PREVENTION OF SURGICAL SITE INFECTIONS

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Disclosures:

Consult for the Washington State Hospitalization Association on HAIs and antimicrobial stewardship
SSI

• #1 healthcare-associated infection in surgical patients, #2 HAI overall (2nd to UTI)
• 2% to 5% of patients undergoing inpt surgery
• 3% mortality, 2-11x higher risk of death
• SSI direct cause of 75% deaths in pts with SSI
• Increases length of stay (7-10 extra days)
• Increases cost (~$10 billion/yr, underestimate)
• Lots of antibiotics used
<table>
<thead>
<tr>
<th>Type of Infection</th>
<th>Rank</th>
<th>No. of Infections</th>
<th>Percentage of All Health Care–Associated Infections (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia†</td>
<td>1 (tie)</td>
<td>110</td>
<td>21.8 (18.4–25.6)</td>
</tr>
<tr>
<td>Surgical-site infection</td>
<td>1 (tie)</td>
<td>110</td>
<td>21.8 (18.4–25.6)</td>
</tr>
<tr>
<td>Gastrointestinal infection</td>
<td>3</td>
<td>86</td>
<td>17.1 (14.0–20.5)</td>
</tr>
<tr>
<td>Urinary tract infection‡</td>
<td>4</td>
<td>65</td>
<td>12.9 (10.2–16.0)</td>
</tr>
<tr>
<td>Primary bloodstream infection§</td>
<td>5</td>
<td>50</td>
<td>9.9 (7.5–12.8)</td>
</tr>
<tr>
<td>Eye, ear, nose, throat, or mouth infection</td>
<td>6</td>
<td>28</td>
<td>5.6 (3.8–7.8)</td>
</tr>
<tr>
<td>Lower respiratory tract infection</td>
<td>7</td>
<td>20</td>
<td>4.0 (2.5–6.0)</td>
</tr>
<tr>
<td>Skin and soft-tissue infection</td>
<td>8</td>
<td>16</td>
<td>3.2 (1.9–5.0)</td>
</tr>
<tr>
<td>Cardiovascular system infection</td>
<td>9</td>
<td>6</td>
<td>1.2 (0.5–2.5)</td>
</tr>
<tr>
<td>Bone and joint infection</td>
<td>10</td>
<td>5</td>
<td>1.0 (0.4–2.2)</td>
</tr>
<tr>
<td>Central nervous system infection</td>
<td>11</td>
<td>4</td>
<td>0.8 (0.3–1.9)</td>
</tr>
<tr>
<td>Reproductive tract infection</td>
<td>12</td>
<td>3</td>
<td>0.6 (0.2–1.6)</td>
</tr>
<tr>
<td>Systemic infection</td>
<td>13</td>
<td>1</td>
<td>0.2 (0.01–1.0)</td>
</tr>
</tbody>
</table>
Table 4. Estimated Numbers of Major Types of Health Care–Associated Infection in the United States in 2011.

<table>
<thead>
<tr>
<th>Type of Infection</th>
<th>Infections Identified in Survey</th>
<th>Surveyed Patients with Type of Infection</th>
<th>Estimated Infections in the United States*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no.</td>
<td>% (95% CI)</td>
<td>no. (95% CI)</td>
</tr>
<tr>
<td>All health care–associated infections</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td>110</td>
<td>24.3 (20.6–28.5)</td>
<td>157,500 (50,800–281,400)</td>
</tr>
<tr>
<td>Surgical-site infection</td>
<td>110†</td>
<td>24.3 (20.6–28.5)</td>
<td>157,500 (50,800–281,400)</td>
</tr>
<tr>
<td>Gastrointestinal infection</td>
<td>86</td>
<td>19.0 (15.6–22.8)</td>
<td>123,100 (38,400–225,100)</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>65</td>
<td>14.4 (11.4–17.9)</td>
<td>93,300 (28,100–176,700)</td>
</tr>
<tr>
<td>Primary bloodstream infection</td>
<td>50</td>
<td>11.1 (8.4–14.2)</td>
<td>71,900 (20,700–140,200)</td>
</tr>
<tr>
<td>Eye, ear, nose, throat, or mouth infection</td>
<td>28‡</td>
<td>6.2 (4.2–8.7)</td>
<td>40,200 (10,400–85,900)</td>
</tr>
<tr>
<td>Lower respiratory tract infection</td>
<td>20</td>
<td>4.4 (2.8–6.6)</td>
<td>28,500 (6900–65,200)</td>
</tr>
<tr>
<td>Skin and soft-tissue infection</td>
<td>16</td>
<td>3.5 (2.1–5.6)</td>
<td>22,700 (5200–55,300)</td>
</tr>
<tr>
<td>Cardiovascular system infection</td>
<td>6</td>
<td>1.3 (0.5–2.7)</td>
<td>8,400 (1200–26,700)</td>
</tr>
<tr>
<td>Bone and joint infection</td>
<td>5</td>
<td>1.1 (0.4–2.4)</td>
<td>7,100 (1000–23,700)</td>
</tr>
<tr>
<td>Central nervous system infection</td>
<td>4</td>
<td>0.9 (0.3–2.1)</td>
<td>5,800 (700–20,700)</td>
</tr>
<tr>
<td>Reproductive tract infection</td>
<td>3</td>
<td>0.7 (0.2–1.8)</td>
<td>4,500 (500–17,800)</td>
</tr>
<tr>
<td>Systemic infection</td>
<td>1</td>
<td>0.2 (0.01–1.1)</td>
<td>1,300 (0–10,900)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>721,800 (214,700–1,411,000)</td>
</tr>
<tr>
<td>Infections in non-neonatal intensive care units</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catheter-associated urinary tract infection</td>
<td>25</td>
<td>5.5 (3.7–7.9)</td>
<td>35,600 (9100–78,000)</td>
</tr>
<tr>
<td>Central-catheter–associated primary bloodstream infection</td>
<td>11</td>
<td>2.4 (1.3–4.2)</td>
<td>15,600 (3200–41,500)</td>
</tr>
<tr>
<td>Ventilator-associated pneumonia</td>
<td>35</td>
<td>7.7 (5.5–10.5)</td>
<td>49,900 (13,600–103,700)</td>
</tr>
<tr>
<td>Surgical-site infections attributed to Surgical Care Improvement Project procedures§</td>
<td>46</td>
<td>10.2 (7.6–13.2)</td>
<td>66,100 (18,700–130,300)</td>
</tr>
<tr>
<td>Hospital-onset infections caused by specific pathogens</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Clostridium difficile infection¶</td>
<td>56</td>
<td>12.4 (9.6–15.7)</td>
<td>80,400 (23,700–155,000)</td>
</tr>
<tr>
<td>MRSA bacteremia¶</td>
<td>7</td>
<td>1.5 (0.7–3.0)</td>
<td>9,700 (1700–29,600)</td>
</tr>
</tbody>
</table>
Public Attention

