Livestock-associated
*Staphylococcus aureus*: an Overview

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Introduction to MRSA

- Methicillin-resistant *Staphylococcus aureus* (MRSA)
- Gram positive bacterium
- Leading cause of hospital-associated infections

Image: http://trouble.philadelphiaweekly.com/archives/MRSA220207_400x379%5B1%5D.jpg
Introduction to MRSA

- ~30% of population carries a strain of *S. aureus*
- ~1.5% colonized with MRSA
- 18,000 deaths, 94,000 invasive infections from MRSA in 2005

*J Infect Dis* 2008;197:1226-34.
Introduction to MRSA

- Not only a hospital problem anymore

Images:
- http://www.rcs.k12.in.us/images/graphics/school_bus.gif
- http://msnbcmedia2.msn.com/i/msnbc/Components/Photos/061015/061015_population_hlg_11a_hlarge.jpg
Introduction to MRSA

NEJM 2005;352:468-75.
Image from http://i.a.cnn.net/si/2007/writers/dr_z/03/23/mailbag/p1_jackson_steven_klutho.jpg
Introduction to MRSA

7th-grader's death sparks parents' superbug concerns

NEW YORK (CNN) -- The death of a 12-year-old student in Brooklyn from the staph infection MRSA has prompted fear among parents and students throughout the New York City school system, forcing officials to respond.

Omar Rivera, a seventh-grader at Intermediate School 211, died October 14 from the infection, according to the New York City school superintendent, but investigators were unable to confirm where he contracted the infection.

MRSA is short for methicillin-resistant Staphylococcus aureus, and is responsible for more deaths in the United States each year than AIDS, according to new data.

"There's often no way to know how an individual person got the infection," said New York City Health Commissioner Tom Frieden. "An infection in a child like this is extremely rare. Fatal infections in children is in the order of 1 in a million. It's a terrible tragedy and our hearts go out to the family."

The Office of School Health sent letters to parents Thursday, notifying them of Rivera's death. Despite assurances from health officials that Rivera's death was an isolated incident, several parents decided to keep their children out of IS 211, which opened at its normal time.

Introduction to MRSA

Methicillin-Resistant Staphylococcus aureus in a Family and Its Pet Cat

To the Editor: Many isolates of community-acquired methicillin-resistant Staphylococcus aureus (MRSA) produce Panton–Valentine leukocidin (PVL), increasing the virulence of the bacteria, which can cause disseminated deep abscesses and necrotizing pneumonia.1 We report the transmission of PVL-positive MRSA between a symptomatic woman and both her asymptomatic family members and their healthy pet cat.

An otherwise healthy woman presented with current multiple deep abscesses. Swabs from oral abscesses and nasal cultures grew MRSA, which was resistant to both beta-lactam and fusidic acid antibiotics. Polymerase-chain-reaction assays revealed the PVL genes hla-PV and hlaF-PV were positive. The genotype of the staphylococcal chromosomal cassette was SCCmec type IV. Nasal, axillary, and inguinal cultures from her husband and their two children yielded MRSA on several occasions. Mupirocin nasal ointment and antiseptic washes were recommended for all family members. Although the patient’s husband and children became MRSA-negative, the patient remained MRSA-positive. Therefore, her three apparently healthy cats were screened. Pharyngeal culture from one cat grew MRSA with the same antimicrobial resistance pattern as that of the human isolates. The clonal identity of the isolates from the family and the cats was found by typing of the spa gene repeat region and multilocus sequence typing,2 which showed spa-type t131 and ST80 in all isolates. This sequence combination does not correspond with that of clone USA300 (http://spa.ridom.de).2

A veterinarian recommended topical decolonization of the MRSA-positive cat with ciprofloxacin and rifampin. Four weeks after the cat’s treatment, screening tests of the family were negative for MRSA. Moreover, the patient’s deep abscesses completely resolved. Further MRSA screening of the asymptomatic cat was declined by the family.

There is evidence that companion animals, mainly dogs, harbor MRSA,3 and interspecies

Image:  http://www.foodpoisonblog.com/dog_cat.jpg
MRSA and Swine

- First identified in the Netherlands, 2005
- 6-month old girl found to have MRSA upon hospital admission
- Family lived on pig farm
- Parents also colonized

MRSA and Swine

- 26 pig farmers swabbed; 6 (23%) positive for MRSA
  - 760x higher than general population
- Pigs cultured
- Same strain in pig and family ("ST398" or "non-typeable" MRSA)
MRSA and Swine

- Swine-associated MRSA also found in Denmark, Germany, Austria, France, Canada, Spain, Italy, Belgium, Sweden, Dominican Republic, China, Malaysia, UK, Switzerland, Portugal, Finland
Swine MRSA in the U.S.?

http://www.iowa.in/IOWA.JPG
http://www.americaslibrary.gov/assets/es/la/es_la_fair_1_e.jpg
http://www.hessdesignworks.com/Illustrations/Corn.jpg
Swine MRSA in the U.S.?

