LABORATORY MEDICINE COURSE 2006
ROLE OF THE CLINICAL MICROBIOLOGY LAB IN DX OF INFECTIOUS DISEASES
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COURSE OBJECTIVES
YOU ARE HERE TODAY BECAUSE??
- Understand how micro tests impact on your dx
- Review differential diagnoses in case presentation format
- Pre-analytical parameters
  - Which diagnostic tests to order
  - Test menu & methods
  - Turnaround time to detection (TAT)
  - Specimen collection
    - Appreciate importance of appropriate specimen collection, handling & transport practices
- Analytical parameters
  - Backstage at the lab — review salient issues
    - Test methods
      - Culture & molecular
  - Considers assay strengths & limitations
- Post analytical
  - Critical interpretation & reporting of tests

IT’S A GERM’S WORLD AFTER ALL
Microbes were the first & will be the last living forms on earth.
Human body: 10-fold more microbial cells than human cells.
INFECTIOUS PATHOGENS
- 1st cause of death worldwide
- Top killers globally
  - Respiratory diseases
    - Tuberculosis
  - Malaria
  - Diarrhea
- 3rd cause of death U.S.
  - Regardless of specialty, your pts will develop infections
- New infectious diseases
  - About 30 in last 20 yrs
    - Avian flu, West Nile, SARS
  - How about M.S., cardiac disease, ulcers??

CLINICAL MICROBIOLOGY ESSENTIAL LINK IN HEALTH CARE CHAIN
Infection Control
Health Care Provider
CLINICAL MICRO
Public Health
Infectious Disease

THE BUILDING BLOCKS OF THE MICROBIOLOGY LAB
- Bacteriology
- Virology
- Molecular DX
- AFB
- Mycology
- Parasitology
- Molecular Epi

BACKSTAGE AT THE LAB JOURNEY OF A SPECIMEN
BEDSIDE
Specimen Collection
SPECIMEN TRANSPORT
Pneumatic Tube
& Sneaker Power
CLINICAL MICRO LAB
Pathogen detection
THE SPECIMEN
GARBAGE IN
GARBAGE OUT

<table>
<thead>
<tr>
<th>SPECIMEN</th>
<th>PITFALLS</th>
<th>SAFETY NETS</th>
</tr>
</thead>
</table>
| BLOOD     | • NONCOMPLIANCE WITH SKIN PREP PROTOCOL
         | • SKIN CONTAMINATION                          | • EDUCATION |
|           | • LOW VOLUME < 10 ML/BOTTLE                    | • QA MONITORS |
|           | • ONLY 1 SET                                  |             |

THE SPECIMEN
MORE GARBAGE
RECYCLING

<table>
<thead>
<tr>
<th>SPECIMEN</th>
<th>PITFALLS</th>
<th>SAFETY NETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOOL</td>
<td>• RAW SEWAGE</td>
<td>• PARA-PAK SAF FIXATIVE FOR O &amp; P</td>
</tr>
<tr>
<td></td>
<td>• OVERGROWTH OF COMMENSALS</td>
<td>• PARA-PAK C &amp; S FIXATIVE FOR ENTERIC</td>
</tr>
<tr>
<td>SURGICALS</td>
<td>• SWAB ONLY</td>
<td>• STERILE CONTAINER</td>
</tr>
<tr>
<td></td>
<td>• TISSUES SENT TO PATHOLOGY &amp; NOT MICRO</td>
<td>• BLOOD CULTURE BOTTLE</td>
</tr>
</tbody>
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SPECIMEN TRANSPORT CHALLENGES

• SPECIMEN DELAY TO MICROBIOLOGY
  ✓ COMPROMISES PATHOGEN VIABILITY
  ✓ INCREASES TURN-AROUND-TIME TO RESULTS
• TRANSPORT MEDIA
  ✓ REDUCE OVERGROWTH OF CONTAMINANTS
  ✓ MAXIMIZES PATHOGEN/NA/TOXIN RECOVERY
• TRANSPORT MEDIA EXAMPLES
  ✓ LIM SELECTIVE MEDIA FOR GROUP B STREP
  ✓ URINE TRANSPORT MEDIA WITH BORIC ACID PRESERVATIVE
  ✓ PARA-PAK FOR PARASITES & ENTERIC-TM BACTERIAL ENTERIC PATHOGENS
  ✓ PRECISION SPUTUM COLLECTORS FOR MYCOBACTERIA
  ✓ ANAEROBIC BD VACUTAINER

