Strategies for the Prevention of Surgical Site Infections

Dale W. Bratzler, DO, MPH
Professor and Associate Dean, College of Public Health
Professor, College of Medicine
Chief Quality Officer – OU Physicians Group
Oklahoma University Health Sciences Center

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Disclosures

• Dr. Bratzler has no financial relationships to disclose related to surgical site infection prevention.

Objectives

• Discuss the burden of surgical site infections (SSIs) in the US
• Review issues related to SSI surveillance
• Highlight the development of new national guidelines on prevention of SSI
• Discuss implementation of performance improvement initiatives to reduce SSI
You are asked to evaluate a patient preparing for surgery......

67 year old female preparing for elective total hip arthroplasty. She is generally independent and has been healthy other than a long history of rheumatoid arthritis. Over the years she has been treated with a variety of medications including NSAIDS, corticosteroids, methotrexate, and most recently etanercept. She was last hospitalized two months ago because of a fall attributed to her painful hip.

Her vital signs are normal. Her height is 5’2” (157.5 cm) and her weight is 165 pounds (75 kg) [BMI 30.2]. With the exception of joint changes due to RA, her physical examination is otherwise normal. Her baseline laboratory is largely unremarkable however, her cholesterol is mildly elevated (210 mg/dL) and her fasting blood sugar was 135 mg/dL.

Current SSI Burden

**Burden-US**
- 160,000 - 300,000 SSIs per year
- 2%-5% of patients undergoing inpatient surgery
- Most common and most costly HAI

**Mortality**
- 2-11 fold higher risk of death compared to non-infected operative patient
- 77% of deaths among SSI patients are directly attributable to SSI

**Length of Hospital Stay**
- ~7-11 additional postoperative hospital days

**Cost**
- Up to $3.5 to 10 billion annually

Factors Affecting Rates of Surgical Site Infections

- Age
- **Endogenous flora**
- Microbial factors
- Surgical team and hospital practice factors
- **Surgical procedures**
- **Host factors**
- **Surgical site**
- Wound classification
- Procedure duration
- Poor hemostasis
- Dignosis/foreign body
- Dead space
- Urgency of surgery
- Abdominal site
- Prophylactic antibiotics timing, selection and duration
- Intraoperative contamination
- Preoperative cleansing with chlorhexidine
- Preoperative screening for resistant organisms and decolonization
- Surgeon's skill
- Surgical volume
- Diabetes
- Morbid obesity
- Malnutrition
- Prolonged preoperative stay
- Infection at distant site
- Cancer
- Diabetes
- SIRS
- Infection at distal site
- ASA score
- Disease severity
- Prior operations, revision vs primary
- ASA score
- Nasal/skin carriage
- Virulence
- Adherence
- Inoculum
- Nasal/skin carriage
- Virulence
- Adherence
- Inoculum
**SSI Risk Varies by Operation**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Pooled Mean SSI Rate (%)</th>
<th>25th, 75th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABG, Chest and Donor Site</td>
<td>4.26</td>
<td>1.33, 5.81</td>
</tr>
<tr>
<td>Colon</td>
<td>7.06</td>
<td>2.38, 9.09</td>
</tr>
<tr>
<td>Abdominal Hysterectomy</td>
<td>4.05</td>
<td>0.00, 4.86</td>
</tr>
<tr>
<td>Hip prosthesis</td>
<td>2.40</td>
<td>0.00, 3.70</td>
</tr>
<tr>
<td>Laminectomy</td>
<td>1.30</td>
<td>0.00, 3.73</td>
</tr>
<tr>
<td>Peripheral Vascular Bypass</td>
<td>6.98</td>
<td>2.75, 8.47</td>
</tr>
</tbody>
</table>

Risk index category "C" operations.  

