SSI: Superficial and Deep Space Infections

Julio Garcia-Aguilar, MD, PhD

Goals of this Presentation

• Discuss the problem of surgical site infection (SSI) in colorectal surgery
• Review the specific measures that may reduce the rate of SSIs

SSI - Background

• The most common nosocomial infection in the surgical patient
• The most common complication after colorectal abdominal surgery
• A SSI adds over $6,200/per patient in cost*
• With 320,000 colorectal operations performed yearly in the USA, national cost for SSIs in the 100s of millions of dollars

Impact of SSIs

Follow-up study of a cohort of patients with SSI matched with patients without SSI in a community hospital (N=510)

<table>
<thead>
<tr>
<th></th>
<th>SSI</th>
<th>No SSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>7.8%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Length of stay</td>
<td>11 days</td>
<td>6 days</td>
</tr>
<tr>
<td>Readmission in 30 days</td>
<td>41%</td>
<td>7%</td>
</tr>
<tr>
<td>Excess cost by readmission</td>
<td>$5,039</td>
<td></td>
</tr>
<tr>
<td>Cost after discharge</td>
<td>$6,200</td>
<td></td>
</tr>
</tbody>
</table>

*Smith et al, Ann Surg 239(15), 2004
SSI – Important Quality Indicator

Impacts the bottom line: Value Based Purchasing Model

<table>
<thead>
<tr>
<th>Measure</th>
<th>Final Score (higher is better: 0-100%)</th>
<th>Rank (lower is better: N=90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital-Acquired Infection</td>
<td>43%</td>
<td>61</td>
</tr>
<tr>
<td>Mortality</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td>Complications not present on admission</td>
<td>89%</td>
<td>4</td>
</tr>
<tr>
<td>HCAHPS</td>
<td>60%</td>
<td>1</td>
</tr>
<tr>
<td>Overall Score</td>
<td>84%</td>
<td>2</td>
</tr>
</tbody>
</table>

Hospital-Acquired Infections
Included in the Value Based Purchasing Model

<table>
<thead>
<tr>
<th>Measure</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheter-Associated Blood Stream Infection (CLABSI) Med-Surg ICU</td>
<td>3/10 (compared to adjusted state rate per 1000 line days)</td>
</tr>
<tr>
<td>Surgical Site Infection (Colon/GYN)</td>
<td>6/10 (compared to adjusted state rate per 100 procedures)</td>
</tr>
<tr>
<td>Surgical Site Infection (Orthopedic)</td>
<td>4/10 (compared to adjusted state rate average per 100 procedures)</td>
</tr>
</tbody>
</table>

Most Important...

- Human suffering
- Distress
- Inconvenience
- Delaying other treatments
- Increase recurrence
- Impact survival

Pathogenesis of SSI

- Host
- Bacteria
- Surgery
Pathogenesis of SSI in Colorectal Surgery

- **Bacteria**
  - $10^{10}$ bacteria/gm feces

- **Host**
  - cancer, IBD, radiation, steroids, immunomodulators, malnutrition, advanced age,…

- **Surgical site**
  - open bowel
  - stomas
  - extensive dissections – more than one field
  - lengthy procedures
  - dead space in the pelvis

Surgical Site Infection (SSI)

**CDC Categories**

- **Superficial Incisional**: skin and subcutaneous tissue
- **Deep Incision**: facial and muscle layers
- **Organ/space**: any part of the anatomy, other than the incision, opened during surgery

Wound Classification

- **I. Clean**: uninfected, no inflammation, no cavities entered: Mastectomy, Thyroidectomy

- **II. Clean/Contaminated**: respiratory, alimentary, genital, urinary tract entered in controlled conditions. Cholecystectomy, Colectomy, Whipple, Laryngectomy, Urology

- **III. Contaminated**: Open accidental wounds, break in sterile conditions, spillage, taking-down stomas. Appendicitis, Diverticulitis

- **IV. Dirty/Infected**: Infection, perforation, devitalized tissue. Abscess, Peritonitis, Enteric fistulas