HOW ARE TESTS CHOSEN?
PATHOGEN DETECTION

• CLINICAL NEED
  ✓ PATIENT POPULATION SERVED
• TEST METHODS AVAILABLE
  ✓ CULTURE VS NON GROWTH DEPENDENT
• PERFORMANCE CHARACTERISTICS
  ✓ SENSITIVITY, SPECIFICITY, PPV, NPV
• RAPIDITY OF RESULTS
  ✓ OPTIMUM: SAME DAY DETECTION
• EASE OF PERFORMANCE BY TECHNOLOGIST & FITS INTO WORKFLOW
• VOLUME OF TESTS PERFORMED
  ✓ PERFORM IN-HOUSE OR SEND OUT
• COST OF THE TEST
  ✓ CONSIDER COST BY PT OUTCOME, LOS NOT JUST COST TO THE LAB BUDGET

TEST MENU

• MICROSCOPY - GRAM STAIN
• GROWTH DEPENDENT
  ✓ GOLD STANDARD
  ✓ CULTURE & ANTIMICROBIC SUSCEPTIBILITY (C & S)
• NON GROWTH DEPENDENT
  ✓ MOLECULAR DIAGNOSTICS
    • NUCLEIC ACID AMPLIFICATION
    • STRAIN FINGERPRINTING
  ✓ RAPID NON-MOLECULAR ASSAYS
    • ANTIGEN DETECTION
    • LATEX AGGLUTINATION

DAY IN THE LIFE OF A
BACTERIOLOGY SPECIMEN

SPECIMEN INOCULATED ONTO AGAR/BROTH MEDIA GRAM STAIN PERFORMED, READ & REPORTED

DAY 1
MEDIA INCUBATED, PATHOGEN IDENTIFIED, ANTIMICROBIAL SUSCEPTIBILITY

DAYS 2-4

FINALLY THE FINAL RESULT
IDENTIFICATION OF PATHOGENS
- MICROSCOPY
  - GRAM STAIN
- PATHOGEN DETECTION & IDENTIFICATION
  - CULTURE (GROWTH DEPENDENT)
  - RAPID METHODS, E.G. ANTIGEN DETECTION
- ANTIMICROBIC SUSCEPTIBILITY TESTS
  - E.G. MICROSCAN & VITEK
- MOLECULAR TESTS
  - STRAIN FINGERPRINTING
  - NUCLEIC ACID AMPLIFICATION TESTS
    - CHLAMYDIA/GC
    - S. AUREUS & MRSA
    - GROUP B STREPTOCOCCI
  - TB
  - DNA PROBES

THE GRAM STAIN
CLINICAL UTILITY
ADVANTAGES
- GROUPS BACTERIA
  - BY CELL WALL DIFFERENCES
    - GRAM POS OR NEG
    - CLUE TO PATHOGEN IDENTITY
  - MICROSCOPIC MORPHOLOGY
    - SHAPE & SIZE
  - ASSESS SPECIMEN QUALITY
    - WBCS, e.g. SPITUM
  - INEXPENSIVE, FAST
  - ROUTINELY PERFORMED ON
    - CSF, RESPIRATORY, WOUNDS, STERILE BODY FLUIDS & TISSUES

LIMITATIONS
- INTERPRETIVE SKILL
  - ATYPICAL GRAM REACTIONS & MORPHOLOGY
- REQUIRES EXPERIENCED MICROBIOLOGISTS
- MODERATELY COMPLEX TEST
- ASSAY SENSITIVITY LIMITED TO HIGH BACTERIAL LOAD
  - >10^5 PER ML
- POOR SPECIFICITY
  - GIVES CLUES
    - NO DEFINITIVE ID
    - FALSE POSITIVES

GRAM -NEGATIVE MORPHOTYPES
NAME THAT BUG!