**Voluntary Reporting to NHSN**

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**SSI Rate in a Clinical Trial Compared to NHSN Reported SSI Rates**

<table>
<thead>
<tr>
<th>Infection</th>
<th>Ertapenem N=338 (%)</th>
<th>Cefotetan N=334 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any SSI</td>
<td>62 (18.1)</td>
<td>104 (31.3)</td>
</tr>
<tr>
<td>Superficial incisional</td>
<td>45 (13.1)</td>
<td>75 (22.4)</td>
</tr>
<tr>
<td>Deep incisional</td>
<td>13 (3.7)</td>
<td>17 (5.1)</td>
</tr>
<tr>
<td>Organ-space</td>
<td>4 (1.2)</td>
<td>12 (3.7)</td>
</tr>
</tbody>
</table>

Total infections identified = 166 (24.7%)  
Deep incisional and organ-space = 46 (6.8%)  
NHSN Pooled Mean = 7.06%  
NHSN 90th Percentile = 13.8%  

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**Cololectal SSI Rate by Quarter (NSQIP)**

Baseline SSI Rate: 27%  
Year 1: 17%  
Year 2: 20%  
Year 3: 11%
Use of Medicare Diagnosis and Procedure Codes to Improve Detection of Surgical Site Infections following Hip Arthroplasty, Knee Arthroplasty, and Vascular Surgery

Claims-based surveillance detected 1.8–4.7-fold more SSIs than traditional surveillance, including detection of all previously identified cases. For hip and vascular surgery, there was a 5-fold and 1.6-fold increase in detection of deep and organ/space infections, respectively.


Whether intentional or unintentional, the pressure to adjudicate cases by persons without familiarity of or strict adherence to NHSN criteria is problematic. Of note, adjudicators can be consciously or unconsciously biased if they are held accountable for institutional HAI performance. This clear conflict of interest creates a disincentive to adjudicate on the side of infection.

Although we must still strive to eliminate all preventable HAIs, the drive to “reach zero” can exacerbate the pressure to err on the side of underreporting HAIs described earlier.
Development of National Guidelines for Antimicrobial Prophylaxis and Prevention of SSI

Clinical Practice Guidelines for Antimicrobial Prophylaxis in Surgery

Antimicrobial Prophylaxis

- Review of new literature since the 1999 publication of the ASHP guideline
  - Searches of MEDLINE®, Embase®, and The Cochrane Collection® database of systematic reviews, and a review of published guidelines on surgical antimicrobial prophylaxis
  - Evidence ratings provided for key recommendations
  - Adult and pediatric recommendations (we do not address newborn or premature infants)
A few principles......

• In almost every study for every type of surgery, antibiotic prophylaxis reduces the risk of SSI
  – However for some operations the risk is so low or consequences so trivial, that antibiotic prophylaxis may not be warranted for all operations
• Guideline was developed to be specialty specific and was posted for open public comment

Dosing (and Re-dosing) Table

Comprehensive Summary Table

Antibiotic Recommendations
Prevention of SSI

“Although antimicrobial prophylaxis plays an important role in reducing the rate of surgical site infections,...

– other factors, such as attention to basic infection control strategies, the surgeon’s experience and technique, duration of procedure, hospital and operating room environments, instrument sterilization issues, preoperative preparation (e.g. surgical scrub, skin antisepsis, and appropriate hair removal), perioperative management (temperature and glycemic control) and the underlying medical condition of the patient, may have a strong impact on surgical site infection rates.”

– Patient-related factors

No single intervention is going to be sufficient to prevent SSIs

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Common Principles

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Antimicrobial Prophylaxis

• Antibiotic selection
  – Narrowest spectrum for efficacy
  – Routine use of vancomycin for prophylaxis is not recommended for any procedure.
    – Limit use of vancomycin to patients with known colonization with MRSA, high risk of MRSA, or in patients with beta-lactam allergy
  – No consensus on patients colonized with other MDROs

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Use of Vancomycin or Clindamycin

“For procedures where pathogens other than staphylococcus and streptococcus are likely, an additional agent with activity against those pathogens could be considered. For example, if there is surveillance data showing that gram negative organisms are a cause of surgical site infections for the procedure, consider combining clindamycin or vancomycin with another agent (cefazolin if not beta-lactam allergic; aztreonam, gentamicin, or single-dose fluoroquinolone if beta-lactam allergic).”

