Prevention of Perioperative Surgical Infections

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Surgical Site Infections (SSI)

2-5% of operated patients will develop SSI
40 million operations annually in the U.S.
⇒ 800,000 – 2,000,000 SSI’s annually in U.S.!!

SSI increases LOS in hospital
average 7.5 days

Excess cost per SSI:
*$5,739-51,191 (adjusted to 2009 USD)
US national costs: $250 million – $1.7 billion/year

Opportunity to Prevent Surgical Infections

An estimated 40-60% of SSIs are preventable.

Overuse, underuse, improper timing, and misuse of antibiotics occurs in 25-50% of operations.
Risk Factors for Infection
Wound Classification

I. **Clean**: uninfected, no inflammation, no mucosal surface transected: Mastectomy, Thyroidectomy

   - Risk of SSI: <2%

II. **Clean/Contaminated**: mucosal-lined lumen entered in controlled conditions. Cholecystectomy, Colectomy, Whipple, Laryngectomy, Urologic procedures.

   - Risk of SSI: 5-15%

III. **Contaminated**: Open accidental wounds, break in sterile conditions, spillage, stomas. Appendicitis, Diverticulitis, Small bowel GSW.

   - Risk of SSI: 15-30%

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

   - Risk of SSI: > 30%

* Dirty wounds ≈ infection - antibiotics indicated as therapy

Medical Conditions Increasing Risk of Surgical Site Infection (SSI)

- Extremes of age
- Under-nutrition
- Obesity
- Diabetes
- Prior site irradiation
- Hypoxemia
- Remote infection
- Corticosteroid therapy
- Recent operation
- Chronic inflammation

*Antibiotic prophylaxis may be indicated in clean cases when associated conditions increase infection risk*
NNIS Risk Index as a Predictor of Risk of Infection

<table>
<thead>
<tr>
<th>Traditional Class</th>
<th>NNIS Risk Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Clean</td>
<td>1.0%</td>
</tr>
<tr>
<td>Clean/Contam</td>
<td>2.1%</td>
</tr>
<tr>
<td>Contaminated</td>
<td>NA</td>
</tr>
<tr>
<td>Dirty</td>
<td>NA</td>
</tr>
<tr>
<td>All</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

Nichols RL, Martone WJ. Surgery 2000; 128: S2-S13
<table>
<thead>
<tr>
<th>Traditional Class</th>
<th>NNIS Risk Index</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0%</td>
<td>2.3%</td>
<td>5.4%</td>
<td>NA</td>
<td>2.1%</td>
</tr>
<tr>
<td>Clean/Contam</td>
<td></td>
<td>2.1%</td>
<td>4.0%</td>
<td>9.5%</td>
<td>NA</td>
<td>3.3%</td>
</tr>
<tr>
<td>Contaminated</td>
<td>NA</td>
<td>3.4%</td>
<td>6.6%</td>
<td>13.2%</td>
<td>6.4%</td>
<td></td>
</tr>
<tr>
<td>Dirty</td>
<td>NA</td>
<td>3.1%</td>
<td>8.1%</td>
<td>12.8%</td>
<td>7.1%</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td></td>
<td>1.5%</td>
<td>2.9%</td>
<td>6.8%</td>
<td>13.0%</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

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Preventing Infection
New(er) Developments in SSI

Attention to problem

New surgical techniques.

Better systems for administration of prophylactic antibiotics

Duration of antibiotics

Recognition of environmental factors that aggravate SSI

Technical factors in wound management
Mechanisms to Prevent SSI

Minimize (or eliminate) bacteria in wound at time of surgery.
- skin decontamination
- excellent surgical technique
- peri-operative prophylactic antibiotics

Maximize delivery (and effectiveness) of host defenses.
- pre-op nutritional state.
- adequate oxygentation.
- excellent perfusion of wound.
## Influence of Shaving on SSI

<table>
<thead>
<tr>
<th>Group</th>
<th>No Hair Removal</th>
<th>Depilatory</th>
<th>Shaved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>155</td>
<td>153</td>
<td>246</td>
</tr>
<tr>
<td>Infection rate</td>
<td>0.6%</td>
<td>0.6%</td>
<td>5.6%</td>
</tr>
</tbody>
</table>

Impact of Oxygen on SSI

500 patients, randomized, double-blind protocol colorectal resection
Subjects received 30% or 80% inspired $O_2$ during operation and for 2 hours post-op.
Wounds evaluated daily
Infection = “Culture-positive” pus

<table>
<thead>
<tr>
<th></th>
<th>30% $O_2$</th>
<th>80% $O_2$</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Subjects</td>
<td>250</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>$O_2$ Saturation</td>
<td>98%</td>
<td>99%</td>
<td>N.S.</td>
</tr>
<tr>
<td>Wound Infection</td>
<td>28 (11.2%)</td>
<td>13 (5.2%)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Hypothermia Mechanisms

- Impaired wound perfusion (thermoregulatory vasospasm)
- Decreased oxygen levels in wound
  - Impaired collagen synthesis
- Impaired immune function
- Decreased delivery of PMNs
Perioperative Normothermia

SSI: 6% normothermia vs. 19% hypothermia

### Impact of Temperature on SSI

Prospective-cohort design, 290 surgical patients
No active study-specific warming interventions.
90% follow-up

<table>
<thead>
<tr>
<th></th>
<th>Hypothermia</th>
<th>Normothermia</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number Patients</td>
<td>156</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>Wound Infection</td>
<td>18 (11.5%)</td>
<td>2 (2%)</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Relative risk of SSI 6.3x increased in hypothermia group

Glucose Control in Diabetics Undergoing Open Heart Surgery

Prospective study: 1987-97
2,467 diabetic pts, open heart surgery

- Control group (N=968) sliding-scale SQ insulin (SQI)
- Study group (N=1,499) continuous iv insulin infusion to maintain glucose ≤ 200 mg/dL.