• Colon
• Hysterectomy
• Knee and hip replacement
• Cardiac

Reduce Hospital Acquired Infections

Colon Surgical Site Infections Per 100 Procedures (NHSN)

Clinical Rational:

More than 15 million surgeries are performed in the United States each year and is a major contributor to healthcare associated infections (HAI). As of March 2014, the CDC reported that surgical site infections (SSI) account for 22% of all HAI per each year.¹ Associated cost of SSI are between 3.5 and 10 billion annually and result in increased readmissions, ICU admissions, long-term surgical complications and death. SSI rates are disproportionately higher among patients following colorectal surgeries.²
Patient Awareness of Interventions to Prevent SSI

![Bar Chart]

- CHG: 298
- Nasal mupirocin: 193
- Nasal Culture: 32
- Smoking cessation: 6
- Improve eating habits/Lose weight: 13
- Avoid shaving: 13
- None of the above: 275

Maslow Orthopedics 2014
Surgery Truths

• All surgeries are contaminated
• You will find bacteria if you look hard enough
• So, why are some surgical sites with bacteria infected and some are not?
Risks at the Surgical Site

- Hematoma, seroma or fluid collection
- Necrotic tissue
- Space
- Foreign bodies/hardware
Patient Risks

- Age
- Tobacco use
- DM/hyperglycemia
- Obesity
- Malnutrition
- Hypothermia
- Hypoxemia
Preventive Measures

• **Preoperative methods**
  – Patient specific factor optimization (DM, nutrition, PI, tobacco, etoh)
  – MRSA decolonization
  – Skin disinfection

• **Intraoperative methods**
  – Antibiotic prophylaxis
  – Cutaneous preparation (hair removal, skin antisepsis, surgical draping)
  – Operative environment (ventilation, body exhaust suits, gloves, lavage)
  – Blood conservation
  – Prosthesis selection

• **Postoperative methods**
  – Antibiotic prophylaxis
  – Evacuation drains

Kapadia BH, The Lancet, June 2015
Colon SSI Bundles

What is a bundle anyway? = ≥3 evidence-based interventions

- Appropriate antibiotic selection/dose
- Prophylactic antibiotics within 60 min before surgery
- Prophylactic antibiotics discontinued within 24 h
- Antibiotic re-dose within 3–4 h after incision
- Glycemic control
- Normothermia pre-operatively
- Normothermia intra-operatively
- Normothermia post-operatively
- Appropriate hair removal
- Supplemental oxygen
- Systolic pressure ≥90 mmHg
- Reduction in intravenous fluids during operation
- Wound edge protector
- CHG cloths on admission
- Preoperative CHG wipes or shower
- CHG in alcohol skin preparation
- Double gloving
- Glove and/or gown change
- Theatre discipline/restricted traffic
- Smoking cessation
- Patient SSI education
- Tray for closure of fascia and skin
- Omission of mechanical bowel preparation
- Mechanical bowel preparation plus oral antibiotics
- Oral antibiotics given with mechanical bowel prep if used
- Penrose drain for patients with BMI ≥25 kg/m²
- Pulse lavage of subcutaneous tissue
- Minimally invasive surgery
- Short duration of surgery
- Silver dressings for 5 days
- Removal of sterile dressing within 48 h
- Postoperative washing of wound with CHG
Compendium SSI Updates I

