CURRENT CONCEPTS IN THE PREVENTION OF SURGICAL SITE INFECTIONS

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Denver Health Medical Center
Associate Professor of Surgery
University of Colorado
SURGICAL SITE INFECTIONS (SSIs) - OUTLINE

- Why You Should Care
- What You Can / Should Do About It
  - The Obvious
  - The Not-So-Obvious
SSIs – SCOPE OF THE PROBLEM

CDC’s National Nosocomial Infections Surveillance (NNIS) System: Third Most Common Nosocomial Infection (14-16%)

38% of Nosocomial Infections in Surgical Pts
Mangram et al, Infect Control Hosp Epidemiol 1999; 20:247
## CONSEQUENCES OF SSIs

### 255 Matched Pairs, 1991-1995

<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>ICU Admit</td>
<td>29%</td>
<td>18%</td>
</tr>
<tr>
<td>Median LOS</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Costs</td>
<td>$7531</td>
<td>$3844</td>
</tr>
<tr>
<td>Readmission</td>
<td>41%</td>
<td>7%</td>
</tr>
</tbody>
</table>

**Excess LOS 12 days, Costs $5038**

*Kirkland et al, Infect Control Hosp Epidemiol 1999; 20:725*
CONSEQUENCES OF SSIs

Extrapolated to U.S.

- 20,000 In-hospital Deaths
- $3 Billion / Year Inpatient Care

Kirkland et al, Infect Control Hosp Epidemiol 1999; 20:725
EXTERNAL FORCES

IOM- *To Err is Human* (2000)

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
AHRQ Patient Safety Indicators Identified Medical Injuries Among 7.45 M Hospital Discharge Abstracts, 994 Hospitals / 28 States, 2000

Zhan et al, JAMA 2003; 290:1868

20% Sample of U.S. Hospitals
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 (0.90)</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>10845 (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>13315 (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>17312 (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>.003</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>21431 (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>13441 (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>54818 (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>21709 (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>53502 (3121)</td>
<td>&lt;.001</td>
<td>21.84 (1.46)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Postoperative sepsis</td>
<td>10.89 (0.90)</td>
<td>&lt;.001</td>
<td>57727 (3077)</td>
<td>&lt;.001</td>
<td>21.92 (1.47)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Postoperative wound dehiscence</td>
<td>9.42 (0.72)</td>
<td>&lt;.001</td>
<td>40323 (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>38656 (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>18929 (10068)</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.
IMPACT OF “ERRORS”

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
Quality health care is a high priority for the Bush administration, the Department of Health and Human Services (HHS), and the Centers for Medicare & Medicaid Services (CMS). In November 2001, HHS announced the Quality Initiative to assure quality health care for all Americans through accountability and public disclosure.

CMS, December 2005
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CMS, December 2005
**SURGICAL CARE IMPROVEMENT PROJECT (SCIP)**

National Quality Partnership

<table>
<thead>
<tr>
<th>CMS</th>
<th>CDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS</td>
<td>AHA</td>
</tr>
<tr>
<td>AORN</td>
<td>ASA</td>
</tr>
<tr>
<td>JCAHO</td>
<td>VA</td>
</tr>
</tbody>
</table>