Risk Stratification

**Risk Index Category (RIC)**

Nooscomial Infection Surveillance Study

<table>
<thead>
<tr>
<th>Components</th>
<th>-1</th>
<th>+1</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASA</td>
<td></td>
<td>≥3</td>
</tr>
<tr>
<td>Duration of Operation</td>
<td></td>
<td>≥ 180 min</td>
</tr>
<tr>
<td>Wound Classification</td>
<td></td>
<td>3.4</td>
</tr>
<tr>
<td>Laparoscopy</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

(RIC ranges from −1 to +3)
Rates of SSI after colorectal surgery varies…

- National Nosocomial Infection Surveillance (NNIS) 2004: 7.4%
  - Am J Infect Control 2004

- Single institution retrospective review: 26%
  - Smith et al, Ann Surg 239(15), 2004

- Multi institutional prospective study: 28% to 43%
  - Itani et al, NEJM 355(25), 2006

Infection Rate by CDC Category

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial</td>
<td>11%</td>
</tr>
<tr>
<td>Deep</td>
<td>1.3%</td>
</tr>
<tr>
<td>Organ Space</td>
<td>4.1%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>16.4%</strong></td>
</tr>
</tbody>
</table>

N=751 patients

Factors associated with SIS

<table>
<thead>
<tr>
<th>Variable</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of surgery &gt; 180’</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI &gt; 30 kg/m²</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>RCI ≥ 2</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Colon vs. Rectal surgery</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Stoma creation</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Glucose compliance</td>
<td>0.06</td>
</tr>
<tr>
<td>Diagnosis-IBD</td>
<td>0.07</td>
</tr>
<tr>
<td>Pelvic vs. abdominal</td>
<td>0.07</td>
</tr>
<tr>
<td>Global compliance</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Variables associated with SSI

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Index Category &gt;2</td>
<td>2.03</td>
<td>0.026</td>
</tr>
<tr>
<td>Duration of surgery &gt; 180 minutes</td>
<td>2.41</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Factors not associated:
- Age, Gender, Diabetes, ASA, Diagnosis, Surgeon, Hospital, Laparoscopy, Compliance with process measures
SSI Prophylaxis – General Measures

- Open wounds healed when possible
- Patient free of infection
- Quit cigarette smoking
- Treat co-morbid conditions
- Optimize nutrition
- Surgical technique
  - bleeding, transfusion, hematoma, devitalized tissue

SSI Prophylaxis Measures with Level 1 Evidence

- Eliminate S. aureus carriers
- Hair removal
- Skin antiseptics
- Mechanical bowel preparation (MBP)
- Antibiotic prophylaxis
- Normothermia (Tem > 36°C)
- Supplemental oxygen (80%)
- Glucose control (<200 mg/dl)
- Intravenous fluid restriction

S. aureus decontamination

- Nasal carriers of S. aureus have a higher risk of infection compared to non-carriers
- Treating carriers with Mupirocin nasal ointment may reduce the risk of SSI
- A recent RCT has proven that S. aureus decontamination reduces the risk of SSI by this organism by 60%.
- The risk reduction was more obvious in deep SSI (Bode, NEJM 2010)

Hair Removal

- Several prospective randomized trials and a systematic review
  - Tanner et al, Cochrane Database Syst Rev 2006
- Hair removal does not prevent wound infection.
- If necessary, it should be done by clipping rather than shaving.
- Depilatory cream also better than shaving
- Should be done immediately prior to the surgical incision
Preoperative Skin Antisepsis

Patients

• Meta-analysis of 7 trials concluded that there is no evidence of benefit for preoperative bathing or showering with antiseptic solutions before surgery (Webster J and Osborne S, Cochrane Database Syst Rev 2006)

• Chlorhexidine-Alcohol is more effective than Povidone-Iodine for surgical prophylaxis in clean contaminated wounds. (Dorouiche et al, NEJM 2010)

Preoperative Skin Antisepsis

Personnel

• Barrier devices carried by operating personal have no impact on the risk of SSI

• Hand-scrubbing with antiseptic soap and hand-rubbing with alcohol-based solution are equally effective in reducing SSI (Parienti JJ et al, JAMA 2002)

Mechanical Bowel Preparation (MBP)

Reasons to do it

• Decrease of fecal flora burden
• Better bowel handling
• Easier to palpate tumors
• Decrease fecal load proximal to anastomosis
• Reduce risk of septic complications and leaks

Mechanical Bowel Preparation (MBP)

