CURRENT CONCEPTS IN THE PREVENTION OF SURGICAL SITE INFECTIONS

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Denver Health Medical Center
Professor of Surgery
University of Colorado
SURGICAL INFECTIONS - OUTLINE

- Surgical Site Infection (SSI) Basics
- Why You Should Care
- SSI Prevention
**CDC DEFINITIONS OF SSIs**

**Superficial Incisional SSI**

- Skin / Subcutaneous
  - Infection ≤30 days after procedure and at least 1 of the following:
    - Purulent drainage from superficial lesion/organisms isolated aseptically
    - At least 1: pain/tenderness, swelling, redness, heat
    - Superficial incision deliberately opened by surgeon unless culture negative
  - or SSI diagnosed by surgeon or attending physician

**Deep Incisional SSI**

- Deep Soft Tissue at Site
  - Infection ≤30 days after procedure (no implant) or ≤1 year (with implant) and at least 1 of the following:
    - Purulent drainage from deep incision but not from organ/space
    - Spontaneous dehiscence or surgical opening of deep incision with fever, pain, or tenderness
    - Abscess or other evidence of infection involving deep incision
  - or SSI diagnosed by surgeon or attending physician

**Organ/Space SSI**

- Any Site Other Than Incision
  - Infection ≤30 days after procedure (no implant) or ≤1 year (with implant) and at least 1 of the following:
    - Purulent drainage from a drain placed through a stab wound into organ/space
    - Organisms isolated from a culture of fluid/tissue
    - Abscess or other evidence of infection involving the organ/space found by histopathologic examination, x-ray, or reoperation
  - or SSI diagnosed by surgeon or attending physician

## SSI RISK FACTORS

### Patient factors
- Ascites
- Chronic inflammation
- Corticosteroid therapy  
  (controversial)
- Obesity
- Diabetes
- Extremes of age
- Hypocholesterolemia
- Hypoxemia
- Peripheral vascular disease  
  (esp lower extremity)
- Postoperative anemia
- Prior site irradiation
- Recent operation
- Remote infection
- Skin carriage of staphylococci
- Skin disease in the area of  
  infection (eg, psoriasis)
- Undernutrition

### Environmental factors
- Contaminated medications
- Inadequate disinfection/sterilization
- Inadequate skin antisepsis
- Inadequate ventilation

### Treatment factors
- Drains
- Emergency procedure
- Hypothermia
- Inadequate antibiotic prophylaxis
- Oxygenation  
  (controversial)
- Prolonged preoperative  
  hospitalization
- Prolonged operative time

WOUND CLASSIFICATION

Clean: No Break in Sterile Field / Resp / GI / GU Tract

Clean-Contaminated: Minor Break in Field, or Resp / GI / GU w/o Spillage

Contaminated: GI Spillage; Infected Urine / Bile; Major Break; Trauma

Dirty / Infected: Infection Encountered
WOUND INFECTION RATES

1967-1977
62,939 pts

Clean 1.5
Clean-Contaminated 7.7
Contaminated 15.2
Dirty / Infected 40.0

# Wound Infection Rates

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td>1.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Clean-Contaminated</td>
<td>7.7</td>
<td>3.6</td>
</tr>
<tr>
<td>Contaminated</td>
<td>15.2</td>
<td>10.5</td>
</tr>
<tr>
<td>Dirty / Infected</td>
<td>40.0</td>
<td>-</td>
</tr>
</tbody>
</table>

- **Cruse et al, Surg Clin North Am 1980; 60:27**
- **Weiss et al, Arch Surg 1999; 134:1041**
RISK ASSESSMENT

Study on the Efficacy of Nosocomial Infection Control (SENIC)

Risk within **Clean Wounds 1 – 15%**

4 Independent Risk Factors:
- Abdominal Operation
- Operation Lasting > 2 hr
- Contaminated / Dirty Wound
- > 3 Discharge Diagnoses
RISK ASSESSMENT

NNIS Risk Index

Operation-Specific (Duration)

ASA Physical Status Classification

Score Used as a Surrogate Measure of Comorbid Medical Conditions

More Accurate than SENIC Index
ASA CLASSIFICATION

ASA I: Normal, Healthy

ASA II: Mild/Mod Systemic Dis w/o Functional Limitations

ASA III: Severe Systemic Dis w/ Functional Limitations

ASA IV: Life-Threatening Systemic Dis

ASA V: Not Expected to Survive

E: Emergency Procedure
## WOUND INFECTION RATES

### Risk Factors: Contaminated / Dirty Wound
- ASA Class 3-5
- Operative Time > 75th Percentile

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clean</strong></td>
<td>1.0</td>
<td>2.3</td>
<td>5.4</td>
<td>-</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Clean-Contaminated</strong></td>
<td>2.1</td>
<td>4.9</td>
<td>9.5</td>
<td>-</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Contaminated</strong></td>
<td>-</td>
<td>3.4</td>
<td>6.6</td>
<td>13.2</td>
<td>6.4</td>
</tr>
<tr>
<td><strong>Dirty / Infected</strong></td>
<td>-</td>
<td>3.1</td>
<td>8.1</td>
<td>12.8</td>
<td>7.1</td>
</tr>
<tr>
<td><strong>All</strong></td>
<td>1.5</td>
<td>2.9</td>
<td>6.8</td>
<td>13.0</td>
<td>2.8</td>
</tr>
</tbody>
</table>