20 Additional Organizations
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

- Prophylactic Antibiotic <1 hr Prior to Incision
- Appropriate Prophylactic Antibiotic
- Prophylactic Antibiotic Discontinued w/i 24 hr
- Cardiac Surgery Pts with Perioperative (24 hr Pre-, 48 hr Post-op) Serum Glucose ≤200 mg/dL
- Appropriate Hair Removal
- Colorectal Surgery Pts with Immediate Postoperative Normothermia
Section 501(b) of the Medicare Prescription Drug, Improvement, and Modernization Act of 2003: A hospital that does not submit performance data for ten stipulated quality measures will receive a 0.4 percentage points reduction in its annual payment update from CMS for FY 2005, 2006, and 2007.
Hospitals will receive bonuses based on their performance…Composite scores will be calculated annually…Hospitals in the top 50% will be reported as “top performers”… Those in the top 20% will be recognized and given a financial bonus…In year three, hospitals will receive lower payments if they score below clinical baselines set in the first year for the bottom 20%
<table>
<thead>
<tr>
<th>Hospital/Medical Center</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVERAGE FOR ALL REPORTING HOSPITALS IN THE UNITED STATES</td>
<td>78%</td>
</tr>
<tr>
<td>AVERAGE FOR ALL REPORTING HOSPITALS IN THE STATE OF COLORADO</td>
<td>84%</td>
</tr>
<tr>
<td>CENTURA HEALTH- ST. ANTHONY NORTH HOSPITAL</td>
<td>77%</td>
</tr>
<tr>
<td>DENVER HEALTH MEDICAL CENTER</td>
<td>85%</td>
</tr>
<tr>
<td>EXEMPLARY ST. JOSEPH HOSPITAL</td>
<td>93%</td>
</tr>
<tr>
<td>ROSE MEDICAL CENTER</td>
<td>61%</td>
</tr>
<tr>
<td>UNIVERSITY OF COLORADO HOSPITAL ANSCHUTZ INPATIENT</td>
<td>79%</td>
</tr>
</tbody>
</table>

**Percent of Surgical Patients Receiving Appropriate Prophylactic Antibiotics**

[www.hospitalcompare.hhs.gov](http://www.hospitalcompare.hhs.gov)
<table>
<thead>
<tr>
<th>Hospital/Location</th>
<th>Percent of Surgical Patients Receiving Prophylactic Antibiotics One Hour Before Incision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average for All Reporting Hospitals in the United States</td>
<td>90%</td>
</tr>
<tr>
<td>Average for All Reporting Hospitals in the State of Colorado</td>
<td>92%</td>
</tr>
<tr>
<td>Centura Healh- St. Anthony North Hospital</td>
<td>96%</td>
</tr>
<tr>
<td>Denver Health Medical Center</td>
<td>83%</td>
</tr>
<tr>
<td>Exempla St. Joseph Hospital</td>
<td>97%</td>
</tr>
<tr>
<td>Rose Medical Center</td>
<td>97%</td>
</tr>
<tr>
<td>University of Colorado Hospital Anschutz Inpatient</td>
<td>80%</td>
</tr>
</tbody>
</table>

Percent of Surgical Patients Receiving Prophylactic Antibiotics One Hour Before Incision

www.hospitalcompare.hhs.gov
### Percent of Surgical Patients With Prophylactic Antibiotics Stopped Within 24 Hours After Surgery

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average for all reporting hospitals in the United States</td>
<td>74%</td>
</tr>
<tr>
<td>Average for all reporting hospitals in the state of Colorado</td>
<td>71%</td>
</tr>
<tr>
<td>Centura Healh- St. Anthony North Hospital</td>
<td>61%</td>
</tr>
<tr>
<td>Denver Health Medical Center</td>
<td>71%</td>
</tr>
<tr>
<td>Exempla St. Joseph Hospital</td>
<td>72%</td>
</tr>
<tr>
<td>Rose Medical Center</td>
<td>77%</td>
</tr>
<tr>
<td>University of Colorado Hospital Anschutz Inpatient</td>
<td>83%</td>
</tr>
</tbody>
</table>

www.hospitalcompare.hhs.gov
Barriers to Compliance

- Lack of awareness / familiarity
- Disagreement with guideline / evidence
- Complex multi-step systems that result in confusion and lack of accountability
DEFINITIONS

Superficial Incisional SSI:

- Within 30 days
- Skin / Subcutaneous tissue
- Purulent drainage or (+) Cx or Pain / Tenderness / Swelling / Redness / Heat AND Opened by surgeon UNLESS Cx (-) or SSI Dx by attending

Not stitch abscesses, burn infections
DEFINITIONS

Deep Incisional SSI:

- Within 30 days (1 year if implant)
- Deep soft tissue
- Purulent drainage or Abscess in deep tissue or Fever / Pain / Tenderness AND Dehiscence / Opened by surgeon UNLESS Cx (-) or SSI Dx by attending
DEFINITIONS

