Prevention of Surgical Site Infections

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Surgical Site Infections (SSI)

- 800,000-1,400,000 surgical site infections complicate ~ 40 million procedures annually in the US
- Account for 38% of all nosocomial infections in the United States each year
- Infections result in longer hospitalization and higher costs

Adverse Clinical and Economic Outcomes Attributable to Surgical Site Infections

Cohort Study

| Outcome | Uninfected control subjects | Patients with MSSA SSI | Patients with MRSA SSI | p
|---------|-----------------------------|------------------------|------------------------|---|
| Death, no. (%) of patients | 4 (1.5) | 11 (3.5) | 26 (9.1) | 0.44 | <0.001 | <0.001
| Total length of hospitalization, median days (IQR) | 5 (3-9) | 14 (2-25) | 25 (10-38) | <0.001 | <0.001 | <0.001
| Wound infection | NA | 16 (5.3) | 16 (17.3) | NA | NA | 0.07
| Other infection | NA | 16 (5.3) | 16 (17.3) | NA | NA | 0.07

NOTE: IQR, interquartile range; MSSA, methicillin-sensitive Staphylococcus aureus; MRSA, methicillin-resistant S. aureus.

CDC Classification of Surgical Site Infection

- Superficial Incisional SSI
  - Skin
  - Subcutaneous Tissue
  - Deep Soft Tissue (Muscle & vessels)
- Deep Incisional SSI
- Organ/Space SSI

National Nosocomial Infections Surveillance (NNIS) System

Microbiology of SSIs

<table>
<thead>
<tr>
<th>Year</th>
<th>Pathogen</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986-1989</td>
<td>Staphylococcus aureus</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Pseudomonas aeruginosa</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Enterococcus</td>
<td>12%</td>
</tr>
<tr>
<td>1990-1996</td>
<td>Staphylococcus aureus</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Pseudomonas aeruginosa</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Enterococcus</td>
<td>14%</td>
</tr>
</tbody>
</table>

Typical Microbiologic Flora at Surgical Sites

<table>
<thead>
<tr>
<th>Operation</th>
<th>Likely Pathogens*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placement of all grafts, prostheses, or stents</td>
<td>Staphylococcus aureus, CO/NOS</td>
</tr>
<tr>
<td>Cardiac</td>
<td></td>
</tr>
<tr>
<td>Abdominal</td>
<td></td>
</tr>
<tr>
<td>Genitourinary</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Head and neck</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

*Staphylococcus will be associated with surgical site infections following all types of operations.
**CO/NOS: Coagulase-negative staphylococci
CO: Coagulase-positive staphylococci
NOS: Non-oxidase-remaining staphylococci

Pathogenesis of SSI

- Relationship equation
  \[ \text{Dose of bacterial contamination} \times \text{Virulence} \]
- Resistance of host
- SSI Risk

Patient Characteristics Associated with Increased Risk of SSI

- Extremes of age
- Diabetes / perioperative hyperglycemia
- Concurrent tobacco use
- Remote infection at the time of surgery
- Obesity

Patient Characteristics Associated with Increased Risk of SSI

- Malnutrition
- Low preoperative serum albumin
- Concurrent steroid use
- Prolonged preoperative stay
- Prior site irradiation
- Colonization with *S. aureus*

Procedural Factors Associated with Increased Risk of SSI

- Inadequate OR ventilation
- Increased OR traffic
- Break in sterile technique and asepsis
- Perioperative hypothermia, hypoxia
- Poor surgical technique (poor hemostasis, tissue trauma)
- Improper use of flash sterilization of instruments

Procedural Factors Associated with Increased Risk of SSI

- Lack of preoperative antiseptic showering
- Shaving of site the night prior to procedure
- Use of razor for hair removal
- Improper preoperative skin preparation
- Improper antimicrobial prophylaxis
- Failure to timely redose antibiotics in prolonged cases

Prophylactic Antibiotic Use

**Historical Aspects**

- **1950s** - Nonrandomization, lack of blinding, faulty timing of initial antibiotic administration, prolonged antibiotic use, incorrect choices of antimicrobial agents, and inappropriate choices of control agents

- **1961** – Burke demonstrated the crucial relationship between timing of antibiotic administration and its prophylactic efficacy