## WOUND INFECTION RATES

<table>
<thead>
<tr>
<th>Procedure</th>
<th>M</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholecystectomy</td>
<td>.45</td>
<td>.68</td>
<td>1.8</td>
<td>3.3</td>
<td>5.7</td>
</tr>
<tr>
<td>Colon</td>
<td></td>
<td>4.0</td>
<td>5.7</td>
<td>8.5</td>
<td>11.3</td>
</tr>
<tr>
<td>Appendectomy</td>
<td>.67</td>
<td>1.3</td>
<td>2.6</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>Gastric</td>
<td>.68</td>
<td>2.6</td>
<td>4.7</td>
<td>8.3</td>
<td></td>
</tr>
</tbody>
</table>

“M” = 0 risk, laparoscopic

Duration cut points (hr): Cholecystectomy = 2; Colon = 3; Appendectomy = 1; Gastric = 3


Laparoscopic vs Open Approach Significantly Decreases SSI Risk in Colorectal Surgery

Wick EC et al. Arch Surg 2011; 146:1068
PITFALLS IN RISK ASSESSMENT

AHRQ Project: Improving the Measurement of SSI Risk Stratification and Outcome Detection

Surgeon Focus Group Findings:

- Current models for SSI risk assessment are inadequate; inappropriately weighted or excessive number of factors.

- Infection rate assessments vary based on methods of documentation, completeness of audit, and consistency in assessing risk factors.

- Different categories of risk might be considered, such as emergency vs elective surgery; well-managed vs poorly-managed or undocumented comorbidities; compliance vs non-compliance with medical care; and scheduling considerations.
SURGICAL INFECTIONS - OUTLINE

- Surgical Site Infection (SSI) Basics
- Why You Should Care
- SSI Prevention
How Hazardous is Healthcare?

Source: Agency for Healthcare Research and Quality (AHRQ)

Dangerous (>1/1000)

Regulated

Ultra-Safe (<1/100K)

Total lives lost per year

100,000

10,000

1,000

100

10

Number of encounters for each fatality

1 10 100 1,000 10,000 100,000 1,000,000 10,000,000

Healthcare

Driving

Scheduled Airlines

Mountain Climbing

Chemical Manufacturing

European Railroads

Bungee Jumping

Chartered Flights

Nuclear Power

FIG. 1. Relative riskiness of various human activities considered dangerous.
HEALTHCARE-ASSOCIATED INFECTIONS (HAIs)

- Surgical Site Infections (SSIs)
- Central Line Associated Bloodstream Infections (CLABSI)
- Catheter-Associated Urinary Tract Infections (CAUTI)
- Ventilator-Associated Pneumonias (VAP)
- C. Difficile Infection (CDI)
SSIs – SCOPE OF THE PROBLEM

Second Most Common Hospital-Acquired Infection (17%)
Klavens et al, Public Health Reports 2007; 122:160

72% of Hospital-Acquired Infections in Surgical Pts
Herwaldt LA et al, Infect Control Hosp Epidemiol 2006; 27:1291

SSI in 2.6% of 30 M Operations
CONSEQUENCES OF SSIs

- Costs Increase 34-226%
- LOS Increases 48-310%

Broex ECJ et al, J Hosp Infect 2009; 72:193

In Older (≥65) Pts:
- Greater Mortality Risk (OR 3.51)
- 2.9X Longer LOS
- 1.9X Greater Hospital Charges

CONSEQUENCES OF SSIs

7020 Colectomy Pts, 2002-2008
SSI 10.3%
Obese 14.5 vs 9.5%

<table>
<thead>
<tr>
<th></th>
<th>SSI</th>
<th>No SSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean LOS</td>
<td>9.5</td>
<td>8.1</td>
</tr>
<tr>
<td>Costs</td>
<td>$31933</td>
<td>$14608</td>
</tr>
<tr>
<td>Readmission</td>
<td>28%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Wick EC et al. Arch Surg 2011; 146:1068
CONSEQUENCES OF SSIs

Nationwide Impact

- 290,485 SSIs
- $25,546 / SSI
- $7.4 Billion / Year
- 13,088 Deaths

Roberts et al, Clin Infect Dis 2003; 36:1424
WHO PAYS FOR SURGICAL COMPLICATIONS?

<table>
<thead>
<tr>
<th>Hospital Reimbursement ($)</th>
<th>Costs of Care ($)</th>
<th>Profit ($)</th>
<th>Profit Margin (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14,266 (uncomplicated)</td>
<td>10,978</td>
<td>3288</td>
<td>23.0</td>
</tr>
<tr>
<td>21,911 (complicated)</td>
<td>21,156</td>
<td>755</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Medical injuries result in 44,000-98,000 deaths and $17 B in health care costs annually

- 44,000 Operations 1977-1990
- 5.4% Complications – Nearly 50% attributable to error
IMPACT OF “ERRORS”

AHRQ Patient Safety Indicators identified medical injuries among 7.45 M hospital discharge abstracts, 994 hospitals / 28 states, 2000

20% Sample of U.S. Hospitals

Zhan et al. JAMA 2003; 290:1868
Table 4. Excess Length of Stay, Charges, and Mortality Attributable to Patient Safety Events*