Organ / Space SSI:
- Within 30 days (1 year if implant)
- Any organ / space manipulated during surgery
- Purulent drainage or (+) Cx or Abscess or SSI Dx by attending
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
62,937 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>1.3</td>
</tr>
<tr>
<td>Clean-Contaminated</td>
<td>7.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Contaminated</td>
<td>15.2</td>
<td>7.1</td>
</tr>
<tr>
<td>Dirty / Infected</td>
<td>40.0</td>
<td>-</td>
</tr>
</tbody>
</table>

- **1967-1977**: 62,937 pts
- **1982-1986**: 20,703 pts
INFECTION FACTORS

Meakins et al, ACS Surgery 2005
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

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

LAPAROSCOPY FACTOR

Subtract 1 for Colon and Gallbladder

Subtract 1 for Stomach and Appendix

ONLY if Pt has No Other Risk Factors

Duration Cut Point (hr):

Appendix 1
Gallbladder 2
Colon 3
Stomach 3

CATS Decrease Surgical Site Infections
Hair Removal:
If hair must be removed from the surgical site, clippers are the best option. *Never use a razor.*

Prophylactic Antibiotics:
Antibiotics consistent with national guidelines should be administered within 1 hour of incision time and discontinued within 24 hours, in most cases.

Normothermia:
Colorectal surgery patients should be normothermic (96.8–100.4°F) within the first hour after surgery.

Glucose Control:
Cardiac surgery patients should have controlled 6 a.m. serum glucose (≤ 200 mg/dL) on postoperative Day 1 and Day 2.

Additional information about reducing surgical site infections is available at www.medqic.org.
PREVENTION STRATEGIES

- Preoperative
- Intraoperative
- Postoperative

Mangram et al, CDC 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)
- 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)
- No recommendations on altering steroid use or enhancing nutritional support
CATS Decrease Surgical Site Infections

Hair Removal:
Hair must be removed from the surgical site. Clippers are the best option. Never use a razor.

Prophylactic Antibiotics:
Antibiotics consistent with national guidelines should be administered within 1 hour of incision time and discontinued within 24 hours in most cases.

Normothermia:
Colorectal surgery patients should be normothermic (96.8–100.4°F) within the first hour after surgery.

Glucose Control:
Cardiac surgery patients should have controlled 6 a.m. serum glucose to 200 mg/dL on postoperative Day 1 and Day 2.

Additional information about reducing surgical site infections is available at www.medqic.org.
HAIR REMOVAL

BEST
No Hair Removal
(Depilatory)
Clipping Immediately Prior to Incision
Shaving Immediately Prior to Incision
Patient Shaving the Day Before Surgery

WORST
Clip immediately before surgery (IA)
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)
CATS Decrease Surgical Site Infections

Clippers

Antibiotics

Temperature

Sugar

Hair Removal: Hair must be removed from the surgical site. Clippers are the best option. Never use a razor.

Prophylactic Antibiotics: Antibiotics consistent with national guidelines should be administered within 1 hour of incision time and discontinued within 24 hours in most cases.

Normothermia: Colorectal surgery patients should be normothermic (96.8–100.4°F) within the first hour after surgery.

Glucose Control: Cardiac surgery patients should have controlled 6 a.m. serum glucose (<200 mg/dL) on postoperative Day 1 and Day 2.

Additional information about reducing surgical site infections is available at www.medqic.org.
OPTIMAL ANTIMICROBIAL PROPHYLAXIS

- Active Against Pathogens Most Likely to Contaminate Wound
- Adequate Concentration at Incision Site at Time of Potential Contamination
- Safe
- Administered for a Brief Period to Minimize Complications, Resistance, and Cost
ANTIMICROBIAL PROPHYLAXIS

- Prophylactic abx when indicated, based on efficacy against likely pathogens (IA)
- Time initial dose of abx so bactericidal tissue concentration is established when incision is made; maintain therapeutic levels until after incision is closed (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)
Table 3. Summary of the Surgical Infection Prevention Guideline Writers Workgroup consensus positions.