- **1964** - Bernard and Cole reported successful use of prophylactic antibiotics in a randomized, prospective, placebo-controlled clinical study of abdominal operations on the gastrointestinal tract
Prophylactic Antibiotic Use

Historical Aspects

1970s - Qualitative and quantitative nature of the endogenous gastrointestinal flora in health and disease was appropriately defined

1980s and 1990s - Definitive recommendations concerning the proper approaches to antibiotic prophylaxis in surgery

Surgical Wound Classification

• Class I/Clean
• Class II/Clean-Contaminated
• Class III/Contaminated
• Class IV/Dirty-Infected


Clean surgery - neurosurgery, thoracic and cardiothoracic procedures

• Cefazolin
  ✓ Methicillin sensitive S. aureus,
  ✓ S. epidermidis, and
  ✓ Non-enterococcal strep
  ✓ E. coli
  ✓ Proteus
  ✓ Citrobacter koseri
  ✓ Klebsiella pneumoniae

Perioperative Antibiotics…

• Complex hepatobiliary and pancreatic procedures and in those patients who have internal or external hepatobiliary stents
  ✓ Consensus guidelines not available
  ✓ Ampicillin/sulbactam

Colin Surgery – Perioperative Antibiotics

• Cefoxitin
  ✓ Gram positives such as MSSA
  ✓ Aerobic Gram negatives such as E. coli, Klebsiella sp, Proteus, Morganella, Neisseria sp, Citrobacter, Serratia
  ✓ Gram negative anaerobes including B. fragilis

Common Misconception

• If a patient is already being treated with a β-lactam agent for a remote site infection, no additional parenteral prophylaxis is needed for a clean or a clean-contaminated procedure.

• Virtually no post antibiotic effect for β-lactam antimicrobials; No residual antibacterial effect is present in uninflamed tissues once the blood is cleared of the β-lactam.


Antibiotic Resistance

- Vancomycin is appropriate for
  - Surgical prophylaxis when prosthetic material/devices are to be implanted at institutions with high rates of MRSA infections
  - Patients with known MRSA colonization
- Linezolid, daptomycin, or tigecycline should not be used for prophylaxis; as they may be most useful for therapy.

Role of Mupirocin

- Among patients with *S. aureus* nasal carriage, the risk of a nosocomial *S. aureus* infection was significantly lower in the mupirocin recipients than those who received placebo
- Meta-analysis that included 3 randomized controlled trials and 4 before-after trials – in the non-general surgery trials, peri-operative intranasal mupirocin decreased the incidence of SSI

Impact of Timing of Antibiotic Prophylaxis

<table>
<thead>
<tr>
<th>Antibiotic Timing</th>
<th>SSI Incidence</th>
<th>Relative Risk</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-24 hours preop</td>
<td>3.8%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>&lt; 2 hours preop</td>
<td>0.6%</td>
<td>0.15</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3 hours postop</td>
<td>1.4%</td>
<td>0.37</td>
<td>0.11</td>
</tr>
<tr>
<td>3-24 hours postop</td>
<td>3.3%</td>
<td>0.86</td>
<td>0.8</td>
</tr>
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Perioperative Antibiotics Timing of Administration

<table>
<thead>
<tr>
<th>Hours From Incision</th>
<th>Infection (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-3</td>
<td>1/4369</td>
</tr>
<tr>
<td>4-3</td>
<td>5/699</td>
</tr>
<tr>
<td>3-2</td>
<td>5/1009</td>
</tr>
<tr>
<td>2-1</td>
<td>2/180</td>
</tr>
<tr>
<td>1-0</td>
<td>1/41</td>
</tr>
<tr>
<td>0</td>
<td>1/47</td>
</tr>
<tr>
<td>1</td>
<td>15/441</td>
</tr>
</tbody>
</table>
Impact of Prolonged Antibiotic Prophylaxis

- 2,641 CABG patients
  - Grp 1 - < 48 hours of antibiotics
  - Grp 2 - > 48 hours of antibiotics
- SSI Rates
  - Grp 1 - 8.7% (131/1502)
  - Grp 2 - 8.8 % (100/1139)
- Antibiotic resistant pathogen - Grp 2
  - Odds Ratio 1.6 (95% CI: 1.1-2.6)