<table>
<thead>
<tr>
<th>MORPHOTYPE</th>
<th>GROUP</th>
</tr>
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<tbody>
<tr>
<td>SHORT RODS</td>
<td>ENTERIC E. coli</td>
</tr>
<tr>
<td>SHORT, PLUMP RODS</td>
<td>ENTERIC Klebsiella</td>
</tr>
<tr>
<td>BIPOLAR STAINING</td>
<td>NON FERMENTER Pseudomonas</td>
</tr>
<tr>
<td>SLENDER, LONG</td>
<td>ANAEROBE Fusobacterium</td>
</tr>
<tr>
<td>FAINT STAINING</td>
<td>Bacteroides</td>
</tr>
<tr>
<td>POINTED ENDS, FILAMENTOUS RODS FAINT STAINING</td>
<td>ANAEROBE Fusobacterium</td>
</tr>
</tbody>
</table>

PATHOGEN DETECTION FROM CULTURE
- GROWTH DEPENDENT AUTOMATED SYSTEMS
  - MICROSCAN, VITEK, PHOENIX
  - IDENTIFICATION & ANTIMICROBIAL SUSCEPTIBILITY
- DIFFERENTIAL GROWTH ON MEDIA
  - BIOCHEMICAL TESTS
- ANTIGEN DETECTION SYSTEMS
  - LATEX AGGLUTINATION TESTS
  - ENZYME IMMUNOASSAYS (EIA)
- MOLECULAR ASSAYS
  - PROBES & PCR

RAPID ID METHODS
- ANTIGEN DETECTION
  - DETECTION OF PATHOGENS FROM CULTURE
  - IMMUNOCHEMOTRAGOGRAPHIC
    - URINE PNEUMO & LEGIONELLA
  - ENZYME IMMUNOASSAY
    - C. DIFFICILE, FLU A & B, RSV
  - LATEX AGGLUTINATION
  - 15-30 MIN
- MOLECULAR – PCR FROM SPECIMEN

LATEX AGGLUTINATION ANTIGEN DETECTION
- STREPTOCOCCI
  - SURFACE POLYSACCHARIDE AG
  - TYPES GRPS A, B, C, D, F, G
- GENERAL PROCEDURE
  - BACTERIAL SUSPENSION FROM CULTURE PLATE
  - PLACE SAMPLE ON TEST CARD
  - ADD CONTROLS TO SEPARATE CIRCLES
  - ROCK & ROLL FOR 10 MIN
  - AGGLUTINATION - AGGLUTINATION
**Urine AG Test**

**Pneumococcal**
- Detects C-polysaccharide cell wall antigen
- Sensitivity 86-90%
- Specificity 71-94%
- Peds: Colonization vs. Disease?
- Adults: Best correlation
  - Bacteremia & Pneumonia

**Legionella**
- L. Pneumophila type 1
  - 70-80% of cases
- Detects Lipo polysaccharide cell wall antigen
  - 1-3 days after onset of symptoms
  - Antigen persists
  - Days-wks post tx
- Sensitivity 70-99%
- Specificity 91-98%

**PCR Molecular Test**

**Group B Strep**

- SMARTCYCLER IDI Kit
  - Real-time PCR
  - Targets cfg gene
    - Extracellular GBS protein
  - Sensitivity 98%
  - Specificity 99%
  - PPV 98%, NPV 99%

- Culture
  - Sensitivity 69%
  - Specificity 100%
  - PPV 99%, NPV 96%
  - Internal Study
    - Poster AMP 2004

**Turnaround Time**

**GP B Strep**

- Culture-based tests
  - > 2 days
- RT PCR testing
  - < 60 minutes

**Brief Case**

A ventilated 53 year old male was transferred from an outside hospital directly to the MICU. On admission he was found to be hypotensive and tachycardic, with a temperature of 39.3°C, a heart rate of 130 beats/minute and a systolic blood pressure of 44 – 80mm Hg.

**Examination**

- Temperature (39.3°C)
- Tachycardia, chest (clear)
- Creatinine = 2.7mg/dl
- WBC ct = 13,000/ul, 45% PMNs & 45% bands

**What is the Clinical Dx in this Case?**

Sepsis

**What Specimens Will You Send to the Lab?**

Blood, Urine

**How Do You Collect the Specimens?**

- Septicemia is a medical emergency
  - >200,000 cases/yr
  - Mortality 20-50%

**Blood Cultures**

**Doing it Right the First Time**

Every Drop Counts

**Blood Culture Collection**

- Skin Preparation?
- What to Collect & When?
- What Site Was Drawn?
  - Antecubital? Central Line?