<table>
<thead>
<tr>
<th>Principle</th>
<th>Consensus position</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General dosing</strong></td>
<td></td>
</tr>
<tr>
<td>Antibiotic timing</td>
<td>Infusion of the first antimicrobial dose should begin within 60 min before the surgical incision.</td>
</tr>
<tr>
<td>Duration of prophylaxis</td>
<td>Prophylactic antimicrobials should be discontinued within 24 h after the end of surgery.</td>
</tr>
<tr>
<td>Screening for β-lactam allergy</td>
<td>For those operations for which cephalosporins represent the most appropriate antimicrobials for prophylaxis, the medical history should be adequate to determine whether the patient has a history of allergy or serious adverse antibiotic reaction. Alternative testing strategies (e.g., skin testing) may be useful for patients with reported allergy.</td>
</tr>
<tr>
<td><strong>Antimicrobial dosing</strong></td>
<td>The initial antimicrobial dose should be adequate based on the patient’s body weight, adjusted dosing weight, or body mass index. An additional antimicrobial dose should be provided intraoperatively if the operation is still continuing 2 half-lives after the initial dose.</td>
</tr>
<tr>
<td><strong>Antibiotic selection, by procedure</strong></td>
<td></td>
</tr>
<tr>
<td>Abdominal or vaginal hysterectomy</td>
<td>Cefotetan therapy is preferred; cefazolin or cefoxitin are alternatives. Metronidazole monotherapy is also used. If the patient has a β-lactam allergy, use clindamycin combined with gentamicin or ciprofloxacin or aztreonam; metronidazole with gentamicin or ciprofloxacin, or clindamycin monotherapy.</td>
</tr>
<tr>
<td>Hip or knee arthroplasty</td>
<td>Use cefazolin or cefuroxime. If the patient has a β-lactam allergy, use vancomycin or clindamycin.</td>
</tr>
<tr>
<td>Cardiothoracic and vascular surgery</td>
<td>Use cefazolin or cefuroxime. If the patient has a β-lactam allergy, use vancomycin or clindamycin.</td>
</tr>
<tr>
<td>Colon surgery</td>
<td>For oral antimicrobial prophylaxis, use neomycin plus erythromycin base or neomycin plus metronidazole. For parenteral antimicrobial prophylaxis, use cefotetan, cefoxitin, or cefazolin plus metronidazole. If the patient has a β-lactam allergy, use clindamycin combined with gentamicin, ciprofloxacin, or aztreonam, or use metronidazole combined with gentamicin or ciprofloxacin.</td>
</tr>
</tbody>
</table>

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* When fluoroquinolone or vancomycin are indicated, infusion of the first antimicrobial dose should begin within 120 min before the incision.
* See table 2.
* Metronidazole monotherapy is included in the Practice Bulletin of the American College of Obstetricians and Gynecologists as an alternative to β-lactams for patients undergoing hysterectomy, although it may be less effective as a single agent for prophylaxis [15].
* A single 750-mg dose of levofloxacin may be substituted for ciprofloxacin.
ANTIMICROBIAL PROPHYLAXIS

**Esophageal, Gastroduodenal**: Cefazolin for high risk (morbid obesity, esophageal obstruction, decreased gastric acidity or GI motility)

**Biliary**: Cefazolin for high risk (Age >70, acute cholecystitis, non-functioning gallbladder, obstructive jaundice, choledocholithiasis)

**Appendiceal**: Cefoxitin/Cefotetan or Cefazolin + Metronidazole

**Perforated Viscus**: Cefoxitin/Cefotetan +/- Gentamicin

*The Medical Letter 2004; 2:27*
ANTIMICROBIAL PROPHYLAXIS

Thoracic: Cefazolin/Cefuroxime OR Vancomycin

Clean (Breast, Hernia): No antibiotics necessary unless implanting prosthetic material

Penicillin Allergy: Vancomycin/Clindamycin; If gram-negative is desirable, add Gentamicin, Ciprofloxacin, Levofloxacin, or Aztreonam

Re-dose if procedure lasts two drug half-lives

No need for postoperative dosing

The Medical Letter 2004; 2:27
Meta-Analysis of PRCTs

No evidence that mechanical bowel prep decreases SSIs (7.4% w/, 5.7% w/o, p=NS)