Timing of Initial Antimicrobial Dose

- Errors in timing: on call to the OR!!
  - Related to delays in transport or schedule changes
  - Led to suboptimal tissue and serum levels

Timing of Initial Antimicrobial Dose

- Goal: To achieve serum and tissue drug levels for the duration of the operation to exceed the minimum inhibitory concentration (MIC) for anticipated organisms
- Antibiotic delivery within 60 minutes prior to the incision is considered “Ideal Timing.”
- Vancomycin infusion should begin within 120 minutes before incision

Strategies to improve Ideal Window

- Nurses in the holding area administer the first dose
- Standing order (with surgeon agreement) on the computer generated operating room schedule.
- Delegating implementation of ordered antibiotic prophylaxis to the anesthesia team led to improved timing
Antimicrobial Dose and Duration

- Based on patient weight, body mass index
- Redose if the operation is still continuing two half-lives after the first dose to ensure adequate antimicrobial levels until the wound is closed
- For most procedures the duration of antimicrobial prophylaxis should be 24 hrs or less, with the exception of cardiothoracic procedures (48-72 hrs)


In Summary…

Remember to do this right:
- Antibiotics – right choice, right time, right duration, right dose

In addition to optimizing patient and procedural factors

Penicillin Allergy

- Craniotomies, laminectomies, carotid endarterectomies, mastectomies, hernia repair - Clindamycin alone is adequate.
- For ALL procedures where cefoxitin is recommended clindamycin plus gentamicin is recommended.


Prevention and Management of Surgical Site Infection

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### Surgical Site Infection

- Definition - infections confined to the surgical wound or involving structures adjacent to the wound
  - 60-80% are incisional
  - 20-40% are adjacent - deep soft tissue, intraabdominal, etc.
- 2nd most frequent nosocomial infection
- Probably most important as a cause morbidity, mortality, and excess cost morbidity, mortality, and excess cost

### Deep SSI – CDC Definition

- Infection occurs within 30 days of operation (1 year if implant)
- Infection involves deep soft tissues (fascia and/or muscle) of incision, and, at least one of the following:
  - Purulent drainage for deep wound but not organ space
  - Deep incision spontaneously dehisces or is opened by surgeon with either fever or localized pain/tenderness
  - Dx of deep SSI made by surgeon

### Superficial SSI – CDC Definition

- Infection occurs within 30 days of operation
- Infection involves skin and subcutaneous tissue of the incision, and, at least one of following:
  - Purulent drainage from wound
  - Organisms cultured from aseptically obtained culture of superficial wound
  - At least 1 of the following – pain/tenderness, swelling, redness or heat AND incision opened by surgeon
  - Dx of superficial SSI by surgeon
- Does not include: stitch abscess, episiotomy incision, infected burn wound, infection that extends into deeper layers

### Organ/Space SSI – CDC Definition

- Infection occurs within 30 days (or 1 year if implant)
- Infection involves any other part of the operative site except incision and at least one of following:
  - Purulence from drain
  - Organisms isolated from aseptically obtained sample from organ/space
  - Abscess in organ/space
  - Dx of organ/space SSI made by surgeon
Preoperative measures to reduce the risk of surgical wound infection are aimed at preventing microbial contamination of the wound and reducing host susceptibility

### Prevention of SSI

- **Important quality indicator**
  - 2009 National Patient Safety Goal
  - CMS’s Surgical Care Improvement Program measures
- CMS to discontinue paying for care of SSI

### NPSG 7E: Prevent SSI

- **Implementation Expectations for Requirement 7E**
  - Educate health care workers about SSI
  - Measure SSI rates, monitor compliance with best practices, evaluate effectiveness of efforts.
  - Provide SSI rate data and prevention outcome measures to key stakeholders
  - Implement policies and practices aimed at reducing the risk of SSI
  - Educate patients and their families about SSI prevention

- **Administer antimicrobial agents for prophylaxis according to standards and guidelines for best practices:**
  - Deliver intravenous antimicrobial prophylaxis within 1 hour before incision
  - Discontinue the prophylactic antimicrobial agent within 24 hours after surgery
- Shaving is an inappropriate hair removal method. If necessary, use clippers or depilatories
- Maintain optimal control of blood glucose levels during the peri-operative period
### SCIP
- Administer prophylactic antibiotic within 60 minutes before incision is made
- Use an appropriate antibiotic(s)
- Discontinue prophylactic antibiotic within 24 hours
- Cardiac surgery patients to have blood sugar controlled by 0600 morning after surgery
- Appropriate hair removal at surgical site

