utilize current data to support change in therapy

- CLSI (EUCAST in Europe) will be adjusting the MIC break points for susceptibility of *P. aeruginosa* to piperacillin-tazobactam.
- Currently an MIC of 64 mg/L is considered susceptible. This will be considered resistant based on published PK/PD data.
- Evaluate your own hospital isolates to determine what % have MIC=64 mg/L.
- When evaluating patients, if the MIC is 64 mg/L, recommend alternative therapy.

CLSI = Clinical and Laboratory Standards Institute  
MIC = minimum inhibitory concentration
Who is Your Audience?

ID MDs
Residents and Fellows
Critical Care
Emergency room MDs
RN
Pharmacists in your department!
Hospitalists
Surgeons
Strategy #4  Take old drugs and maximize the PK/PD
Implement Continuous/Extended Infusion pip/tazo

• Why do this?
  Have knowledge of the literature

• How do I do this?
  Talk with the IV room pharmacists, discuss logistics and work load, discuss infusion pump-related issues

• Think about who might object to the idea?
  The person who is inconvenienced most is the RN
  Need to worry about drug incompatibility
  Ties up the line
Pharmacodynamic Dose Optimization

- **Extended infusion**
  pip/tazo, **Purpose**: optimize current antimicrobials
  Maximize dosing to treat resistant or high MIC organisms

- **Efficacy of pip/tazo extended infusion**
  reduced mortality compared with intermittent infusion in patients with *P. aeruginosa* infection and APACHE II scores ≥17

  APACHE II = Acute Physiological and Chronic Health Evaluation-II
Extended-Infusion Dosing Strategy
Slide used at OSUMC to Educate RNs

### Strategy #5

**Checklist of Interventions to Decrease Healthcare-Associated \textit{C. difficile} Infection**

Bundled approach: antimicrobial use, infection control, and proper environmental cleaning

\textit{Clostridium difficile} infection checklist at Brigham and Women’s Hospital.

#### Prevention Checklist
- When an MD, PA, NP, or RN suspects a patient has CDI:
  - Physician, Physician Assistant, or Nurse Practitioner:
    - Initiate Contact Precautions Plus
    - Order stool \textit{C. difficile} toxin testing
    - Discontinue non-essential antimicrobials
    - Discontinue all anti-peristaltic medications
  - Registered Nurse:
    - Obtain stool sample for \textit{C. difficile} toxin test
    - Place patient in single-patient room
    - Place Contact Precautions Plus sign on patient’s door
    - Ensure that gloves and gowns are easily accessible from patient’s room
    - Place dedicated stethoscope in patient’s room
    - Remind staff to wash hands with soap and water following patient contact
  - Microbiology Laboratory Staff Person:
    - Call relevant patient floor with positive \textit{C. difficile} toxin test result
    - Provide daily list of positive test results for Infection Control
  - Infection Control Practitioner:
    - Check microbiology results daily for positive \textit{C. difficile} toxin test results
    - Call relevant floor to confirm patient with positive \textit{C. difficile} toxin test results is in a single-patient room and that the Contact Precautions Plus sign is on the patient’s door
    - Flag the patient’s \textit{C. difficile} status in the hospital’s clinical information system or in the patient’s chart
    - Alert housekeeping that the patient is on Contact Precautions Plus
  - Environmental Services Staff Person:
    - Prior to discharge cleaning, check for Contact Precautions Plus sign on the patient’s door
    - If Contact Precautions Plus sign is on the door, clean the room with a bleach-based cleaning agent
    - Confirm for supervisor that bleach-based cleaning agent was used for discharge cleaning for every patient on Contact Precautions Plus

#### Treatment Checklist
- When an MD, PA, or NP diagnoses mild CDI: All of the following criteria are present: diarrhea (≥ 3 BM/day), no fever, WBC ≤ 10,000, no abdominal signs, and no evidence of sepsis
  - Physician, Physician Assistant, or Nurse Practitioner:
    - Initiate oral metronidazole at dose 500mg every 8 hours
    - If no clinical improvement by 48-72 hours after discharge, treat patient as moderate CDI
    - Continue therapy for at least 14 days total and at least 10 days after symptoms have abated

- When an MD, PA, or NP diagnoses moderate CDI: At least one of the following criteria is present: diarrhea (≥ 3 BM/day), fever, WBC > 12,000, abdominal pain or tenderness, leucocytosis, leukopenia, and/or fever > 38°C, constitutional symptoms, and/or sepsis
  - Physician, Physician Assistant, or Nurse Practitioner:
    - Initiate oral vancomycin at dose 250mg every 6 hours
    - If no clinical improvement by 48-72 hours, add IV metronidazole at dose 500mg every 8 hours
    - Consider obtaining infectious disease consultation
    - Consider obtaining abdominal CT scan
    - Continue therapy for at least 14 days total and at least 10 days after symptoms have abated