Mechanical bowel prep appears to be associated with higher rates of anastomotic dehiscence (5.5% w/, 2.9% w/o, p<0.05)

ANTIMICROBIAL PROPHYLAXIS

Baseline Data for National Surgical infection Prevention Project

34,133 Medicare inpatients undergoing select operative procedures at 2965 acute-care hospitals, 2001

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

**Table 2. Proportion of Patients Who Received a Prophylactic Antimicrobial Within 1 Hour Before the Surgical Incision***

<table>
<thead>
<tr>
<th>Type of Operation</th>
<th>No. of Patients Who Received Antimicrobial Within 1 h/No. of Patients Undergoing Operation†</th>
<th>Unweighted % (95% CI)</th>
<th>Weighted % (95% CI)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>6367/11 220</td>
<td>56.8 (55.8-57.7)</td>
<td>55.7 (54.8-56.6)</td>
</tr>
<tr>
<td>Cardiac</td>
<td>1984/3287</td>
<td>60.4 (58.7-62.0)</td>
<td>58.5 (56.8-60.2)</td>
</tr>
<tr>
<td>Vascular</td>
<td>525/1116</td>
<td>47.0 (44.1-50.0)</td>
<td>47.0 (44.0-49.9)</td>
</tr>
<tr>
<td>Hip or knee arthroplasty</td>
<td>2694/4402</td>
<td>61.2 (59.8-62.6)</td>
<td>59.7 (58.3-61.2)</td>
</tr>
<tr>
<td>Colon</td>
<td>732/1603</td>
<td>45.7 (43.2-48.1)</td>
<td>46.0 (43.5-48.4)</td>
</tr>
<tr>
<td>Hysterectomy</td>
<td>432/812</td>
<td>53.2 (49.8-56.6)</td>
<td>54.8 (51.4-58.3)</td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval.

*These results include patients who received vancomycin from 1 to 2 hours before the incision (n=213).

†Cases were excluded from this performance measure if there were insufficient data to determine the time interval between prophylactic antimicrobial dose and surgical incision (n=22 902). In addition, patients undergoing colon surgery who received oral antimicrobials only for prophylaxis were excluded from the denominator (n=11).

‡Weighted results reflect adjustment based on the state-specific sampling scheme.

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

### Table 3. Proportion of Patients Who Received a Prophylactic Antimicrobial Drug Consistent With Published Guidelines*

<table>
<thead>
<tr>
<th>Type of Operation</th>
<th>No. of Patients Who Received Appropriate Antimicrobial/No. of Patients Undergoing Operation†</th>
<th>Unweighted % (95% CI)</th>
<th>Weighted % (95% CI)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>30 866/33 229</td>
<td>92.9 (92.6-93.2)</td>
<td>92.6 (92.3-92.8)</td>
</tr>
<tr>
<td>Cardiac</td>
<td>7517/7843</td>
<td>95.8 (95.4-96.3)</td>
<td>95.1 (94.7-95.6)</td>
</tr>
<tr>
<td>Vascular</td>
<td>2886/3140</td>
<td>91.9 (90.9-92.8)</td>
<td>91.5 (90.5-92.5)</td>
</tr>
<tr>
<td>Hip or knee arthroplasty</td>
<td>14 605/14 996</td>
<td>97.4 (97.1-97.6)</td>
<td>97.2 (96.7-97.5)</td>
</tr>
<tr>
<td>Colon</td>
<td>3683/4855</td>
<td>75.9 (74.6-77.1)</td>
<td>75.8 (74.6-77.0)</td>
</tr>
<tr>
<td>Hysterectomy</td>
<td>2175/2395</td>
<td>90.8 (89.6-91.9)</td>
<td>90.2 (89.0-91.3)</td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval.

*Antimicrobials were considered prophylactic if they were given before surgery, given intraoperatively, or given within 24 hours after the end of surgery.