- Iowa: #1 pork producing state
- 25% of hogs raised in the U.S.

Do Iowa swine carry MRSA?
Our study

- Initial testing: 7 farms in E. Iowa, W. Illinois
- All part of one closed confinement system; collectively “Production System A”
- ~60,000 animals at any one time
Our study

- 209 nasal swabs obtained (30 per age group)
- 9-24 weeks of age + sows
Results

- Overall prevalence: **147/209 (70%)**

### Figure 1: Prevalence of MRSA in Swine by Age

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Prevalence (%)</th>
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<tbody>
<tr>
<td>9 week</td>
<td>100%</td>
</tr>
<tr>
<td>12 week</td>
<td>100%</td>
</tr>
<tr>
<td>15 week</td>
<td>90%</td>
</tr>
<tr>
<td>18 week</td>
<td>50%</td>
</tr>
<tr>
<td>21 week</td>
<td>63%</td>
</tr>
<tr>
<td>24 week</td>
<td>50%</td>
</tr>
<tr>
<td>Adult</td>
<td>36%</td>
</tr>
</tbody>
</table>

Molecular epi of Iowa swine MRSA

- Found to be MLST 398 ("ST398"), previously associated with pigs

- Most isolates tested resistant to penicillin, methicillin, clindamycin, erythromycin, tetracycline
Are swine farmers carrying MRSA?
Are swine farmers carrying MRSA?

- First sampling, 14 workers from Production System A

- 9/14 positive (64%), ST398 (limited isolates tested)
Multi-state study
Multi-state study

- 18 farms per investigator (9 confinement, 9 organic/antibiotic free)
- 24 animals (6-9 weeks) tested per farm
Multi-state study

- Nasal samples, pigs
- Nasal + pharyngeal sampling, humans
- 18 IA/IL farms tested (9 confinement, 9 organic/antibiotic free)
Multi-state study

- No MRSA found on antibiotic-free farms in Iowa (0/9)
- 4/9 confinements with positive pigs (44%), additional farm with 2 MRSA+ humans
- Overall prevalence, swine: 45/432 (10%)
- Confinement swine: 45/216 (21%)
Summary

- Prevalence humans: 27/88 (31%)
- Humans working in confinement facilities: 27/63 (44%)
Minnesota & Ohio: no MRSA found in pigs

Why not?
What about ST398 infections?
ST398 infections

- ST398 human infections recognized in a number of countries (The Netherlands, Denmark, Belgium, Austria, Spain, Italy, France, Finland, German, Sweden, Norway, Canada, Dominican Republic, Colombia, United States, China, Hong Kong)
ST398 infections

- Skin/soft tissue infections

ST398 infections

- Invasive infections (bacteremia, ventilator-associated pneumonia, necrotizing fasciitis ("flesh-eating disease"), endocarditis, multi-organ failure, death)

Rasigade et al EID 2010
ST398 infections

- Not all have known contact with livestock/poultry—but much missing data
- Animal-adapted human lineage?
- Secondary spread into community?
3.7% reported physician-diagnosed MRSA infection (x43K in NPB database = 1500 MRSA infections)

Retrospective ID of 13 CC398 infections in New Jersey (under review)
Beyond ST398

- US/Canada more heterogeneous than just ST398

- Other “human” types found in pigs (USA100/ST5, USA300/ST8—tet resistant); bidirectional spread?

- How do we know whether an infection is “livestock” origin ST5 or “human” origin ST5?
MRSA in meat

- MRSA found in meat products (pork, beef, chicken, turkey)—Canada, US, Netherlands
- \( \sim 1-12\% \) prevalence
- Mix of “livestock” strains and “human” strains

Unanswered questions

- Specific roles of antibiotics vs. other pressures
- Transmission potential from animals & meat products
- Ecology, ecology, ecology
Summary

- MRSA is present in U.S. swine & swine workers
- Geographic variation in prevalence?
- Many types besides ST398
- Potential for transmission to community via farmers, air, meat products, water/manure—risk uncertain
Collaborators and team members

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