<table>
<thead>
<tr>
<th>Patient Safety Indicators</th>
<th>Excess LOS, d</th>
<th>P Value</th>
<th>Excess Charge, $</th>
<th>P Value</th>
<th>Excess Mortality, %</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidental puncture or laceration</td>
<td>1.34 (0.08)</td>
<td>&lt;.001</td>
<td>8271 (344)</td>
<td>&lt;.001</td>
<td>2.16 (0.20)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Birth trauma, injury to neonate</td>
<td>−0.09 (0.08)</td>
<td>.27</td>
<td>298 (295)</td>
<td>.32</td>
<td>−0.08 (0.07)</td>
<td>.27</td>
</tr>
<tr>
<td>Complications of anesthesia</td>
<td>0.17 (0.09)</td>
<td>.26</td>
<td>1598 (660)</td>
<td>.02</td>
<td>0.24 (0.36)</td>
<td>.51</td>
</tr>
<tr>
<td>Decubitus ulcer</td>
<td>3.98 (0.10)</td>
<td>&lt;.001</td>
<td>10 845 (368)</td>
<td>&lt;.001</td>
<td>7.23 (0.23)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Foreign body left during procedure</td>
<td>2.08 (0.68)</td>
<td>.002</td>
<td>13 315 (3329)</td>
<td>&lt;.001</td>
<td>2.14 (1.06)</td>
<td>.04</td>
</tr>
<tr>
<td>Iatrogenic pneumothorax</td>
<td>4.38 (0.24)</td>
<td>&lt;.001</td>
<td>17 312 (1091)</td>
<td>&lt;.001</td>
<td>6.99 (0.73)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Obstetric trauma, cesarean birth</td>
<td>0.43 (0.14)</td>
<td>.001</td>
<td>2718 (551)</td>
<td>&lt;.001</td>
<td>−0.02 (0.02)</td>
<td>.32</td>
</tr>
<tr>
<td>Obstetric trauma, vaginal birth with instrumentation</td>
<td>0.07 (0.02)</td>
<td>&lt;.001</td>
<td>220 (104)</td>
<td>.03</td>
<td>0.00</td>
<td>.32</td>
</tr>
<tr>
<td>Obstetric trauma, vaginal birth without instrumentation</td>
<td>0.05 (0.01)</td>
<td>&lt;.001</td>
<td>-93 (66)</td>
<td>.16</td>
<td>0.00</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Postoperative hemorrhage or hematoma</td>
<td>3.94 (0.27)</td>
<td>&lt;.001</td>
<td>21 431 (1257)</td>
<td>&lt;.001</td>
<td>3.01 (0.46)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Postoperative hip fracture</td>
<td>5.24 (0.69)</td>
<td>&lt;.001</td>
<td>13 441 (1945)</td>
<td>&lt;.001</td>
<td>4.52 (1.34)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Postoperative physiologic and metabolic derangement</td>
<td>8.89 (0.75)</td>
<td>&lt;.001</td>
<td>54 818 (5099)</td>
<td>&lt;.001</td>
<td>19.81 (2.27)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Postoperative pulmonary embolism or deep vein thrombosis</td>
<td>5.36 (0.15)</td>
<td>&lt;.001</td>
<td>21 709 (747)</td>
<td>&lt;.001</td>
<td>6.56 (0.33)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Postoperative respiratory failure</td>
<td>9.08 (0.57)</td>
<td>&lt;.001</td>
<td>53 502 (3121)</td>
<td>&lt;.001</td>
<td>21.84 (1.46)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Postoperative sepsis</strong></td>
<td><strong>10.89 (0.90)</strong></td>
<td><strong>&lt;.001</strong></td>
<td><strong>57 727 (3077)</strong></td>
<td><strong>&lt;.001</strong></td>
<td><strong>21.92 (1.47)</strong></td>
<td><strong>&lt;.001</strong></td>
</tr>
<tr>
<td>Postoperative wound dehiscence</td>
<td>9.42 (0.72)</td>
<td>&lt;.001</td>
<td>40 323 (3467)</td>
<td>&lt;.001</td>
<td>9.63 (1.55)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Selected infection due to medical care</td>
<td>9.58 (0.23)</td>
<td>&lt;.001</td>
<td>38 656 (1026)</td>
<td>&lt;.001</td>
<td>4.31 (0.35)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Transfusion reaction</td>
<td>3.44 (1.94)</td>
<td>.09</td>
<td>18 929 (10 068)</td>
<td>.07</td>
<td>−1.04 (1.04)</td>
<td>.33</td>
</tr>
</tbody>
</table>

*Data are expressed as mean (SE). Excess length of stay (LOS) is the difference in LOS for a case and a matching control or mean LOS for controls if multiple matching controls were found. The paired t test was used to test the hypothesis of whether mean excess LOS is significantly different from 0. Excess mortality and charges were calculated similarly.

Zhan et al. JAMA 2003; 290:1868
Consequences of These 18 Types of Medical Injuries:

- 2.4 M Hospital Days
- $4.6 B Cost
- 32,591 Attributable Deaths

Zhan et al. JAMA 2003; 290:1868
DEMAND FOR QUALITY

Transparency - Public Reporting
Accountability - Pay for Performance
2002 SURGICAL INFECTION PREVENTION PROJECT (SIP)

- Prophylactic Antibiotic <1 hr Prior to Incision
- Appropriate Prophylactic Antibiotic
- Prophylactic Antibiotic Discontinued w/i 24 hr
# Surgical Infection Prevention Collaborative

<table>
<thead>
<tr>
<th>Process measure</th>
<th>Median performance, by quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>Antibiotic timing within 1 h</td>
<td>72</td>
</tr>
<tr>
<td>Appropriate antibiotic selection</td>
<td>90</td>
</tr>
<tr>
<td>Discontinuation of antibiotic within 24 h</td>
<td>67</td>
</tr>
<tr>
<td>Normothermia</td>
<td>57</td>
</tr>
<tr>
<td>Avoid shaving surgical site</td>
<td>59</td>
</tr>
<tr>
<td>Oxygenation</td>
<td>75</td>
</tr>
<tr>
<td>Glucose control</td>
<td>46</td>
</tr>
</tbody>
</table>


2005 - Improve Safety of Surgical Care Through Reduction of Postoperative Complications

Ultimate Goal: Reduce Surgical Complications 25% by 2010
Prevent:

- Surgical Site Infections
- Perioperative Myocardial Infarction
- Postoperative Pneumonia
- Venous Thromboembolism
SCIP PROCESS AND OUTCOME MEASURES RELATED TO SSI - 2010

- Prophylactic Antibiotic <1 hr Prior to Incision
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- Prophylactic Antibiotic Discontinued w/i 24 hr
- Cardiac Surgery Pts with Serum Glucose <200 mg/dL on POD 1 and 2
- Appropriate Hair Removal (No Razors)
- Urinary Catheter Removal POD 1 or 2
- Active Warming Used -OR- T >36 within 30 mins Prior to or 15 mins After Anesthesia End Time
“Proposed” IPPS rule suggested that hospitals needed to start reporting SIP measures in January to avoid losing 2% of their Medicare annual payment update. Final rule did not require reporting until July 2006.
HOSPITAL COMPARE

- DHHS database of clinical quality of care for AMI, heart failure, pneumonia, surgery
- Maintained by the CMS
- Data reported “voluntarily” by ~4,200 hospitals
- New measures will be added over time

http://www.hospitalcompare.hhs.gov
Deficit Reduction Act of 2005: CMS began selecting hospital-acquired conditions determined to be “reasonably preventable.” If a condition is acquired during the hospital stay, Medicare will not pay the additional cost of the hospitalization, and the patient is not responsible for the additional cost. The original conditions included:

- Catheter-associated urinary tract infections
- Pressure ulcers (decubitus ulcers)
- Never events (serious preventable events)
  - *Object left in surgery*
  - *Air embolism*
  - *Blood incompatibility reactions*
- Vascular catheter-associated infections
- **Surgical site infection** – mediastinitis after CABG
- Hospital-acquired injuries – fractures, dislocations, intracranial injury, crushing injury, burn, and other unspecified effects of external causes
2008 Final acute care inpatient prospective payment (IPPS) rule updated Medicare payments to hospitals for fiscal year (FY) 2009, adding preventable conditions for which it would not make additional payments for:

- **Surgical site infections following elective:**
  - Total Knee Arthroplasty
  - Laparoscopic gastric bypass and gastroenterostomy
  - Ligation and stripping of varicose veins

- **Certain manifestations of poor control of blood sugar levels**

- **Deep vein thrombosis or pulmonary embolism following total knee replacement and hip replacement procedures**
SSI PREVENTION- SUCCESS OF BUNDLES 1

Retrospective Study of Premier Inc Perspective Database = D/C Data from Acute Care Hospitals - 1 in 5 Discharges

405,720 Pts, 3996 SSIs

Adherence to Global All-or-None Composite was Assoc with Lower SSI Rate (14.2 to 6.8 per 1000 D/Cs)

Stulberg JJ et al. JAMA 2010; 303:2479
SSI PREVENTION- SUCCESS OF BUNDLES 2

ACS NSQIP Database Review, 2008
SCIP 1-3 and 6 (Hair Removal)
Compliance was >92%

Only Significant Association was Between SCIP-2 Compliance (Appropriate Abx) and SSI

SSI PREVENTION- SUCCESS OF BUNDLES 3

Single-Institution PRCT Colorectal Surgery

Standard Bundle (SCIP Abx, MBP, Bair Hugger, FiO2 30%, Fluid ad lib)

Extended Bundle (SCIP Abx, No MBP, Normothermia, FiO2 80%, Limited Fluids, Wound Protector)

211 Pts Randomized, 197 Analyzed

SSIs 45% Extended vs 24%

SSI PREVENTION- SUCCESS OF BUNDLES 4

National VA Retrospective Cohort Study- SCIP Cases

VASQIP Database Analysis

SCIP 1-3, Hair Removal, Normothermia

60,853 Operations

After Adjusting for Pt and Procedure Factors, No Assoc Between SCIP Adherence and SSI

WHY AREN’T BUNDLES EFFECTIVE?

- SCIP Measures were Already Indoctrinated
- Databases are not Accurate
- Some Measures are Harmful
- SCIP is only a Fraction of the Equation
- High Compliance Impairs Ability to Discriminate Between Hospitals
- Multitasking Distracts Providers from Effective Interventions
- Study Populations were not the Focus of SCIP Interventions
WHAT DOES THIS MEAN?

- PFP Should not be Linked to Process Measures Until they Are Proven to Improve Outcomes
- Using These Measures to Compare Hospital Quality is Misleading
- Further Research is Warranted
SCIP PROCESS AND OUTCOME MEASURES RELATED TO SSI - 2010

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- Appropriate Hair Removal (No Razors)
- Urinary Catheter Removal POD 1 or 2
- Active Warming Used -OR- T >36 within 30 mins Prior to or 15 mins After Anesthesia End Time
Perioperative Prophylactic Antibiotics: Timing Of Administration

TABLE 3. Association Between Timing of Prophylaxis and Infection Risk

<table>
<thead>
<tr>
<th>Timing Interval Relative to Incision</th>
<th>Infection/N-at-Risk</th>
<th>Infection Risk*</th>
<th>Unadjusted Relative Risk of Infection (95% CI)</th>
<th>Adjusted Risk Odds Ratio for Infection From Conditional Logistic Regression (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1: Vancomycin/fluoroquinolones within 60 min or cephalosporins within 30 min before incision</td>
<td>38/1844</td>
<td>2.1%</td>
<td>Referent Group</td>
<td>Referent Group</td>
</tr>
<tr>
<td>Group 2: Vancomycin/fluoroquinolones 61–120 min or cephalosporins 31–60 min before incision</td>
<td>43/1796</td>
<td>2.4%</td>
<td>1.16 (0.75, 1.79), P = 0.50</td>
<td>1.48 (0.92, 2.38), P = 0.06</td>
</tr>
<tr>
<td>Group 3: Any other preincision administration regimen</td>
<td>18/644</td>
<td>2.8%</td>
<td>1.36 (0.78, 2.36), P = 0.28</td>
<td>1.30 (0.70, 2.41), P = 0.39</td>
</tr>
<tr>
<td>Group 4: Post-incision</td>
<td>10/188</td>
<td>5.3%</td>
<td>2.58 (1.31, 5.10), P = 0.005</td>
<td>2.20 (1.03, 4.66), P = 0.02</td>
</tr>
</tbody>
</table>

*Test for overall association between timing and infection risk, P = 0.04.