†Cases were excluded from this performance measure if no antimicrobials were administered, if no antimicrobials administered were considered prophylactic, or if there were insufficient data to make the determination on timing (n=336). In addition, because there are no published guidelines for antimicrobial selection for β-lactam-allergic patients undergoing colon surgery or hysterectomy, cases with a documented β-lactam allergy that did not pass the performance measure for these 2 operations were excluded from the denominator (n=568).

‡Weighted results reflect adjustment based on the state-specific sampling scheme.

Bratzler et al, Arch Surg 2005; 140:174
# Antimicrobial Prophylaxis

## Table 5. Proportion of Patients Whose Antimicrobial Prophylaxis Was Discontinued Within 24 Hours of the End of Surgery*

<table>
<thead>
<tr>
<th>Type of Operation</th>
<th>No. of Patients With Discontinued Antimicrobial Prophylaxis Within 24 h/No. of Patients Undergoing Operation†</th>
<th>Unweighted % (95% CI)</th>
<th>Weighted % (95% CI)‡</th>
<th>Median Time to Discontinuation, h</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>13 266/32 603</td>
<td>40.7 (40.2-41.2)</td>
<td>40.7 (40.2-41.2)</td>
<td>40.4</td>
</tr>
<tr>
<td>Cardiac</td>
<td>2621/7635</td>
<td>34.3 (33.3-35.4)</td>
<td>34.4 (33.4-35.5)</td>
<td>40.9</td>
</tr>
<tr>
<td>Vascular</td>
<td>1305/2913</td>
<td>44.8 (43.0-46.6)</td>
<td>45.2 (43.4-47.0)</td>
<td>42.7</td>
</tr>
<tr>
<td>Hip or knee arthroplasty</td>
<td>5295/14 575</td>
<td>36.3 (35.5-37.1)</td>
<td>36.7 (35.9-37.4)</td>
<td>39.0</td>
</tr>
<tr>
<td>Colon</td>
<td>2013/4911</td>
<td>41.0 (39.6-42.4)</td>
<td>40.8 (39.5-42.2)</td>
<td>57.0</td>
</tr>
<tr>
<td>Hysterectomy</td>
<td>2032/2569</td>
<td>79.1 (77.5-80.7)</td>
<td>77.9 (76.3-79.5)</td>
<td>21.4</td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval.

*Antimicrobials were considered prophylactic if they were given before surgery, given intraoperatively, or given within 24 hours after the end of surgery.

†Cases were excluded from this performance measure if no antimicrobials were administered, if no antimicrobials administered were considered prophylactic, or if there were insufficient data to make the determination of timing (n=344). Any patient with documentation in the medical record of an infection during surgery or within 48 hours after the end of surgery was excluded from the denominator (n=634). In addition, patients who underwent more than 1 surgical procedure of interest during the hospitalization were excluded from the denominator (n=552).

‡Weighted results reflect adjustment based on the state-specific sampling scheme.

Bratzler et al, Arch Surg 2005; 140:174
OPERATING ROOM

- Positive pressure (IB)
- 15 air changes/hr (3 fresh air) (IB)
- Filter air; Introduce air at the ceiling, exhaust at the floor (IB)
- Do not use UV radiation (IB)
- Keep OR doors closed except as needed (IB) and limit the number of personnel entering (II)
- Consider performing orthopedic implant operations in rooms supplied with ultraclean air (II)
OPERATING ROOM

- Use EPA-approved hospital disinfectant to clean visible blood/body fluid soiling or contamination before the next operation (IB)
- **Do not perform special cleaning or closing of OR** after contaminated or dirty operations (IB)
- **Do not use tacky mats** at the OR entrance (IB)
- **Wet vacuum the OR floor** after the last operation of the day with EPA-approved disinfectant (II)
INSTRUMENTS

- **Sterilize all surgical instruments** according to published guidelines (IB)
- Perform flash sterilization only for patient care items that will be used immediately (IB)
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)
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)
CATS Decrease Surgical Site Infections

Clippers

Antibiotics

Temperature

Sugar

Additional information about reducing surgical site infections is available at www.medqic.org.
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
Kurz A et al, NEJM 1996; 334:1209