**Most Important Variable!**

- Blood Volume
  - What volume is drawn & why?
- Septic Adults only 1-10 colonies/ml
Central Line Bundle

- **BUNDLE DEFINITION**
  - Group of evidence-based interventions for patients with central venous catheters that when implemented together results in better outcomes.
    - Hand hygiene
    - Maximal barrier precautions for insertion
    - Chlorhexidine skin antisepsis
    - Optimal site selection
    - Daily review of line necessity with prompt removal if necessary

- **RELIABILITY DEPENDS ON INFRASTRUCTURE USING**
  - Central line checklists (insertion, maintenance, necessity)
  - Multi-disciplinary rounds

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**LAB RESULTS FROM PT BLOOD**

**DAY 1**

- CONTAMINANT OR PATHOGEN?
  - What are the GPR morphotypes?
  - How many sets were positive?

- CONSIDER
  - PROPORTION OF BLOOD CULTURE SETS POS TO # SETS OBTAINED
  - TIME FOR GROWTH DETECTION IN BLOOD CULTURE
  - IDENTITY OF MICROORGANISM

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**DIFFERENTIATE FROM**

- **BACILLUS ANTHRACIS**
  - Non-hemolytic on BAP
  - Short chains, square ends, non-motile, encapsulated
  - Can cause pediatric sepsis

- **BACILLUS CEREUS**
  - Can cause pediatric sepsis

- **NOCARDIA**
  - Can mimic mycobacteria (NTM) or diphtheroids

- **DIPHTHEROID OR CORYNE-BACTERIA**

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**BLOOD CULTURE RESULTS**

- **BLOOD CULTURE SIGNALS POSITIVE BY SEMIAUTOMATED INSTRUMENT**

  **DAY 1**
  - Gram stain

  **DAY 2**
  - Gram stain & morphology on media indicates gram negative rod

  **DOES THIS ALTER EMPIRIC THERAPY?**

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**LAB RESULTS FROM PT BLOOD**

**DAY 2**

- Empiric Therapy changes from Vanco + Pip/Tazo to
  - Pip/Tazo + tobramycin

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**BACTERIAL MASQUERADE BALL**

**GRAM-STAIN IMPERSONATORS**

<table>
<thead>
<tr>
<th>BACTERIAL CLASSIFICATION</th>
<th>RESULT OFTEN APPEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acinetobacter</strong></td>
<td>GNR</td>
</tr>
<tr>
<td><strong>Bacillus</strong></td>
<td>GPR</td>
</tr>
<tr>
<td><strong>Listeria</strong></td>
<td>GPR</td>
</tr>
</tbody>
</table>
**BLOOD CULTURE RESULTS**

BLOOD CULTURE SIGNALS POSITIVE BY SEMIAUTOMATED INSTRUMENT

- **DAY 1**
  - **GRAM STAIN**

- **GRAM- POSITIVE RODS CALLED TO DOC**

- **DAYS 2-4**
  - **GNR ID & SUSCEPTIBILITY TESTS**

**FINAL RESULT**

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**GROWTH METHODS BLOOD CULTURES**

<table>
<thead>
<tr>
<th>SYSTEMS</th>
<th>METHOD</th>
<th>DETECTION</th>
<th>TAT</th>
</tr>
</thead>
</table>
| **BACTEC**
  - **ADULTS:** 8-10 ml/bottle
  - 2 bottles/ set
  - **PEDIATRICS:** 1-3 ml in 1 bottle
| Continuous monitoring every 10 minutes
  - Signals positives 24/7
| **CO2, bacteria & yeast reacts with dye in sensor**
  - Fluorometrics
| 1-5 d |
| **ISOLATOR**
  - **ADULTS:** 10 ml
  - **PEDIATRICS:** 1-5 ml
| Saponin lyses
  - WBC
  - Centrifugation & plating on media
| Conventional growth media
| 1-2 d
| **MAC**
| 1-8 wk |

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**BLOOD CULTURES PREDICTING THE PATHOGEN**

- **KNOW YOUR MEDICAL CTRS PREVALENT BLOOD CULTURE ISOLATES**
- **CUMC 2006 BLOOD CULTURE DATA**
  - **TOP 3 GRAM POSITIVES**
    - Staphylococcus (coagulase negative)
    - S. aureus
    - Enterococcus faecalis
  - **TOP 3 GRAM NEGATIVES**
    - E. coli
    - Klebsiella pneumoniae
    - P. aeruginosa

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**BLOOD CULTURE FROM SEPTIC PATIENT**