Reasons to avoid it

• Poorly tolerated by some patients
• Electrolyte imbalances / renal failure
• Increased bacterial translocation
• Increases risk of intraoperative fecal spillage
• Less physiologic for bowel mucosa
• May increase surgical complications
Evidence Regarding MBP

Multiple recent RCT’s comparing MBP to no MBP show no difference, possibly fewer complications in no MBP group

- Santos JCM, Br J Surg, 1994  n=149  MBP, ↑wound infn.
- Burke P, Br J Surg 1994  n=169  No difference
- Miettinen R, DC & R, 2000  n=267  No difference
- Zmora O, Ann Surg, 2003  n=380  No difference
- Ram E, Arch Surg, 2005  n=329  No difference

Evidence Regarding MBP

Multiple RCT’s comparing MBP to no MBP show no difference, possibly fewer complications in no MBP group

Meta-Analyses show trend toward better outcomes with no MBP

- Bucher P, Arch Surg, 2004  (n=1297)
- Slim K, Br J Surg, 2004  (n=1454)
- Wille-Jorgensen P, Colorectal Disease, 2005  (n=1592)
  (also published as Cochrane Review)

Wound Infection Rate: MBP vs No MBP

Trend is also toward a lower SSI rate without MBP

Newer Studies on MBP

- Swedish study - 21 hospitals
- 686 MBP, 657 no MBP
- No difference in length of stay, CV complications or SSI
- “MBP does not lower the complication rate and can be omitted before elective colonic resection”

Newer Studies on MBP

- Netherlands study - 13 hospitals
- 707 MBP, 724 no MBP
- Colon and rectal resections included
- No difference in length of stay, complications, or leaks
- "The conclusion that elective colorectal surgery can be safely done without MBP is justified"


<table>
<thead>
<tr>
<th>Measure</th>
<th>OR (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotics vs. no Treatment/placebo</td>
<td>0.30 (0.22 to .41)</td>
<td>&lt;0.00001</td>
</tr>
<tr>
<td>Short vs. Long term use</td>
<td>1.06 (0.89 to 1.27)</td>
<td>0.51</td>
</tr>
<tr>
<td>Anaerobic + Aerobic</td>
<td>0.41 (0.23 to 0.71)</td>
<td>0.002</td>
</tr>
<tr>
<td>Aerobic + Anaerobic</td>
<td>0.55 (0.35 to 0.85)</td>
<td>0.008</td>
</tr>
<tr>
<td>Orally vs. Intravenous (1 study)</td>
<td>2.11 (0.20 to 22.29)</td>
<td>0.53</td>
</tr>
<tr>
<td>Oral + Intravenous vs. Intravenous</td>
<td>0.55 (0.41 to 0.74)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Oral + Intravenous vs. Oral (3 studies)</td>
<td>0.34 (0.13 to 0.87)</td>
<td>0.02</td>
</tr>
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(*) only one study using same antibiotics – Kanamycin and Metronidazole

Newer Studies on MBP

<table>
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<tr>
<th>Measure</th>
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<th>P value</th>
</tr>
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<tbody>
<tr>
<td>Jung et al</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaks</td>
<td>13 (1.9%)</td>
<td>17 (2.6%)</td>
<td>0.596</td>
</tr>
<tr>
<td>Abscesses</td>
<td>5 (0.7%)</td>
<td>11 (1.7%)</td>
<td>0.110</td>
</tr>
<tr>
<td>Contant et al</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaks</td>
<td>32 (4.8%)</td>
<td>37 (5.4%)</td>
<td>0.69</td>
</tr>
<tr>
<td>Abscesses</td>
<td>15 (2.2%)</td>
<td>32 (4.7%)</td>
<td>0.020</td>
</tr>
<tr>
<td>Combined data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaks</td>
<td>45 (3.3%)</td>
<td>54 (4.0%)</td>
<td>0.437</td>
</tr>
<tr>
<td>Abscesses</td>
<td>20 (1.5%)</td>
<td>43 (3.2%)</td>
<td>0.003</td>
</tr>
<tr>
<td>Leaks + abscesses</td>
<td>65 (4.8%)</td>
<td>97 (7.2%)</td>
<td>0.027</td>
</tr>
</tbody>
</table>