- Indirect surveillance works well
- Discontinuation of prophylactic antimicrobials within 24 hours
- Improving SIP is associated with improved SSI rate
- Surgical Care Improvement Project
Specific training for ICPs for SSI surveillance
Weight based antimicrobial dosing
Alcohol containing preoperative skin preparatory agents
Impervious plastic wound protectors
WHO checklist
No benefit to using antiseptic-impregnated sutures
Types of Surgeries by Risk

• Class I: Clean
  – No infection or inflammation
  – No entry into pulmonary, alimentary or GU

• Class II: Clean-contaminated
  – Into the pulm, alimentary or GU tract
  – Biliary tract
  – Minor violation of aseptic technique

• Class III: Contaminated
  – Fresh traumatic wounds
  – GI or pulm with major contamination
  – Acute inflammation

• Class IV: Dirty-infected
Skin

Subcutaneous Tissue

Deep soft tissue (muscle and fascia)

Organ Space

Superficial Incisional SSI

Deep Incisional SSI

Organ Space SSI
Pathogen Source

Endogenous

– Patient flora
  • skin
  • Mucous membranes
  • GI tract

– Seeding from distant focus of infection
Pathogen Source

Exogenous

– Surgical personnel
  • Soiled attire
  • Breaks in aseptic technique
  • Breaks in hand hygiene
– OR physical environment
– Tools, equipment, materials
Most common microorganisms, 2006-2007

- *Staphylococcus aureus* 30%
- Coagulase-negative staphylococci 13.7%
- *Enterococcus* spp. 11.2%
- *Escherichia coli* 9.6%
- *Pseudomonas aeruginosa* 5.6%
- *Enterobacter* 4.2%
- *Klebsiella pneumoniae* 3.0%
- Candida spp. 2.0%
- *Klebsiella oxytoca* 0.7%
- *Acinetobacter baumannii* 0.6%
Challenges

• Detection
  – Lack of standardized methods, especially in outpatient setting
  – # outpatient surgeries increasing
  – Shorter inpt stays

• Antimicrobial prophylaxis: increasing antimicrobial resistant may overcome standard prophylaxis recs
Drug-Resistance

• MDR *Bacteroides fragilis*, Seattle, 2013
  – 70ish yo man dx with met adenocarcinoma while in India, received abx while there, then returned to US and admitted to HMC
  – Received chemo, surgical resection, then developed multiple peritoneal abscesses
  – Blood cultures and abd fluid cultures grew *B fragilis* resistant to metronidazole, imipenem, pip/tazo, clindamycin, moxi, cefotetan, amp/sulb
  – Treated with linezolid + ertapenem

• MDR NDM-1+ polymicrobial wound infection, Seattle, 2011
  – 20 yo man s/p traumatic amputation of RLE in India transferred to HMC
  – Multiple GNRs with broad drug resistance, including to carbapenems
  – Cure took 4 surgeries, neutropenia, AKI + colistin, meropenem, rifampin and tigecycline

Kalapila MMWR 2013
A Case from Portugal

- 74 yo woman with DM/CKD on HD develops critical limb ischemia
- Undergoes revascularization and amputation of 2 toes
- H/o P aeruginosa and MRSA from toe wounds
- May 2013 VRSA isolated (MIC >256!) along with VRE and P aeruginosa
- VRSA was mecA and vanA positive

Melo-Christino Lancet 2013
Modifiable Risks (ABCDE....)

• ABC = airway, breathing, circulation (temperature, oxygenation, fluids)
• ABCD = ABC + drugs (antibiotics): choice, timing, dose (ex. for high BMI)
• EFGH...
  – Skin or site preparation (remove hair by clipping or depilatory agent, only if needed)
  – Colorectal procedures
    • Inadequate bowel prep/non-absorbable PO antibiotics
    • Intraoperative temperature

From Dellinger 2013 and CDC.gov
Modifiable Risks (...FCGHI....)

- OR traffic
- Wound dressing: keep sterile dressing in place 24-48hrs
- Glucose control, <200mg/dL
- Colonization with preexisting organisms
- Intraoperative oxygen levels (>49% fraction inspired O2 intra and immed post-op)