†Adjusted for duration of surgery and procedure type.

‡Non cephalosporin antibiotics comprised <5% of those designated to be given with short infusion times and are included.
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- Appropriate Hair Removal (No Razors)
- Urinary Catheter Removal POD 1 or 2
- Active Warming Used -OR- T >36 within 30 mins Prior to or 15 mins After Anesthesia End Time
## RELATIVE BENEFIT FROM ANTIBIOTIC 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>Total joint repl</td>
<td>0.5-1</td>
<td>2-9</td>
<td>12-100</td>
</tr>
<tr>
<td>Breast &amp; hernia</td>
<td>3.5</td>
<td>5.2</td>
<td>58</td>
</tr>
</tbody>
</table>

NNT = number needed to treat; repl = replacement
ANTIBIOTIC CHOICE

605 Colorectal Surgery Pts
Use of a “Nonstandard” Abx Regimen (ie, Non-SCIP-Compliant) was Assoc with Increased Risk of SSI (OR 2.069, 1.078-3.969)

Ho VP et al. Surg Infect 2011; 12:255
SCIP PROCESS AND OUTCOME MEASURES RELATED TO SSI - 2010

- Prophylactic Antibiotic <1 hr Prior to Incision
- Appropriate Prophylactic Antibiotic
- **Prophylactic Antibiotic Discontinued w/i 24 hr**
- Cardiac Surgery Pts with Serum Glucose ≤200 mg/dL on POD 1 and 2
- Appropriate Hair Removal (No Razors)
- Urinary Catheter Removal POD 1 or 2
- Active Warming Used -OR- T >36 within 30 mins Prior to or 15 mins After Anesthesia End Time
SIP BASELINE – ABX DISCONTINUATION

Bratzler et al, Arch Surg 2005; 140:174
ANTIBIOTIC PROPHYLAXIS

DURATION

- Most studies have confirmed efficacy of \( \leq 12 \) hours
- Many studies have shown efficacy of a single dose
- Whenever compared, the shorter course has been as effective as the longer course
SINGLE- VS MULTIPLE-DOSE PROPHYLAXIS

## DURATION OF PROPHYLAXIS: INFECTION AND ANTIBIOTIC RESISTANCE IN CARDIAC SURGERY

<table>
<thead>
<tr>
<th></th>
<th>&lt;48 Hr Short</th>
<th>&gt;48 Hr Long</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>1502</td>
<td>1139</td>
<td></td>
</tr>
<tr>
<td>SSI</td>
<td>131 (8.7%)</td>
<td>100 (8.8%)</td>
<td>1.0 (0.8-1.3)</td>
</tr>
<tr>
<td>Acq Ab Res</td>
<td>6%</td>
<td></td>
<td>1.6 (1.1-2.6)</td>
</tr>
</tbody>
</table>

Acq ab res = acquired antibiotic resistance
Harbarth et al, Circulation 2000; 101:2916
SCIP PROCESS AND OUTCOME MEASURES RELATED TO SSI - 2010

- Prophylactic Antibiotic <1 hr Prior to Incision
- Appropriate Prophylactic Antibiotic
- Prophylactic Antibiotic Discontinued w/i 24 hr
- Cardiac Surgery Pts with Serum Glucose <200 mg/dL on POD 1 and 2
- Appropriate Hair Removal (No Razors)
- Urinary Catheter Removal POD 1 or 2
- Active Warming Used -OR- T >36 within 30 mins Prior to or 15 mins After Anesthesia End Time
PERIOPERATIVE GLUCOSE CONTROL

Hyperglycemia adversely affects granulocyte adherence, chemotaxis, phagocytosis, and bactericidal activity

Postoperative hyperglycemia (>200 mg/dL) is associated with SSIs in cardiac surgery pts. Preoperative glucose control is not related to SSIs


Prospective trials have demonstrated reduced SSIs among diabetics with tight glucose control (<150-200 mg/dL)

Furnary AP et al, Endocr Pract 2004; 10S:21
Lazar HL et al, Circulation 2004; 109:1497
SCIP PROCESS AND OUTCOME MEASURES RELATED TO SSI - 2010

- Prophylactic Antibiotic <1 hr Prior to Incision
- Appropriate Prophylactic Antibiotic
- Prophylactic Antibiotic Discontinued w/i 24 hr
- Cardiac Surgery Pts with Serum Glucose <200 mg/dL on POD 1 and 2
- **Appropriate Hair Removal (No Razors)**
- Urinary Catheter Removal POD 1 or 2
- Active Warming Used -OR- T >36 within 30 mins Prior to or 15 mins After Anesthesia End Time
11 PRCTs

No diff b/w hair removal vs no hair removal

Clipping or Depilatory Cream both Superior to Razor

No trials compared clipping with Depilatory

Tanner J et al. Cochrane Database of Systematic Reviews, 2006, Issue 3
SCIP PROCESS AND OUTCOME MEASURES RELATED TO SSI - 2010