Beta-lactam Allergy

- Cephalosporins and carbapenems can safely be used in patients with an allergic reaction to penicillins other than IgE mediated reactions (e.g. anaphylaxis, urticaria, bronchospasm) or exfoliative dermatitis (Stevens-Johnson syndrome and toxic epidermal necrolysis)

- Patients should be carefully questioned about their history of beta-lactam allergies.

Don’t overuse non-beta lactam antibiotics in patients with a history of penicillin allergy, without an appropriate evaluation.

While about 10 percent of the population reports a history of penicillin allergy, studies show that 90 percent on more of these patients are not allergic to penicillins and are able to take these antibiotics safely.
Antimicrobial Timing

- The first dose of prophylaxis should be initiated within 60 minutes prior to incision (120 minutes for vancomycin or fluoroquinolones).
- Patients receiving therapeutic antibiotics for a remote infection prior to surgery should also be given antibiotic prophylaxis prior to surgery to ensure adequate serum and tissue levels of antibiotics with activity against likely pathogens for the duration of the operation.

Antibiotic Dosing

- Weight-based dosing – very little data upon which to make recommendations
  - Cefazolin ~25 mg/kg
  - Gentamicin 5 mg/kg single preoperative dose based on the dosing weight
  - Vancomycin 15 mg/kg
Antimicrobial Prophylaxis

- Re-dosing
  - Specific intervals provided – two half-lives of the drug

- Duration
  - The duration of antimicrobial prophylaxis should be less than 24 hours for all operations

- Topical antibiotics
  - “Superior to placebo but not superior to parenteral administration, and topical administration does not increase the efficacy of parenteral antibiotics when used in combination for prophylaxis.”

Colorectal Surgery

- In most patients undergoing elective colorectal surgery, a mechanical bowel prep combined with oral neomycin sulfate plus oral erythromycin base; or oral neomycin sulfate plus oral metronidazole should be given in addition to intravenous prophylaxis.

Preoperative Oral Antibiotics Reduce Surgical Site Infection Following Elective Colorectal Resections

Jamie A. Canton, M.D. 1, 2, 3, Laura K. Allen, M.D., M.S.P.H.E 3
Shannon L. Debroh, M.P.H. 4, 5, Melanie Smith, M.D. 6, 7
Judson S. Richman, M.D., Ph.D. 8, 9, Catherine C. Vo, M.A. 10

Department of Surgery, Division of Colon and Rectal Surgery, Boston Medical Center, Boston, Massachusetts


A Statewide colorectal experience

The Role of Full Bowel Preparation in Preventing Surgical Site Infection

Robert K. Kim, M.D., P.C. 1, 2, 3, Sue T. Min, M.D. 1, 2, 4
John Kuo, M.D. 1, 2, 3
Scott D’Amico, M.D. 1, 2, 3
Anna Burdick, M.D. 1, 2, 3
Erick E. Cerez, M.D. 1, 2, 3
Marijn J. M. van der Horst, M.D. 1, 2, 3
These results strongly suggest that preoperative oral antibiotics should be administered for elective colorectal resections.

Pre-surgical Screening for *S. aureus*

*S. aureus* Preoperative Screening

- Patients with nasal carriage of *S. aureus* are at an increased risk of *S. aureus* skin colonization and 2- to 14-fold increased risk for SSI with this microorganism compared with non-carriers.
- Preoperative screening and decolonization
  - “Recent studies confirm that *S. aureus* decolonization of the anterior nares decreases SSI rates in many surgical patients. The data are most compelling in cardiac and orthopedic surgery patients.”
Update of the 1999 HICPAC guideline on Prevention of Surgical Site Infections
- Core section
- Arthroplasty section

Draft guidelines have been presented at the HICPAC meeting but are not final.