From Dellinger 2013 and CDC.gov
## Relative Benefit from Abx Prophylaxis

<table>
<thead>
<tr>
<th>Operation</th>
<th>Prophylaxis (%)</th>
<th>Placebo (%)</th>
<th>NNT*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colon</td>
<td>4-12</td>
<td>24-48</td>
<td>3-5</td>
</tr>
<tr>
<td>Other (mixed) GI</td>
<td>4-6</td>
<td>15-29</td>
<td>4-9</td>
</tr>
<tr>
<td>Vascular</td>
<td>1-4</td>
<td>7-17</td>
<td>10-17</td>
</tr>
<tr>
<td>Cardiac</td>
<td>3-9</td>
<td>44-49</td>
<td>2-3</td>
</tr>
<tr>
<td>Hysterectomy</td>
<td>1-16</td>
<td>18-38</td>
<td>3-6</td>
</tr>
<tr>
<td>Craniotomy</td>
<td>0.5-3</td>
<td>4-12</td>
<td>9-29</td>
</tr>
<tr>
<td>Spinal operation</td>
<td>2.2</td>
<td>5.9</td>
<td>27</td>
</tr>
<tr>
<td>Total joint repl</td>
<td>0.5-1</td>
<td>2-9</td>
<td>12-100</td>
</tr>
<tr>
<td>Brst &amp; hernia ops</td>
<td>3.5</td>
<td>5.2</td>
<td>58</td>
</tr>
</tbody>
</table>

From Dellinger 2013
Relative Effect of Abx Prophylaxis by Baseline Risk

Antibiotic Prophylaxis

Clean Operative Procedures

- Proportional reduction of infection is similar to other procedures
- Absolute number of infections prevented is lower with lower baseline infection rates
- Benefit of prophylaxis depends on
  - Baseline rate of infection
  - Effectiveness of prophylaxis
  - Cost of prophylaxis
  - Cost of infections prevented
Antibiotic Prophylaxis

Demonstrated Benefit: “Clean” Procedures

- Orthopedic joint replacements
- Open reduction of closed fractures
- Vascular prostheses
- Vascular procedures on the leg
- Median sternotomy
- Craniotomy
- Breast and hernia procedures
Perioperative Prophylactic Antibiotics: Timing of Administration

Timing of Prophylactic Antibiotic Administration for Total Hip Arthroplasty

Timing of Prophylactic Antibiotic Administration
– Cardiac, Arthroplasty, Hysterectomy

Steinberg. TRAPE. Ann Surg 2009; 250:10
Timing of Prophylactic Vancomycin Administration & SSI Risk
Cardiac Surgery
Overall SSI Rate – 147/2048=7.2%

Post-Operative Antibiotic Prophylaxis

• Only 14.5% of 32,603 pts undergoing major surgery had antibiotic prophylaxis discontinued with 12hrs
• 26.7% were still receiving this treatment 48hrs after surgery
• A Japanese survey found that 56.4% of surgeons continue prophylaxis in clean-contaminated operations for 3-4 days

Bratzler Arch Surg 2005
Sumiyama Jpn J Chemotherapy 2004
Post-Operative Antibiotic Prophylaxis

  – 7 hospitals, 355 pts, stop abx at end of surgery vs 2 days
  – SSI in 5% of the “short” group vs 9% in the “long” group (no statistical difference)
Post-Operative Antibiotic Prophylaxis

• Short duration of antibiotic prophylaxis in open fracture does not enhance risk of subsequent infection. Dunkel et al. Bone Joint J. 2013.

Antibiotic-Containing Cement in TKR

• “Risk factors associated with deep surgical site infections after primary total knee arthroplasty”
  – Observational study of 56,216 knees
  – Antibiotic-containing cement significantly associated with risk of infection

• “The use of erythromycin and colistin-loaded cement in total knee arthroplasty does not reduce the incidence of infection. A prospective randomized study of 3000 knees”
  – No difference between the 2 groups (both ~1.4%)

Namba J Bone Joint Surg 2013
Hinarejos J Bone Joint Surg 2013
Antibiotic-Containing Cement in TKR

• “Risk factors associated with deep surgical site infections after primary total knee arthroplasty”
  – BMI .34
  – DM
  – Male sex
  – ASA score >2
  – Osteonecrosis
  – Post-traumatic arthritis
  – Protective: antibiotic irrigation, bilateral procedure, lower annual hospital volume

Namba  J Bone Joint Surg 2013
Influence of Oxygen on the Development of Wound Infection

![Graph showing the diameter of infectious necrosis (mm) over time for different oxygen concentrations.](image)
Near InfraRed O2 Saturation in the Surgical Incision at 12 hrs

Arm Tissue $O_2$ Saturation and SSI

Govinda. Anesth & Analg 2010; 111: 946-52
Oxygen and SSI

• Oxygen tension in the wound is important.

• How to translate that into clinical practice that lowers SSI is less obvious.
MRSA Colonization

- *S aureus* colonization is common (~20-30% with persistent colonization)
- Higher rates in hospitalized pts, HIV+, IVDU, HD
- Nose, throat, perineum, GI tract, wounds
- Colonization confers 2-12x greater risk of infection, bacterial density may also play a role in SSI risk
- MRSA colonization may confer > risk than MSSA
MRSA DE-colonization

- Many topical agents: bacitration, chlorexidine, fusidic acid, medicinal honey, mupirocin, neomycin, triclosan, etc
- Systemic: rifampicin, vancomycin, TMP/SMX
- Other: photodynamic therapy, phages, vaccination
- Decolonization with mupirocin or chlorhexidine, alone or together, decreased colonization and a decrease in nosocomial infection, esp SSI, compared to placebo (ARR 6.4%, p=0.002)