- **DAY 2**
  - **CORRECTION OF GRAM STAIN FROM GPR TO GNR**
  - **HOW DO YOU CHANGE THE ANTIBIOTIC REGIMEN?**
- **DAY 3**
  - **BOTH SETS OF BLOOD CULTURES GREW ACINETOBACTER BAUMANII**
  - **DO YOU CHANGE YOUR ANTIBIOTIC REGIMEN?**
  - **DOES THIS ORGANISM HAVE A PREDICTABLE ANTIBIограмМ?**
  - **KNOW PATHOGEN'S TYPICAL ANTIBIограмМ PATTERN**

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**BRIEF CASE**

- A 46 y o male developed RT MIDDLE LOBE PNEUMONIA WHILE IN THE SURGICAL ICU
- HIS RECENT MEDICAL HISTORY WAS SIGNIFICANT FOR A ORTHOTOPIC HEART TRANSPLANT 1 WK PRIOR TO THIS EVENT
- LOWER RESPIRATORY SECRETIONS FROM FIBEROPTIC BRONCH SENT TO MICROBIOLOGY FOR ANALYSIS

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**RESULTS FROM LAB**

- **Gram Stain**
  - >10-25 polys & <10 Epithelial Cells
  - Polys are GRAM-NEG
  - **Interpretation**
    - Quality Sputum
  - **Consequences**
    - Delay in Dx & Tx
    - Repeat Specimens collected after Tx

- **Gram Stain**
  - <10-25 polys & >10 Epithelial Cells
  - Interpretation
    - Spit, not sputum
    - Specimen Rejected

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ICU CASE

GRAM STAIN CLUES

- Lab calls with Gram stain result
  - Many GNR

Large, plump

Translation?

Nosocomial pneumonia

- Differential...consult for morphology
  - Klebsiella spp.
  - Acinetobacter spp.
  - Pseudomonas spp.
  - Legionella spp.

- Hallmarks of nosocomial pneumonia
  - Most often GNRs
  - Antibiotic resistant
  - > 5 days after admission
  - Distinguish infection vs colonization

Nosocomial pneumonia

- Defined as new pulmonary infiltrate that usually occurs
  - > 1 week of hospitalization
- Most patients have fever & leukocytosis

Community associated

- Legionella
  - S. pneumoniae
  - H. influenzae
  - M. catarrhalis

Nosocomial pneumonia

- P. aeruginosa

Klebsiella

- Antimicrobial resistance testing
  - Susceptible
    - Imipenem
    - Polymyxin B
  - Resistant
    - Cephalosporins
    - Beta lactams
    - Aminoglycosides

- Think:
  - Extended spectrum beta lactamase (ESBL) producer?
  - Carbapenemase producer? KPC

Super bugs, dumb drugs

Forecasting pre antibiotic era

Nosocomial pneumonia

- Empiric therapy
  - Monotherapy
    - Imipenem
    - PIP/Tazo
  - Combination regimens
    - Carbapenem plus
      - Levoflaxacin
      - Aztreonam
      - Amikacin

Neonatal ICU case

- PT is 13 day old ex-24 wk baby girl
- APGAR score 6.7
- Intubated on first day of life
- Sepsis workup at birth was negative
- 11th day of life, you noted more frequent desaturations, hypotension & increasing WBCs to 21.7
DECISIONS ON THE FLOOR

- WHAT MICROBIOLOGY SPECIMENS ARE COLLECTED?
  - BLOOD CULTURE
  - URINE

- HOW IS BLOOD CULTURE SITE PREPARED?
  - <2 MTHS USE ALCOHOL

- WHAT IS THE EMPIRIC THERAPY?
  - VANCO, GENTA & PIP/TAZO

MICRO LAB TESTS

CULTURE ONLY

Blood Bottle

DAY 1

- GRAM STAIN-GPC clusters
- DAY 2 – GROWTH
  - Rapid Ag test - S. aureus +
  - PBP2a latex agglutination for oxacillin-resistance +
- DAY 3 – MICROSCAN OR VITEK ID SYSTEM
  - MIC ≥ 4 μg/ml by antibiotic susceptibility test
- DAY 4 – FINAL REPORT
  - MRSA

GRAM STAIN REPORTS

DAY 1

- GPC, clusters, tetrads, bunches
- Rapid test available, distinguishes S. aureus from coagulase-negative staph

TRANSLATION

- If S. aureus
  - Consider:
    - Methicillin Resistance
    - Susceptibility Pattern

GPC

GPC, PRS, CHAINS & CLUSTERS

Lab speaking in tongues!