Minimally Invasive Cardiac Surgery

Mitral Valve Replacement

Off-Pump CABG

Example Shown: Axiomat ® Guidant Corporation

Minimal access mitral valve replacement
D Richens, RS Jutley, M Baker and M Shajarf
Minimally Invasive Surgery Technique for Saphenous Vein Harvest

Example Shown: Vasoview 5® Guidant Corporation
Minimally Invasive Vein Harvest

568 patients, Non-randomized.
Risk factors for wound complication
  Open harvesting (p< or =0.001)
  Diabetes (p< or =0.001)
  Obesity (p< or =0.02)
Histologic evaluation no difference between the groups

<table>
<thead>
<tr>
<th></th>
<th>Open</th>
<th>Endoscopic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number Patients</td>
<td>388</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>Wound Complications</td>
<td>14.2%</td>
<td>5%</td>
<td>0.001</td>
</tr>
</tbody>
</table>

# External Bacterial Challenge of Experimental Incisions

<table>
<thead>
<tr>
<th>Time of Challenge</th>
<th>Incisions Infected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Closed with Staples</td>
</tr>
<tr>
<td>0 hour</td>
<td>90</td>
</tr>
<tr>
<td>0.5 hour</td>
<td>70</td>
</tr>
<tr>
<td>1 hour</td>
<td>30</td>
</tr>
<tr>
<td>4 hours</td>
<td>None</td>
</tr>
</tbody>
</table>

## Impact of Prophylactic Antibiotics on SSI Rates

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Prophylaxis (%)</th>
<th>Placebo (%)</th>
<th>NNT&lt;sup&gt;a&lt;/sup&gt;</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 replacement</td>
<td>0.5–1</td>
<td>2–9</td>
<td>12–100</td>
</tr>
<tr>
<td>Breast and hernia operations</td>
<td>3.5</td>
<td>5.2</td>
<td>58</td>
</tr>
</tbody>
</table>

*<sup>a</sup>*Approximate number needed-to-treat (NNT) to avoid one surgical site infection.

GI, gastrointestinal.
Relation Between Antibiotic Timing and Surgical Wound Rate

Quality Indicators

National Surgical Infection Prevention Project

Quality Indicators

#1) Receive antibiotics within 1 hour* before surgical incision.

#2) Receive prophylactic antibiotics consistent with current recommendations.

#3) Prophylactic antibiotics discontinued within 24 hours of surgery end.

* Because of the longer required infusion times, vancomycin or fluoroquinolones, when indicated for beta-lactam allergy, may be started within 2 hours before the incision.
Antibiotic Timing Related to Incision

Medicare National Baseline

Discontinuation of Antibiotics

Patients were excluded from the denominator of this performance measure if there was any documentation of an infection during surgery or in the first 48 hours after surgery.

Based on medical record abstraction from the charts of patients discharged in the 2nd quarter of 2004. Benchmark rates were calculated for all hospitals in the US based on discharges during April 2003-March 2004 using the Achievable Benchmarks of Care™ methodology (http://main.uab.edu/show.asp?durki=14527).
Prevention of Surgical Site Infection (SSI)

Importance of Systems
Factors the Surgeon “Controls”

**What** operation is done.
- conduct of operation.

**When** the surgery takes place.
- elective vs. emergent.
- adequacy of resuscitation.
- monitoring employed.

**Antibiotic administration.**
- choice of agent.
- timing of administration.
- intra-operative re-dosing.

**Blood transfusion.**
Inferior performance

Superior performance

NSQIP Annual Report
Mortality O/E Ratios for All Operations
Surgical Care Improvement Project (SCIP)

Preventable Complication Modules

- Surgical infection prevention
- Cardiovascular complication prevention
- Venous thromboembolism prevention
- Respiratory complication prevention
Surgical Care Improvement Project: Why?

Medicare could prevent* up to:
13,027 perioperative deaths
271,055 surgical complications

There are substantial opportunities to improve outcomes from surgery!

* Major surgical cases
UCSF SSI Rate After Major Colorectal Surgery

Surgical Site Infection Rate Following Selected Abdominal Surgery Performed by Center for Colorectal Surgery Surgeons

Percentage monthly rate

4/06 - 3/07: Implement IHI Bundle
4/07 - 3/08: Monitor IHI Compliance
4/08 - present: Tighten up Processes

- April 2006 to March 2007: Implement IHI Bundle
- April 2007 to March 2008: Monitor IHI Compliance
- April 2008 to present: Tighten up Processes

Graph shows the percentage of surgical site infections over time, with a decrease from an initial rate of 37.5% in April 2006 to 3.3% in November 2008, indicating improvement in infection rates through implemented strategies.
Preventing Surgical Site Infections: Evidence-Based Interventions

- Choose Appropriate Antibiotic
- Timely Administration of Antibiotics (30-60 min prior to incision)
- Clip rather than shave operative site.
- Maintain intraoperative $O_2$ saturation.
- Maintain patient body temperature.
- "Tight" glucose management.
- Infection surveillance.
The End