Segers JAMA 2006
Treatment of the Nares to Prevent SSI

- Chlorhexidine soap + nasal mupirocin (5 days) = significant reduction in SSI (RCT data)
- Barriers to patient adherence using mupirocin (time, cost, AEs) leads to inconsistent use
- Povidone-iodine is less costly, applied immediately prior to surgery and has fewer AEs
Equivalence of Mupirocin and Pov-Iodine

Patients undergoing arthroplasty or spine fusion, all used chlorhexidine wipes

| TABLE 2. Number of Subjects with Deep Surgical Site Infection (SSI) and SSI Rates |
|-------------------------------------------------|------|-----------------|-----------------|------|
| Analysis                                        | No. of subjects | No. of cases | Rate, cases per 100 subjects | P*   | No. of cases | Rate, cases per 100 subjects | P*   |
| Intent to treat                                 |                 |               |                               |      |               |                               |      |
| Mupirocin                                       | 855             | 14            | 1.6                           | .1   | 5             | 0.6                           | .2   |
| Povidone-iodine                                  | 842             | 6             | 0.7                           |      | 1             | 0.1                           |      |
| Per protocol                                    |                 |               |                               |      |               |                               |      |
| Mupirocin                                       | 763             | 13            | 1.7                           | .06  | 5             | 0.7                           | .03  |
| Povidone-iodine                                  | 776             | 5             | 0.6                           |      | 0             | 0                             |      |

* By χ² test.
Effect of a Preoperative Decontamination Protocol on Surgical Site Infections in Patients Undergoing Elective Orthopedic Surgery With Hardware Implantation

JAMA Surg. Published online March 04, 2015.

Table 2. Types of Surgical Site Infection

<table>
<thead>
<tr>
<th>Surgical Site Infection</th>
<th>Patients, No.</th>
<th>Control Group (n = 13)</th>
<th>Intervention Group (n = 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superficial</td>
<td></td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Deep</td>
<td></td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Organ/space</td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 4. Multivariate Analysis of Independent Risk Factors Associated With the Development of SSIs\textsuperscript{a}

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Adjusted OR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decontamination</td>
<td>0.24 (0.08-0.77)</td>
<td>.02</td>
</tr>
<tr>
<td>Duration of surgery ≥150 min</td>
<td>4.59 (1.67-12.65)</td>
<td>.003</td>
</tr>
<tr>
<td>COPD</td>
<td>6.76 (2.16-21.19)</td>
<td>.001</td>
</tr>
</tbody>
</table>

Abbreviations: COPD, chronic obstructive pulmonary disease; OR, odds ratio; SSIs, surgical site infections.

\textsuperscript{a} Only risk factors found to be statistically significant on multivariate analysis are shown.
<table>
<thead>
<tr>
<th>Adverse Reaction</th>
<th>MO Group</th>
<th>PI Group</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>18 (2.07)</td>
<td>3 (0.37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhinorrhea</td>
<td>52 (5.99)</td>
<td>1 (0.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burning or itching in the nose</td>
<td>14 (1.61)</td>
<td>9 (1.11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lung or throat congestion</td>
<td>15 (1.73)</td>
<td>3 (0.37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cough</td>
<td>6 (0.69)</td>
<td>3 (0.37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sore throat</td>
<td>11 (1.27)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pruritus</td>
<td>7 (0.81)</td>
<td>12 (1.48)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin rash</td>
<td>4 (0.46)</td>
<td>3 (0.37)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: MO, mupirocin ointment; PI, povidone-iodine.
Mupirocin vs Povidone-Iodine

- Mupirocin
  - 5 days, BID
  - Press 0.25g per nostril
  - Maintain x 1 minutes
  - Expensive ($25-$135)
  - Not always easy to obtain (at pharmacy)
  - Resistance

- Povidone-iodine
  - 1-2 applications just prior to surgery
  - 30 seconds
  - Inexpensive ($1.70-$16)
  - Easy to obtain (immediately pre-op)
### Nasal decolonization to prevent SSI by Gram positive bacteria