MRSA AG TEST FROM CULTURE

DAY 2

LATEX AGGLUTINATION ASSAY

- PBP2a low-affinity penicillin binding protein
- Latex beads sensitized with monoclonal Antibody vs PBP2a
- PURE CULTURE ONLY
  - Not directly from specimen
  - Need 10^8 cells
- 1 hr test

MICRO LAB TESTS

CULTURE & PCR

Blood Bottle

DAY 1

- GRAM STAIN-GPC clusters
- PCR TEST
  - Nuc + = S. aureus
  - mecA += oxacillin-resistant
- FINAL RESULT IN ONE DAY
  - MRSA
MOLECULAR DX  
MRSA DETECTION

• PCR – NEW GOLD STANDARD?
  ✓ meca & nuc genes – coamplification
  ✓ SAMPLES
    BLOOD CULTURES, NASAL SWABS OR PURE CULTURE
• SmartCycler
  ✓ AMPLIFICATION & DETECTION
    • Thermocycler & fluorimeter
  ✓ CLOSED INSTRUMENT SYSTEM
    • Minimizes contamination
  ✓ 1 ½ HR TEST
  ✓ EXPENSIVE, TECHNICALLY CHALLENGING

TURNAROUND TIMES

<table>
<thead>
<tr>
<th>CULTURE-BASED TESTS</th>
<th>&gt; 2 days</th>
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<tbody>
<tr>
<td>PCR-Based Testing</td>
<td>&lt; 90 Minutes</td>
</tr>
</tbody>
</table>

MOLECULAR ASSAY FORMATS
PCR, SDA, TMA, bDNA, Sequencing, Chip Technology

MRSA PROFILE

• NOSOCOMIAL MRSA 1970s
  ✓ Resistant to penicillins, cephalosporins, carabapenems & monobactams
  ✓ Vanco-1st line
  ✓ Often multiply resistant to gentamicin, rifampin, clindamycin & T/S
  ✓ Staph Chromosomal Cassette (SCC) meca 1-III
  ✓ Multiple Clones
  ✓ MRSA infections vs MSSA
    - »LOS 12 days + $5000
• COMMUNITY ASSOC MRSA 1990s
  ✓ Usually susceptible to genta, clinda, tetra, T/S
  ✓ SCC meca IV
    • Smaller more mobile lacks R genes
    • +/- Panton-Valentine Leukocidin (PVL)
      • Recurrent furuncles
  ✓ More virulent than MSSA
  ✓ 2 Major Clones

RAPID DETECTION OF VIRULENCE FACTORS (SUPERANTIGENS*)

• WHAT ARE SUPERANTIGENS?
  ✓ PROTEINS THAT ELICIT POWERFUL IMMUNE RESPONSES
  ✓ MASSIVE CYTOKINE RELEASE OR CASCADE
  ✓ 5 TO 30% OF T CELLS
  ✓ MASSIVE ORGAN FAILURE
• PANTON VALENTINE LEUKOCIDIN (pvl)
  ✓ 2-3% of SA
• CA-MRSA
  ✓ STAPH ENTEROTOXIN ALPHABET, e.g.
    • B (seo)
    • C & H (sec & seh)
• TOXIC SHOCK
  ✓ TSST-1 TOXIN (tstH)
  Annu Rev Microbiol 55:77-104

CA-MRSA STUDY

• 8 POSTPARTUM WOMEN
  ✓ SKIN/SOFT TISSUE INFECTIONS
    • MASTITIS, ABSCESS, CELLULITIS, PUSTULOSIS
    • MEAN TIME AFTER DELIVERY: 23 DAYS
  ✓ RESULTS SHOW VIRULENT CA STRAIN IN NORTHEAST
    • SPREAD FROM MIDWEST (STRAIN MW2)
    • 1ST REPORT TO DOCUMENT HOSP TRANSMISSION CA-MRSA
• MICROBIOLOGY STUDIES
  ✓ MOLECULAR ANALYSIS
    • SCC TYPE IV & PVL PRESENT
    • PFGE CLONE "I" SAME AS MW2 prototype
  ✓ SURVEILLANCE
    • EMPLOYEES, ENVIRON, NEONATES NEG FOR OUTBKR STRAIN & ROUTE OF TRANSMISSION UNKNOWN

PUBLICATION – MAJOR ARTICLE – CLIN INFECT DIS 2003; 37:131