Disclaimer

- This guideline is not final
- The discussion does not reflect the official position of the Centers for Disease Control and Prevention

Draft Guideline for the Prevention of Surgical Site Infection

Participants

CDC/HICPAC SSI Guideline Content Experts
- Core Writing Group
- University of Pennsylvania
- Evidence-Based Practice

American College of Surgeons (ACS)
- American Academy of Orthopaedic Surgeons (AAOS)
- Association of periOperative Registered Nurses (AORN)
- Musculoskeletal Infection Society (MSIS)
- Surgical Infection Society (SIS)
- European Union Academic Institutions
So, what can we say after grading the evidence?

Antimicrobial Prophylaxis

• No recommendation can be made regarding optimal timing of preoperative parenteral prophylactic antimicrobial agent for prevention of SSI. (No recommendation/unresolved issue*)

• Administer the appropriate parenteral prophylactic antimicrobial agent prior to skin incision in all cesarean sections. (Category IA)

*Observational studies but no randomized controlled trials.

Antimicrobial Prophylaxis (cont)

• No recommendation can be made
  – Weight-adjusted dosing
  – Intraoperative redosing
  (No recommendation/unresolved issue*)

*Observational studies but no randomized controlled trials.
Antibiotic Duration

<table>
<thead>
<tr>
<th>Specialty</th>
<th>RCTs</th>
<th>Publication Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic</td>
<td>1</td>
<td>1964</td>
</tr>
<tr>
<td>Ear, Nose, Throat</td>
<td>2</td>
<td>2003</td>
</tr>
<tr>
<td>Orthopaedics-Arthroplasty</td>
<td>2</td>
<td>1989</td>
</tr>
<tr>
<td>General Surgery-Other</td>
<td>3</td>
<td>2007(2), 2005</td>
</tr>
<tr>
<td>Mixed general, urologic, GYN</td>
<td>1</td>
<td>1992</td>
</tr>
</tbody>
</table>

38 71% published before 1999

Disclaimer: The findings and conclusions are draft and have been presented at HICPAC but have not been formally disseminated by the CDC and should not be construed to represent any agency determination or policy.

Antibiotic Duration

• In clean and clean-contaminated procedures, do not administer additional prophylactic antimicrobial agent doses after the surgical incision is closed in the operating room. (Category IA*)

*While there are many studies there is not a RCT for every type of surgery.

Topical Antimicrobials/Antiseptics

• No recommendation/unresolved issues:
  – Intraoperative antimicrobial irrigation
  – Soaking prosthetic devices in antimicrobial or antiseptic solutions prior to implantation

• Category II
  – Consider intraoperative irrigation of deep or subcutaneous tissues with aqueous iodophor solution (but not for contaminated or dirty abdominal procedures)

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**Topical Antimicrobials/Antiseptics (cont)**

- Category IB
  - Do not apply topical antimicrobial agents (ointments, solutions, powders) to the surgical incision
- Category IA
  - Do not use autologous platelet-rich plasma for prevention of SSI

**Antimicrobial Sutures**

- Not necessary to prevent surgical site infections. *(No recommendation/ unresolved issue)*

  *FDA approved as sutures (FDA approval did not require any evidence that these products prevented surgical site infections). HICPAC doing an updated literature review to see if newer studies show any evidence that these products reduce SSI.*

**Antimicrobial Dressings**

- No recommendation can be made regarding the safety and effectiveness of antimicrobial dressings applied to surgical incisions following primary closure in the operating room for the prevention of surgical site infection. *(No recommendation/ unresolved issue)*

  *No randomized controlled trials showing reduced SSIs.*
Glucose control

• Implement perioperative glycemic control and use blood glucose target levels < 200 mg/dL in diabetic and non-diabetic surgical patients (Category 1A)
  – No recommendation can be made regarding the safety and effectiveness of lower or narrower blood glucose target levels and SSI. (No Recommendation/unresolved issue)
  – No recommendation can be made regarding hemoglobin A1C target levels and the risk of surgical site infection in diabetic and non-diabetic patients. (No recommendation/unresolved issue)

Normothermia

• Maintain perioperative normothermia (Category 1A)
  – No recommendation can be made regarding the safety or effectiveness of strategies to achieve and maintain normothermia, the lower limit of normothermia, or the optimal timing and duration of normothermia.