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>No of events/total</th>
<th>Risk ratio (95% CI)</th>
<th>Weight (%)</th>
<th>Risk ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention</td>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M-H, random</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Randomized controlled trials</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bode 2010²⁷</td>
<td>3/278</td>
<td>17/227</td>
<td>4.4</td>
<td>0.14 (0.04 to 0.49)</td>
</tr>
<tr>
<td>Kalmeijer 2002²⁸</td>
<td>5/315</td>
<td>8/299</td>
<td>5.0</td>
<td>0.59 (0.20 to 1.79)</td>
</tr>
<tr>
<td>Konvalinka 2006²⁴</td>
<td>5/130</td>
<td>4/127</td>
<td>4.0</td>
<td>1.22 (0.34 to 4.44)</td>
</tr>
<tr>
<td>Perl 2002²⁵</td>
<td>9/353</td>
<td>11/346</td>
<td>6.6</td>
<td>0.80 (0.34 to 1.91)</td>
</tr>
<tr>
<td>Segers 2006²⁶</td>
<td>34/485</td>
<td>40/469</td>
<td>11.0</td>
<td>0.82 (0.53 to 1.28)</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>56/1561</td>
<td>80/1468</td>
<td>31.0</td>
<td>0.63 (0.36 to 1.13)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for heterogeneity: $\tau^2=0.01$, $\chi^2=8.07$, df=4, $P=0.09$, $I^2=50%$</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Test for overall effect: $z=1.55$, $P=0.12$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observational studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cimochowski 2001²⁹</td>
<td>5/854</td>
<td>19/992</td>
<td>5.8</td>
<td>0.31 (0.11 to 0.82)</td>
</tr>
<tr>
<td>Coskun 2004³⁵</td>
<td>9/2329</td>
<td>14/920</td>
<td>6.9</td>
<td>0.25 (0.11 to 0.58)</td>
</tr>
<tr>
<td>Coskun 2005³⁰</td>
<td>27/7555</td>
<td>27/4511</td>
<td>9.9</td>
<td>0.60 (0.35 to 1.02)</td>
</tr>
<tr>
<td>Gemaat-van der Sluis 1998³⁶</td>
<td>7/1044</td>
<td>14/1260</td>
<td>6.4</td>
<td>0.60 (0.24 to 1.49)</td>
</tr>
<tr>
<td>Graf 2009³¹</td>
<td>9/154</td>
<td>22/154</td>
<td>7.7</td>
<td>0.41 (0.19 to 0.86)</td>
</tr>
<tr>
<td>Hacek 2009³⁸</td>
<td>10/912</td>
<td>15/583</td>
<td>7.3</td>
<td>0.43 (0.19 to 0.94)</td>
</tr>
<tr>
<td>Kluytmans 1996³²</td>
<td>11/752</td>
<td>6/116</td>
<td>5.8</td>
<td>0.28 (0.11 to 0.75)</td>
</tr>
<tr>
<td>Martorell 2004³³</td>
<td>3/469</td>
<td>11/466</td>
<td>4.1</td>
<td>0.27 (0.08 to 0.97)</td>
</tr>
<tr>
<td>Nicholson 2006³⁶</td>
<td>4/1077</td>
<td>16/954</td>
<td>5.1</td>
<td>0.22 (0.07 to 0.66)</td>
</tr>
<tr>
<td>Price 2008³⁷</td>
<td>0/43</td>
<td>2/41</td>
<td>1.0</td>
<td>0.19 (0.01 to 3.86)</td>
</tr>
<tr>
<td>Sankar 2005³⁰</td>
<td>0/231</td>
<td>1/164</td>
<td>0.9</td>
<td>0.24 (0.01 to 5.78)</td>
</tr>
<tr>
<td>Wilcox 2003³⁹</td>
<td>11/2959</td>
<td>26/1161</td>
<td>8.1</td>
<td>0.17 (0.08 to 0.33)</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>96/18379</td>
<td>173/11322</td>
<td>69.0</td>
<td>0.35 (0.27 to 0.46)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for heterogeneity: $\tau^2=0.02$, $\chi^2=11.88$, df=11, $P=0.37$, $I^2=7%$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect: $z=7.64$, $P&lt;0.001$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>152/19940</td>
<td>253/12790</td>
<td>100.0</td>
<td>0.41 (0.30 to 0.55)</td>
</tr>
<tr>
<td>Test for heterogeneity: $\tau^2=0.17$, $\chi^2=30.21$, df=16, $P=0.02$, $I^2=47%$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect: $z=5.73$, $P&lt;0.001$</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
S aureus Vaccination?

• New cardiac valve or endograft, mortality ~50% with infection (mostly S aureus)
• 4-year, multicenter RCT of V710 to prevent bacteremia and deep sternal wounds after cardiac surgery (n = 7045)
• Vaccine generated excellent Ab responses
• No significant difference between the groups (22 and 27 cases)
• There were significantly more deaths in the vaccinated group who did get S aureus infection (mortality rates 23 vs 4.2/100py)

Fowler JAMA 2013
A Bundled Approach

• De-colonization plus....
Bundle intervention to prevent surgical site infections caused by Gram positive bacteria

Schweizer BMJ 2013
Surgical Site Infection Prevention Checklist

**MSQC SSI Prevention Measures**

<table>
<thead>
<tr>
<th>MSQC SSI Prevention Measures</th>
<th>✔️</th>
<th>✗</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate (SCIP-2) selection of intravenous prophylactic antibiotics</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>Postoperative normothermia (Temp &gt;98.6°F)</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>Oral antibiotics with mechanical bowel prep</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>Postoperative day 1 glucose less than or equal to 140 mg/dl</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>Minimally invasive surgery</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td>Short operative duration (Incision to closure) &lt;100 min</td>
<td>✔️</td>
<td>✗</td>
</tr>
</tbody>
</table>

Waits, Surgery, 2014
More bundle elements = lower SSI risk
SSI Prevention Bundles Prevent Colorectal Surgery SSI