- Prophylactic Antibiotic <1 hr Prior to Incision
- Appropriate Prophylactic Antibiotic
- Prophylactic Antibiotic Discontinued w/i 24 hr
- Cardiac Surgery Pts with Serum Glucose <200 mg/dL on POD 1 and 2
- Appropriate Hair Removal (No Razors)
- Urinary Catheter Removal POD 1 or 2
- Active Warming Used - OR - T >36 within 30 mins Prior to or 15 mins After Anesthesia End Time
Hypothermia is Common in Surgery
- Impaired Thermoregulation
- Altered Heat Distribution, Exposure
Hypothermia is Common in Surgery
- Impaired Thermoregulation
- Altered Heat Distribution, Exposure

...and Increases Susceptibility to Infection
- Vasoconstriction
- Decreased Wound Oxygen
- Impaired Immune Functions
- Impaired Wound Healing
200 Colorectal Surgery Pts
Routine Care (Hypothermia) vs Warming (Normothermia)
- I.V. Abx, Hydration, O₂ 6 L/min
- Forced Air Heat, Fluid Warmer

Wound Evaluation Daily x 2 Wk
Collagen Deposition
CORE TEMPERATURES

Kurz A et al, NEJM 1996; 334:1209
<table>
<thead>
<tr>
<th>Variable</th>
<th>Warm</th>
<th>Hypo</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>104</td>
<td>96</td>
<td>-</td>
</tr>
<tr>
<td>Infection</td>
<td>6 (6%)</td>
<td>18 (19%)</td>
<td>0.009</td>
</tr>
<tr>
<td>ASEPSIS Score</td>
<td>7 ± 10</td>
<td>13 ± 16</td>
<td>0.002</td>
</tr>
<tr>
<td>Collagen μg/cm</td>
<td>328 ± 135</td>
<td>254 ± 114</td>
<td>0.04</td>
</tr>
<tr>
<td>Days to Solids</td>
<td>6 ± 3</td>
<td>7 ± 2</td>
<td>0.006</td>
</tr>
<tr>
<td>Days to SR</td>
<td>10 ± 3</td>
<td>11 ± 2</td>
<td>0.002</td>
</tr>
<tr>
<td>Hospital LOS</td>
<td>12 ± 4</td>
<td>15 ± 7</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Kurz A et al, NEJM 1996; 334:1209
## Risk Factors

### Multivariate Analysis

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco Use</td>
<td>10.5</td>
</tr>
<tr>
<td><strong>Hypothermia</strong></td>
<td>4.9</td>
</tr>
<tr>
<td>Rectum vs Colon</td>
<td>2.7</td>
</tr>
<tr>
<td>NNISS Score</td>
<td>2.5</td>
</tr>
<tr>
<td>Age</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Kurz A et al, NEJM 1996; 334:1209
WARMING

Melling AC et al, Lancet 2001; 358:876

421 Clean Surgery Pts

- Routine Care (Standard)
- Local Warming (Radiant Heat)
- Systemic Warming (Forced Air)

30 min Pre-Op

F/U 2 & 6 Wks
OUTCOMES

- Core Temp Inc w/ Local or Systemic Warming
- Wound Infection 5% vs 14%
- ASEPSIS Scores Lower w/ Warming

Melling AC et al, Lancet 2001; 358:876
Response to SCIP-10
Matched Case Control Study- 146 Cases with SSI, 323 Controls without SSI

No Association Between Warming and SSI

OTHER PREVENTION STRATEGIES

- Preoperative
- Intraoperative
- Postoperative

Mangram et al, HICPAC Guidelines 1999
RECOMMENDATIONS

Category IA: Supported by well-designed studies

Category IB: Supported by some studies + Strong theoretical rationale

Category II: Suggested based on suggestive studies or theoretical rationale
PATIENT PREPARATION

- Eradicate **remote site infections** (IA)
- Control **blood glucose** (IDSA A-II)
- Encourage **tobacco cessation** (IB)
- **Patient bath** with antiseptic agent (IB)*
- **Remove gross contamination** before prep (IB)
- **Antiseptic skin prep** (IB) in concentric circles over large area (II)
- Minimize preoperative **hospital stay** (II)
6 Trials, 10,007 pts

1 large study showed benefit of chlorhexidine shower vs no bathing; 2 smaller studies found no benefit

No clear evidence of benefit of chlorhexidine over other wash products/placebo.

Webster J, Osborne S. Cochrane Database of Systematic Reviews, 2007, Issue 2. (Also Br J Surg 2006; 93:1335)
PRCT, 234 pts

Povidone-iodine paint equivalent to scrub-and-paint in SSI rate

Save OR time and cost


3209 Pts, Sequential implementation
1. Povidone-iodine scrub-and-paint with alcohol in between
2. 2% chlorhexidine + 70% isopropyl alcohol (ChloraPrep)
3. Iodine povacrylex in isopropyl alcohol (DuraPrep)
SSIs Period 3, 3.9% vs 6.4% (1) and 7.1% (2)
Povidone-iodine based = 4.8% SSI, vs 8.2% chlorhexidine

Swenson BR et al. Infect Control Hosp Epidemiol 2009; 30:964
SKIN PREP

PRCT, 849 pts Clean-contaminated surgery
- 2% chlorhexidine + 70% isopropyl alcohol (ChloraPrep)
- 10% Povidone-iodine scrub-and-paint

Table 2. Proportion of Patients with Surgical-Site Infection, According to Type of Infection (Intention-to-Treat Population).