ASA measure is now 35.5°C.
**Oxygenation**

- For patients with normal pulmonary function undergoing surgery with general anesthesia with endotracheal intubation, administer increased fraction of inspired oxygen (FiO₂) intraoperatively and post-extubation in the immediate postoperative period in combination with strategies to optimize tissue oxygen delivery through maintenance of perioperative normothermia and adequate volume replacement. (Category 1A)

**Oxygenation**

- No recommendation for
  - Those without endotracheal intubation
  - Mechanism (facemask, cannula) postoperatively
  - Optimal FiO₂ target, duration, and delivery method

**Skin Preparation**

- Require patients to shower or bathe (full body) with an antimicrobial or non-antimicrobial soap or antiseptic agent on at least the night before the operative day. (Category 1B)
  - No recommendation can be made regarding the optimal timing of the preoperative shower or bath or the total number of soap or antiseptic agent applications for the prevention of surgical site infection. (No recommendation/ unresolved issue)
Skin Preparation

- Perform intraoperative skin preparation with an alcohol-based antiseptic agent, unless contraindicated. **(Category 1A)**
- Do not use an antimicrobial sealant following intraoperative skin preparation and prior to skin incision for the prevention of surgical site infection. **(Category 1A)**
- Use of plastic adhesive drapes with or without antimicrobial properties, is not necessary for the sole purpose of the prevention of surgical site infection. **(Category II)**

Periprosthetic Joint Arthroplasty Section

Except for antibiotic duration, we could not make any recommendations for any of the key questions (No recommendation/unresolved issue)

What about other recommendations that were in the 1999 HICPAC Guideline?

- Restate recommendations that are now considered "standard of care"
- Eliminate discussion of recommendations that are covered in other HICPAC guidelines
Example: Preparation of the Patient

Whenever possible, identify and treat all infections remote to the surgical site before elective operation and postpone elective operations on patients with remote site infections until the infection has resolved.

Do not remove hair preoperatively unless the hair at or around the incision site will interfere with the operation. If hair removal is necessary, remove immediately before the operation, with clippers, and preferably outside of the operating room.

Thoroughly wash and clean at and around the incision site to remove gross contamination before performing antisepsic skin preparation.

Another example:

• Immediate-use steam sterilization should never be used for reasons of convenience, as an alternative to purchasing additional instrument sets, or to save time. This practice should be reserved only for patient care items that will be used immediately in emergency situations when no other options are available (e.g., to reprocess an inadvertently dropped instrument).

One of my key takeaways

• There is still considerable need for well-designed RCTs to evaluate best practices for prevention of SSI
  – Some questions will never be subjected to a randomized controlled trial
  – Need observational studies that have better designs
Where is the guideline now?

• Updated literature review
  – 500+ abstracts identified
  – 99 articles underwent full-text review by two authors
  – 62 articles now being extracted into grade tables

Most of the new articles address use of triclosan-coated sutures, oxygenation, preoperative bathing, antibiotic duration, and antibiotic timing for C-section.

Final (hopefully) discussion of HICPAC SSI guideline at the next HICPAC meeting (Nov or Dec).

Hospitals improved in measures related to appropriate antimicrobial agent selection, timing, and duration; normothermia; oxygenation; euglycemia; and appropriate hair removal. The infection rate decreased 27%, from 2.3% to 1.7% in the first versus last 3 months.

Developing an argument for bundled interventions to reduce surgical site infection in colorectal surgery

There was a strong stepwise inverse association between bundle score and incidence of SSI. Patients who received all 6 bundle elements had risk-adjusted SSI rates of 2.0% (95% confidence interval [CI], 7.9–0.5%), whereas patients who received only 1 bundle measure had SSI rates of 17.5% (95% CI, 27.1–10.8%).
Conclusions

• Surgical site infections are the most frequent healthcare-associated infection reported in hospitals
  – Probably far more common than voluntary reporting to NHSN suggests
• Risk of SSI varies by operation type
• There are multiple factors that contribute to the development of SSIs
  – No single intervention is going to be sufficient to prevent SSIs

dale-bratzler@ouhsc.edu