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Care Bundle</th>
<th>Control</th>
<th>Risk Ratio M-H, Random, 95% CI</th>
<th>Risk Ratio M-H, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthony 2010</td>
<td>45</td>
<td>24</td>
<td>1.82 [1.21, 2.74]</td>
<td></td>
</tr>
<tr>
<td>Berenguer 2010</td>
<td>7</td>
<td>15</td>
<td>0.63 [0.27, 1.47]</td>
<td></td>
</tr>
<tr>
<td>Bull 2011</td>
<td>22</td>
<td>27</td>
<td>0.84 [0.50, 1.41]</td>
<td></td>
</tr>
<tr>
<td>Cima 2012</td>
<td>8</td>
<td>52</td>
<td>0.41 [0.20, 0.85]</td>
<td></td>
</tr>
<tr>
<td>Crolla 2012</td>
<td>61</td>
<td>86</td>
<td>0.74 [0.55, 1.00]</td>
<td></td>
</tr>
<tr>
<td>Hedrick 2007</td>
<td>21</td>
<td>45</td>
<td>0.62 [0.39, 0.99]</td>
<td></td>
</tr>
<tr>
<td>Keenan 2014</td>
<td>18</td>
<td>55</td>
<td>0.33 [0.20, 0.54]</td>
<td></td>
</tr>
<tr>
<td>Liu 2010</td>
<td>11</td>
<td>33</td>
<td>0.14 [0.07, 0.28]</td>
<td></td>
</tr>
<tr>
<td>Lutfyaa 2012</td>
<td>13</td>
<td>91</td>
<td>0.32 [0.18, 0.55]</td>
<td></td>
</tr>
<tr>
<td>Pastor 2010</td>
<td>49</td>
<td>45</td>
<td>1.02 [0.71, 1.47]</td>
<td></td>
</tr>
<tr>
<td>Tillman 2013</td>
<td>12</td>
<td>19</td>
<td>0.48 [0.25, 0.93]</td>
<td></td>
</tr>
<tr>
<td>Waits 2013</td>
<td>2</td>
<td>17</td>
<td>0.13 [0.03, 0.56]</td>
<td></td>
</tr>
<tr>
<td>Wick 2012</td>
<td>59</td>
<td>76</td>
<td>0.67 [0.49, 0.90]</td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>4649</td>
<td>3866</td>
<td>0.55 [0.39, 0.77]</td>
<td></td>
</tr>
<tr>
<td>Total events</td>
<td>328</td>
<td>585</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.30; Chi² = 73.22, df = 12 (P < 0.00001); I² = 84%
Test for overall effect: Z = 3.47 (P = 0.0005)
Clinical Surgery-American

Surgical team behaviors and patient outcomes

Karen Mazzocco, R.N., J.D.\textsuperscript{a,*}, Diana B. Petitti, M.D., M.P.H.\textsuperscript{b},
Kenneth T. Fong, M.S.\textsuperscript{c}, Doug Bonacum, M.B.A.\textsuperscript{c}, John Brookey, M.D.\textsuperscript{d},
Suzanne Graham, R.N., Ph.D.\textsuperscript{e}, Robert E. Lasky, Ph.D.\textsuperscript{f}, J. Bryan Sexton, Ph.D.\textsuperscript{g},
Eric J. Thomas, M.D., M.P.H.\textsuperscript{f}

\textsuperscript{a}Sharp Metropolitan Medical Campus, Sharp Healthcare, Patient Relations and Concierge Services, San Diego, CA USA;
\textsuperscript{b}Arizona State University, Tempe, AZ, USA; \textsuperscript{c}Kaiser Permanente Program Offices, Oakland, CA, USA;
\textsuperscript{d}Kaiser Permanente Southern California, Pasadena, CA, USA; \textsuperscript{e}Kaiser Permanente Northern California, Oakland, CA, USA;
\textsuperscript{f}University of Texas Medical School, Houston, TX, USA; \textsuperscript{g}Johns Hopkins School of Medicine, Baltimore, MD, USA
Surgical Safety Checklist

Before Induction of anaesthesia
(with at least nurse and anaesthetist)

- Has the patient confirmed his/her identity, site, procedure, and consent?
  - Yes
  - No

- Is the site marked?
  - Yes
  - Not applicable

- Is the anaesthesia machine and medication check complete?
  - Yes
  - No

- Does the patient have a:
  - Known allergy?
    - Yes
    - No
  - Difficult airway or aspiration risk?
    - Yes
    - No
    - Yes, and equipment/assistance available
  - Risk of >500mL blood loss (2mL/kg in children)?
    - Yes
    - No
    - Yes, and two IVs/central access and fluids planned

Before skin incision
(with nurse, anaesthetist and surgeon)

- Confirm all team members have introduced themselves by name and role.
- Confirm the patient’s name, procedure, and where the incision will be made.
- Has antibiotic prophylaxis been given within the last 60 minutes?
  - Yes
  - No
  - Not applicable

Anticipated Critical Events
To Surgeon:
- What are the critical or non-routine steps?
- How long will the case take?
- What is the anticipated blood loss?