### Preoperative Measures to Reduce SSI
- Treatment of active infection elsewhere in body
- Preoperative duration of hospitalization
- Hair removal
- Bathing with anti-microbial soap
- Nutritional support
- Tapering steroids
- Stop smoking
- Weight loss

### SSI Prevention
- Has focused on perioperative antibiotics
- Beginning to see other factors considered

### Hair Removal
- All adults undergoing CABG 1988-1989
- Switched from preoperative shaving to clipping in January, 1989
- Deep sternotomy infections dropped from 1.2% to 0.2%
- Venectomy site infections decreased from 1.6% to 0.4%
### Hair Removal

**Alexander et al: Arch Surg, 1983**

- 1013 patients randomized to shaving versus clipping either PM before or AM of operation
- AM clipping was associated with significantly fewer wound infections at discharge or 30 day follow up
- Estimated $270,000 savings/1000 patients compared to PM shaving

### Preoperative Bathing


- Prospective, randomized trial of preoperative showering with:
  - Chlorhexidine gluconate
  - Povidone-iodine
  - Lotion soap
- Chlorhexidine significantly reduced colony counts of Staph at subclavian and inguinal swab sites at time of operation

### Hair Removal


- Preoperative shaving versus no hair removal
- Clean operations
- Shaving - 2.7% wound infection rate
- No shaving - 1.3% wound infection rate

### Preoperative Bathing

**Lynch et al: J Hosp Infect, 1992**

- 3482 patients randomized to chlorhexidine versus placebo shower 3 times prior to clean or clean-contaminated operations
- No difference in incidence of wound infection diagnosed either in the hospital or after discharge
  - > 60% of wound infections diagnosed after discharge
Prediction of Risk

- 1205 Cancer patients undergoing surgery
- 17.3% incidence of Surgical Site Infection
- Multivariate logistic regression - 6 independent factors:
  - Contaminated and infected operations
  - Operation > 280 minutes
  - Male gender
  - Prior radiotherapy
  - Anesthesia class III - V
  - Antimicrobial prophylaxis not according to protocol

Management of Superficial SSI

- Open wound
  - Almost always necessary to open entire wound
- Antibiotics for surrounding cellulitis

Blood Sugar Control in Diabetics

- 8910 patients undergoing cardiac surgery
  - 1585 were diabetic
- Sternal wound infection rate:
  - Diabetics: 1.7%
  - Non-diabetics: 0.4%
- Blood glucose > 200, obesity, and use of int. mammary art. all risk factors for SSI
- Institution of protocol to maintain glucose < 200 for first 2 postop days decrease SSI rate from 2.4% to 1.5%

Open Wounds

- Now that wound is open, what next?
- First rule – almost all acute wounds will heal NO MATTER WHAT you do to them
- Second rule – if an acute wound will not heal there is usually either undrained, underlying pus or a foreign material in the depths of the wound
- Third rule – dead tissue will not heal. Debride necrotic debris in wound
Non-Healing Acute Wounds

- Image body part to assess underlying tissue – CT, U/S
  - Underlying fluid collections must be assessed for infection, usually by aspiration or drainage
- Read operative report(s) to determine what is in wound
  - Permanent suture?
  - Mesh?

Open Wound

- Dressings
  - Saline soaked gauze
  - Betadine soaked gauze
  - All sorts of other materials have been used in wound – honey, sugar, silver-containing dressings, hydrocolloid, alginate, foam, hydrogels, hydrofiber, parrafin
- No good study shows quicker healing with one product over another

Retained Foreign Material

- Must be removed if wound is to heal
  - May be done in office under local anesthesia if dealing with a suture or two
  - May need to be done in operating room if anything more extensive

Vacuum-Assisted Dressings

- Has been shown useful in chronic wounds
  - Decreased time to healing
  - Decreased exudate
  - Decreased bacterial count
  - Thought to enhance healing by reducing tissue edema and improving blood flow
- In acute wounds, little evidence that vacuum-assisted dressing systems are associated with quicker healing, but they may be useful for other reasons