Platell C, Hall J Lancet 2007

Antibiotic Prophylaxis


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Oral Antibiotics

- Still recommended by the 2005 National Surgical Infection Prevention Project and the 2006 Medical Letter
- Supported by prospective randomized trial and meta-analysis
- Neomycin/Erythromycin or Neomycin/Metronidazole
- Initiated no more than 18 to 24 hours before surgery
- Administered along with MBP

Lewis RT, Can J Surg 2002
Intravenous Antibiotics - General

- Given within 60 minutes of skin incision (120 if vancomycin or fluoroquinolone is given)
- Redosing for surgery lasting more than 3 hours
- Redosing every one to two half-lives of the drug (3 hours for cefoxitin)
- Disagreement regarding redosing after closing skin – but never after 24 hours

Intravenous Antibiotics - Agents

General Population
- Cefoxitin or Cefotetan 1g < 80Kg or 2g >80Kg
- Cefazolin 1g < 80Kg or 2g >80Kg plus Metronidazole 15 mg/Kg first dose and 7.5 mg/Kg the second dose
- Ampicillin-Sulbactam 3g

Penicillin Allergy
- Clindamycin plus Gentamicin or Fluoroquinolone
- Metronidazole or Aztreonan plus Gentamicin or Fluoroquinolone

Intravenous Antibiotics - Ertapenem

- Long-acting carbapenem
- Appropriate coverage against colorectal flora
- Long half-life: no need for redosing
- Less SSI than Cefotetan (18% vs. 31%)
- Higher risk of C. difficile colitis?

Perioperative Normothermia

- Hypothermia increases susceptibility to infection
  - causes vasoconstriction - ischemia
  - impairs immunity
- Common during surgery
- Patients often hypothermic at the time of incision

Perioperative Normothermia

- SSI: 6% normothermia vs. 19% hypothermia

Supplemental Oxygen Administration

- Three randomized trials in colorectal surgery patients
  - Belda FJ, JAMA 2005
  - Mayzler O, Minerva Anestesiol 2005
- 80% vs. 30% FiO$_2$ during and 2 hours after surgery
- Reduced SSI with 80% FiO$_2$ - RRs 0.46 – 0.67
- Supplemental oxygen reduces SSI in colorectal surgery patients
- One study in general surgery patients provided negative results (Pryor KO et al, JAMA 2004)

Glucose Control

- Hyperglycemia and diabetes increases the risk of SSI after CABG
- Preoperative glucose above 200mg/dl or postoperative hyperglycemia increases the risk of SSI
- Use of insulin and perioperative glucose control reduced the risk of SSI in diabetic patients undergoing CABG
- No same level of evidence in colorectal surgery

Perioperative Fluid Management

- Several studies investigated restricted vs. standard fluid administration
- One looked specifically to infective complications (Brandstrup B, Ann Sur 2003)
- Less mortality and complications in restricted group
- Less SSI in the restricted group (19% vs. 39%)
**Quality and Benchmarking Programs**
(National Initiatives to Improve Quality of Surgical Care)

- National Surgical Quality Improvement Project (NSQIP)
- National Nosocomial Infection Surveillance System (NNIS) → National Healthcare Safety Network (NHSN)
- Surgical Infection Prevention Project (SIP) → Surgical Care Improvement Project (SCIP)

Is compliance with process measures associated with a decrease in SSI Rates?

![Graph showing SCIP adherence and postoperative infection over time](image)

Colorectal Surgery Surgical Site Infection Reduction Program: A National Surgical Quality Improvement Program-Driven Multidisciplinary Single-Institution Experience

Cima et al. Journal of the American College of Surgeons Volume 216, Issue 1 2013 23 - 33

Implementation of a Surgical Comprehensive Unit-Based Safety Program to Reduce Surgical Site Infections

Elizabeth C Wick, MD, FACS, Deborah B Hobson, RN, Jennifer I Bennett, BA, Renee Demski, MBA, MSN, Lisa Maragakis, MD, Susan L Gearhart, MD, FACS, Jonathan Efron, MD, FACS, Sean M Berenholtz, MD, MS, FCCM, Martin A Makary, MD, MPH, FACS
Conclusions

• Surgical site infection is a common cause of morbidity in colorectal surgery patients
• Rates of SSI probably exceed reports from national quality initiatives
• Several interventions have been proven to reduce SSI
• Compliance with process measures proven to reduce infection