To Anaesthetist:
- Are there any patient-specific concerns?

To Nursing Team:
- Has sterility (including indicator results) been confirmed?
- Are there equipment issues or any concerns?

Is essential imaging displayed?
- Yes
- No

Before patient leaves operating room
(with nurse, anaesthetist and surgeon)

Nurse Verbally Confirms:
- The name of the procedure
- Completion of instrument, sponge and needle counts
- Specimen labelling (read specimen labels aloud, including patient name)
- Whether there are any equipment problems to be addressed

To Surgeon, Anaesthetist and Nurse:
- What are the key concerns for recovery and management of this patient?
Prior to Skin Incision:

**Briefing**

All Team Members (Attending Surgeon Leads):

- Each person introduces self by name and role
- Surgeon, Anesthesia team and Nurse confirm patient (at least 2 identifiers), site, procedure
- Personnel exchanges: timing, plan for announcing changes
- Description of procedure and anticipated difficulties
- Expected duration of procedure
- Expected blood loss & blood availability
- Need for instruments/supplies/IV access beyond those normally used for the procedure
- Questions/issues from any team member and invitation to speak up at any time in the procedure

**Nursing/Tech reviews:**

- Equipment issues (instruments ready, trained on, requested implants available, gas tanks full)
- Sharps management plan
- Other patient concerns

**Anesthesia reviews:**

- Airway or other concerns
- Special meds (beta blockers, etc.)
- Allergies
- Conditions affecting recovery
Prior to Skin Incision:

*Process Control*

**Surgeon** reviews (as applicable):

- Essential imaging displayed; right and left confirmed
- Antibiotic prophylaxis given in last 60 minutes
- Active warming in place
- Special instruments and/or implants

*If case expected to be ≥ 1 hour, add:*

**Surgeon** reviews:

- Glucose checked for diabetics
- Insulin protocol initiated if needed
- DVT/PE chemoprophylaxis and/or mechanical prophylaxis plan in place
- If patient on beta blocker, post-op plan formulated
- Re-dosing plan for antibiotics
- Specialty-specific checklist
After Skin Closure Complete:  
No Retained Objects, Debriefing, Care Transition

All Team Members  
(Attending Surgeon Leads):

- Confirm final needles/sponges/instruments count correct
- Nursing/Tech show Surgeon and Anesthesia all sponges and laps in holders (“Show Me Ten”) 
- Confirm name of procedure
- If specimen, confirm label and instructions (e.g., orientation of specimen, 12 lymph nodes for colon CA)
- Equipment issues to be addressed?
- Response planned (who/when)
- What could have been better?
- Improvement planned (who/when)

Surgeon and Anesthesia:

- Key concerns for patient recovery
- What is the plan for pain mgmt?
- What is the plan for prevention of PONV?
- Does patient need special monitoring (time in RR, ICU, tele?)
- If patient has elevated blood glucose, plan for insulin drip formulated
- If patient on beta blocker, post-op continuation plan formulated
## Checklist and Complications

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=3773</td>
<td>n=3955</td>
</tr>
<tr>
<td>SSI</td>
<td>6.2%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Unplan Return-O.R.</td>
<td>2.4%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Any Complic</td>
<td>11.0%</td>
<td>7.0%</td>
</tr>
<tr>
<td>Death</td>
<td>1.5%</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

Haynes. NEJM 2009; 360: 491-9
## Checklist and Complications

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=3760</td>
<td>n=3820</td>
<td></td>
</tr>
<tr>
<td>SSI</td>
<td>3.8%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Complic/100 pts</td>
<td>27.3</td>
<td>16.7</td>
</tr>
<tr>
<td>Pts with Complic</td>
<td>15.4%</td>
<td>10.6%</td>
</tr>
<tr>
<td>Death</td>
<td>1.5%</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

de Vries. NEJM 2010; 363: 1928-37
<table>
<thead>
<tr>
<th>Checklist Completion</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above median</td>
<td>7.1%</td>
</tr>
<tr>
<td>Below median</td>
<td>11.7%</td>
</tr>
</tbody>
</table>

de Vries. NEJM 2010; 363: 1928-37
Less Obvious Risk Factors for SSI

Blood transfusion after cardiac surgery

- 5,128 pts prospectively enrolled
- 31% bypass, 30% valve, 19% re-operations
- Each unit of PRBC was associated with a 29% increase in crude risk of major infection (pneumonia and BSI)

Horvath Ann Thorac Surg 2013
Effect of Noise in the O.R. on SSI Risk

Preventing SSI

• Have good teamwork at all times
• Prewarm the patient
• Enough of the right antibiotic at the right time and repeat if necessary
• Don’t shave
• Thorough skin prep
• Warm the patient in the O.R.
• High FiO$_2$
• Control glucose
• Good teamwork
“Adaptive work requires changing peoples values, attitudes, beliefs, and behaviors to foster a culture of safety, improve clinician engagement, and improve multidisciplinary teamwork.”

Septimus, et al, ICHE May 2014