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
## OUTCOMES

<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>.009</td>
</tr>
<tr>
<td>ASEPSIS Score</td>
<td>7 ± 10</td>
<td>13 ± 16</td>
<td>.002</td>
</tr>
<tr>
<td>Collagen μg/cm</td>
<td>328 ± 135</td>
<td>254 ± 114</td>
<td>.04</td>
</tr>
<tr>
<td>Days to Solids</td>
<td>6 ± 3</td>
<td>7 ± 2</td>
<td>.006</td>
</tr>
<tr>
<td>Days to SR</td>
<td>10 ± 3</td>
<td>11 ± 2</td>
<td>.002</td>
</tr>
<tr>
<td>Hospital LOS</td>
<td>12 ± 4</td>
<td>15 ± 7</td>
<td>.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>Hypothermia</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 Infxn 5% vs 14%**
- ASEPSIS Scores Lower w/ Warming

Melling AC et al, Lancet 2001; 358:876
CATS Decrease Surgical Site Infections

Clippers

Antibiotics

Temperature

Sugar

Hair Removal:
Hair must be removed from the surgical site. Clippers are the best option. Never use a razor.

Prophylactic Antibiotics:
Antibiotics consistent with national guidelines should be administered within 1 hour of incision time and discontinued within 24 hours in most cases.

Normothermia:
Colorectal surgery patients should be normothermic (95.8–100.4°F) within the first hour after surgery.

Glucose Control:
Cardiac surgery patients should have controlled 6 a.m. serum glucose (<200 mg/dL) on postoperative Day 1 and Day 2.

Additional information about reducing surgical site infections is available at www.medqic.org.
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
OXYGEN

Strong Anecdotal Evidence and Expert Opinion Indicate that Oxygen is Beneficial to Patients

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% \( \text{O}_2 / 70\% \text{N}_2 \)
vs
80% \( \text{O}_2 / 20\% \text{N}_2 \)

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>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>

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
<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
- 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% O_2 vs 80% O_2

Intraop + 2 Hr Postop
## OUTCOMES

<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
O$_2$ OR NO O$_2$?

- It defies logic that colorectal surgery patients have opposite response to oxygen.
- Turn up the oxygen - there is NO downside!
ERADICATION OF NASAL S. AUREUS

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

Intranasal mupirocin:
- Prevents sternal wound infxns
- Prevents orthopedic MRSA SSIs
  Wilcox MH et al, J Hosp Infect 2003; 54:196
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

TRANSFUSIONS AND POSTOPERATIVE INFECTION

Transfusion is Associated with Increased Postop Infection Rates

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

BLOOD TRANSFUSION

Bowel Surgery
1472 Pts / 31 Centers

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

WalzJM et al, Arch Surg 2006; 141:1014
<table>
<thead>
<tr>
<th>Concept</th>
<th>Process measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timeliness of antibiotics</td>
<td>Percent of cases with prophylactic antibiotic started within 1 hr of incision (vancomycin within 2 hr)</td>
</tr>
<tr>
<td>Appropriate selection of antibiotics</td>
<td>Percent of cases receiving prophylactic antibiotics consistent with the current guidelines</td>
</tr>
<tr>
<td>Correct duration of antibiotics</td>
<td>Percent of cases receiving prophylactic antibiotics whose antibiotics were discontinued within 24 hr after surgery</td>
</tr>
<tr>
<td>Prevent hyperglycemia</td>
<td>Percent of cases maintaining glucose ≤200 mg/dL</td>
</tr>
<tr>
<td>Maintain normothermia</td>
<td>Percent of cases with temperature maintained &gt;36°C</td>
</tr>
<tr>
<td>Optimize oxygen tension</td>
<td>Percent of cases providing supplemental oxygen during operation (FIO₂ &gt; 80%) and in recovery (high-flow mask)</td>
</tr>
<tr>
<td>Avoid shaving surgical site</td>
<td>Percent of surgical cases with appropriate hair removal</td>
</tr>
</tbody>
</table>

### 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>

*Dellinger et al, Am J Surg 2005; 190:9*

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
- Perform surveillance, analyze SSIs