- When an MD, PA, or NP diagnoses severe CDI: At least one of the following criteria is present: diarrhea (≥ 3 BM/day), fever > 38°C, WBC > 25,000, abdominal pain, tenderness, and/or fever > 39°C, leukocytosis, and/or constitutional symptoms (e.g., anorexia, nausea, vomiting, abdominal pain, diarrhea, and/or fever)
  - Physician, Physician Assistant, or Nurse Practitioner:
    - Obtain immediate infectious disease consultation
    - Obtain immediate general surgery consultation
    - Obtain abdominal CT scan
    - Initiate oral vancomycin at dose 250mg every 6 hours together with IV metronidazole at dose 500mg every 6 hours and follow with general surgery regarding its use, consider rectal vancomycin
    - Ask general surgery service to assess the need for colectomy
Checklist of Interventions to Decrease HCA-C. difficile Infection

Bundled approach: antimicrobial use, infection control, and proper environmental cleaning

Hospital-wide impact of a standardized order set for the management of bacteremic severe sepsis

Order sets were derived from the Surviving Sepsis Campaign

A retrospective before after study design of 400 patients

Patients had have a diagnosis of severe sepsis & + blood culture

Patients in the after group received more IV fluids in the 1st 12 hours after hypotension more likely to receive appropriate initial antibiotics lower in-house mortality (55% vs 39.5%, p<0.01)

Order sets improved the management of severe sepsis and improved survival.

Strategy #6 New diagnostic tests
Multiplex PCR detection enhancement of bacteremia and fungemia

- **Objective**: test a multiplex RT-PCR method for simultaneous detection of multiple organisms in bloodstream infections

- **Methods**: Prospective observational study of 200 patients at risk of BSI with signs of SIRS.

Louie R. et al 2008 CCM :36(5);1487-1492.
Tsalk E et al 2010 JCM 48(1); 26-33.
### Organisms detected by multiplex PCR

<table>
<thead>
<tr>
<th>Gram-Positive</th>
<th>Gram-Negative</th>
<th>Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoNS§</td>
<td>Acinetobacter baumannii</td>
<td>Aspergillus fumigatus</td>
</tr>
<tr>
<td>Enterococcus faecium</td>
<td>Enterobacter aerogenes/cloacae</td>
<td>Candida albicans</td>
</tr>
<tr>
<td>Enterococcus faecalis</td>
<td>Escherichia coli</td>
<td>Candida glabrata</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>Klebsiella pneumoniae/oxytoca</td>
<td>Candida kruzei</td>
</tr>
<tr>
<td>Streptococcus pneumoniae</td>
<td>Proteus mirabilis</td>
<td>Candida parapsilosis</td>
</tr>
<tr>
<td>Streptococcus sp.</td>
<td>Pseudomonas aeruginosa</td>
<td>Candida tropicalis</td>
</tr>
<tr>
<td>MRSA (mecA gene)§</td>
<td>Serratia marcescens</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stenotrophomonas maltophilia</td>
<td></td>
</tr>
</tbody>
</table>

Louie R. et al CCM 2008:36(5);1487-1492.
PCR detected bacteria/fungi in 45 cases vs 37 by blood culture.

PCR detected mecA in all 3 culture confirmed MRSA

PCR did not detect *E. faecalis* in 5 BC confirmed cases

7 samples could be tested simultaneously in 6.54 hours
Conclusion

• Despite limitations of both blood culture and RT multiplex PCR methods
  1. PCR could be an adjunct to BC
  2. PCR can facilitate early detection
  3. Early detection can facilitate evidence-based treatment decisions

Louie R. et al 2008 CCM 36(5);1487-1492.
Tsali E et al 2010 JCM 48(1); 26-33.
Use of procalcitonin to reduce patients exposure to antibiotics in ICU (PRORATA trial)

A randomized multicenter effectiveness trial to assess the benefit of procalcitonin to help MD start, continue, or stop antibiotics for patients in ICU with suspected bacterial infections

Results: Procalcitonin guided antibiotic treatment
Lowers antibiotic exposure by 2.7 days and is Non-inferior to standard care with respect to outcomes.

Ref: Bouadma et al Lancet 2010;375:463-474
Strategy #7 New technology

Soap-sniffing Technology Encourages Hand Washing To Reduce Hospital-acquired Infections, Save Money

ScienceDaily (June 5, 2009) — Call it a Breathalyzer for the hands. Using sensors capable of detecting drugs in breath, new technology developed at University of Florida monitors health-care workers’ hand hygiene by detecting sanitizer or soap fumes given off from their hands.

Here’s how it works.

1. The hospital workers squirt sanitizer gel or wash with soap before passing their hands under a wall-mounted sensor.
2. A wireless signal from a badge the worker is wearing activates a green light on the handwashing sensor.
3. When the worker approaches the patient’s bedside, a monitor detects the status of the badge. Clean hands get a green light.
4. If the person has not washed, or if too much time has passed since washing up, the badge will vibrate as a reminder to wash their hands again.
Infectious Disease resources for the iPhone

50 million users

Leading handheld platform for medical personnel

Over 100,000 apps

Outbreaks near me app

Swine flu tracker map app

In 2008 Apple created a medical community

OSU is developing a STAB-IT app for internal use

Ref: Oehler et al CID 2010;50:9