<table>
<thead>
<tr>
<th>Type of Infection</th>
<th>Chlorhexidine–Alcohol (N = 409)</th>
<th>Povidone–Iodine (N = 440)</th>
<th>Relative Risk (95% CI)*</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any surgical-site infection</td>
<td>39 (9.5)</td>
<td>71 (16.1)</td>
<td>0.59 (0.41–0.85)</td>
<td>0.004</td>
</tr>
<tr>
<td>Superficial incisional infection</td>
<td>17 (4.2)</td>
<td>38 (8.6)</td>
<td>0.48 (0.28–0.84)</td>
<td>0.008</td>
</tr>
<tr>
<td>Deep incisional infection</td>
<td>4 (1.0)</td>
<td>13 (3.0)</td>
<td>0.33 (0.11–1.01)</td>
<td>0.05</td>
</tr>
<tr>
<td>Organ-space infection</td>
<td>18 (4.4)</td>
<td>20 (4.5)</td>
<td>0.97 (0.52–1.80)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Sepsis from surgical-site infection</td>
<td>11 (2.7)</td>
<td>19 (4.3)</td>
<td>0.62 (0.30–1.29)</td>
<td>0.26</td>
</tr>
</tbody>
</table>

* Relative risks are for chlorhexidine–alcohol as compared with povidone–iodine. The 95% confidence intervals were calculated with the use of asymptotic standard-error estimates.
† P values are based on Fisher’s exact test.
SKIN PREP

Chlorhexidine vs Povidone-Iodine Meta-Analysis of 6 PRCTs, 5031 Pts PRCT, 234 pts
Chlorhexidine reduced SSIs (OR 0.68; 0.50-0.94)

SURGICAL TEAM

- No artificial nails (IB) or jewelry (II)
- Scrub 2-5 minutes (IB)
- Keep hands up and away; dry with sterile towel (IB)
- Encourage personnel to report signs and symptoms of a transmissible infectious illness (IB)
- Exclude surgical personnel who have draining skin lesions (IB)
ANTIMICROBIAL PROPHYLAXIS

- Time initial dose of abx so **bactericidal tissue concentration** is established when incision is made; maintain therapeutic levels **until after incision is closed** (i.e., re-dose) (IA)

- Before elective colorectal operations, also **mechanically prepare** the colon and administer **nonabsorbable oral antimicrobials** (IA)

- **Do not routinely use vancomycin** for antimicrobial prophylaxis (IB)

- Increase dose for morbid obesity (IDSA- All)
Meta-Analysis of 14 PRCTs, 4859 Pts:
No difference in anastomotic leak, pelvic/abdominal abscess, “wound sepsis”
Considering all SSIs, No MBP was favored
Excluding small trials, higher risk of deep pelvic abscesses with no MBP
Not enough data on rectal surgery

BARRIERS

- Surgical mask that fully covers mouth and nose (IB)
- Cap or hood to fully cover hair on the head and face (IB)
- Sterile gloves after sterile gown (IB)
- Use gowns and drapes that are effective barriers when wet (IB)
- Change scrub suits that are visibly soiled, contaminated, and/or penetrated by blood or other potentially infectious materials (IB)
SURGICAL TECHNIQUE

- Adhere to principles of asepsis when placing devices or when dispensing or administering intravenous drugs (IA)
- Assemble sterile equipment and solutions immediately prior to use (II)
- Handle tissue gently, maintain effective hemostasis, minimize devitalized tissue and foreign bodies and eradicate dead space (IB)
- Use delayed primary skin closure or leave an incision open if it is heavily contaminated (IB)
- Use closed-suction drains placed through a separate incision (IB)
Bactericidal Activity of Neutrophils is Oxygen-Dependent

Subcutaneous Wound Oxygen Tension is Inversely Correlated with Wound Infection Rates

Hypothesis: Supplemental Oxygen Decreases Wound Infections

Hopf et al, Arch Surg 1997; 132:997
OXYGEN

500 Colorectal Surgery Pts

30% O₂ / 70% N₂
vs
80% O₂ / 20% N₂
Intraop + 2 Hr Postop

- I.V. Abx, Hydration, Forced Air Heat, Fluid Warmer
- Wound Evaluation Daily x 2 Wk
- Collagen Deposition

Grief et al, NEJM 2000; 342:161
<table>
<thead>
<tr>
<th>Variable</th>
<th>30%</th>
<th>80%</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>250</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>SQ O2 Tension</td>
<td>59</td>
<td>109</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Infection</td>
<td>28 (11%)</td>
<td>13 (5%)</td>
<td>.01</td>
</tr>
<tr>
<td>ASEPSIS Score</td>
<td>5 ± 9</td>
<td>3 ± 7</td>
<td>.01</td>
</tr>
<tr>
<td>Collagen µg/cm</td>
<td>267 ± 109</td>
<td>258 ± 118</td>
<td>.38</td>
</tr>
<tr>
<td>Days to Solids</td>
<td>4 ± 2</td>
<td>5 ± 2</td>
<td>.27</td>
</tr>
<tr>
<td>Hospital LOS</td>
<td>12 ± 4</td>
<td>12 ± 6</td>
<td>.26</td>
</tr>
</tbody>
</table>

OUTCOMES

Grief et al, NEJM 2000; 342:161
Pryor et al, JAMA 2004; 291:79

165 Surgical Pts

35% O₂ vs 80% O₂

Intraop + 2 Hr Postop
## OUTCOMES

<table>
<thead>
<tr>
<th>Variable</th>
<th>35%</th>
<th>80%</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>80</td>
<td>80</td>
<td>-</td>
</tr>
<tr>
<td>Infection</td>
<td>9 (11%)</td>
<td>20 (25%)</td>
<td>.02</td>
</tr>
<tr>
<td>Reoperation</td>
<td>0</td>
<td>4 (5%)</td>
<td>.07</td>
</tr>
<tr>
<td>Hospital LOS</td>
<td>6.4</td>
<td>8.3</td>
<td>.06</td>
</tr>
</tbody>
</table>

Pryor et al, JAMA 2004; 291:79
CRITICISMS

- Retrospective chart review for infections
- Small, heterogeneous population
- Did not consider anesthetic / fluid management, temperature, pain control
- Obesity, operative time, blood loss, fluid volume, postoperative intubation greater in the 80% group
Belda et al, JAMA 2005; 294:2035

291 Colorectal Surgery Pts

30% O₂ vs 80% O₂

Intraop + 2 Hr Postop
<table>
<thead>
<tr>
<th>Variable</th>
<th>30%</th>
<th>80%</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>143</td>
<td>148</td>
<td>-</td>
</tr>
<tr>
<td>Infection</td>
<td>35 (24%)</td>
<td>22 (15%)</td>
<td>.04</td>
</tr>
<tr>
<td>Hospital LOS</td>
<td>10.5</td>
<td>11.7</td>
<td>.09</td>
</tr>
</tbody>
</table>

Belda et al, JAMA 2005; 294:2035
The PROXI Trial

Meyhoff et al, JAMA 2009; 302:1543

1400 Abdominal Surgery Pts

30% O_2 vs 80% O_2
Intraop + 2 Hr Postop

SSI 20% vs 19%
Deep SSI 3.7% vs 2.9%
Meta-Analysis: Effect of Perioperative Supplemental Oxygen (FiO2 80%) on SSI Risk

- **Colorectal**
  - Excluding NO
  - Excluding *Pryor*

Carried in nares of 20-30% healthy persons. Carriers are at risk of *S. aureus* SSIs.

Intranasal mupirocin:
- Prevents sternal wound infections
- Prevents orthopedic MRSA SSIs

ERADICATION OF NASAL *S. AUREUS*
ERADICATION OF NASAL S. AUREUS

PRCT 3864 pts
Low rate (2.3-2.4%) of S. aureus SSIs
891 (23%) nasal carriers of S. aureus
Fewer S. aureus nosocomial infxns
(4.0% vs 7.7%) among carriers

Potential cost-effective strategy
ERADICATION OF NASAL S. AUREUS

PRCT 917 pts; 808 (81%) Surgery
Intranasal Mupirocin + Chlorhexidine Soap vs Placebo
S. Aureus Infxn 3.4% vs 7.7%*
Deep SSI 0.9% vs 4.4%*
Superficial SSI 1.6% vs 3.5%*

Transfusion is Associated with Increased Postop Infection Rates

- Penetrating Abdominal Trauma
- Colon Resection
- Coronary Artery Bypass
- Orthopedic Surgery
- Hysterectomy

Bowel Surgery
1472 Pts / 31 Centers

Independent SSI Risk Factors:
- Transfusion (OR 1.64)
- Infection (OR 2.46)

Walz JM et al, Arch Surg 2006; 141:1014
IMPACT OF LOW-VOLUME LEUKOREDUCED TRANSFUSION

- ACS-NSQIP
- 125,223 Pts, 121 Hospitals
- Transfusion Risk Index
- SSI, UTI, PNA, Sepsis, Morbidity, Mortality

Pts receiving a single unit of PRBCs had higher rates of SSIs, UTI, pneumonia, sepsis/shock, composite morbidity, and 30-day mortality.

After adjustment, 1 U PRBCs significantly (p < 0.05) increased the risk of mortality (OR = 1.32), composite morbidity (OR = 1.23), pneumonia (OR = 1.24), and sepsis/shock (OR = 1.29) but not SSI.

Transfusion of 2 U increased the risk for these outcomes (OR = 1.38, 1.40, 1.25, and 1.53, respectively; p ≤ 0.05) and was associated with increased risk for SSI (OR = 1.25; p < 0.05).

Adhere to **principles of asepsis** when placing devices or when dispensing or administering intravenous drugs (IA)

Assemble sterile equipment and solutions immediately prior to use (II)

Handle tissue gently, maintain effective hemostasis, **minimize devitalized tissue** and foreign bodies and **eradicate dead space** (IB)

Use **delayed primary skin closure** or leave an incision open if it is heavily contaminated (IB)

Use closed-suction drains placed through a separate incision (IB)
POSTOPERATIVE CARE

- Protect incision with a **sterile dressing** for 24-48 hours (IB)
- **Wash hands** before and after dressing changes and any contact with the surgical site (IB)
- Use **sterile technique** to change an incision dressing (II)
- Educate the patient and family regarding incision care and infection prevention (II)
EFFICACY OF PROTOCOL IMPLEMENTATION

Colorectal Surgery Pts
Abx, Normothermia, Normoglycemia
SSIs decreased 39%
Hedrick TL et al, J Am Coll Surg 2007; 205:432

Colorectal, Hepatobiliary Surgery Pts
Intervention to improve abx, normothermia, normoglycemia
SSIs decreased 14.3% to 8.7%
EFFICACY OF PROTOCOL IMPLEMENTATION

Mayo Clinic Florida
28-point SSI Bundle Implementation

Class I SSIs decreased 1.78% to 0.51%
Class II SSIs decreased 2.82% to 1.44%

SUMMARY

- Prepare the patient- and yourself
- Use antibiotic prophylaxis appropriately
- Maintain normothermia
- Maintain serum glucose <200 mg/dL
- Give oxygen
- Eradicate S. aureus if you find it
- Avoid transfusion
SUMMARY

- Surveillance
- Feedback
- Education