Prevention of Surgical Site Infections

Prof. Matthias Maiwald,
A Webber Training Teleclass

Objectives

• To provide a brief overview of the impact of surgical site infections (SSIs)
• To highlight the causation of surgical site infections as complex and multifactorial
• To provide an overview of different classes of surgery and different categories of infection
• To highlight important measures for preventing surgical site infections, in particular:
  • Surgical hand and skin antisepsis
  • Surgical antibiotic prophylaxis
• To point out bundles, checklists and SSI initiatives
• To discuss a few areas of controversy and misconceptions:
  • The “Chlorhexidine Myth”
  • Fire risk from flammable skin antiseptics

Frequency and impact of SSIs in the USA

• About 30 million operations annually
• SSIs are the 2nd to 3rd most common nosocomial infection
• Overall SSI rate 2.6% (CDC, 1999)
• Each SSI increases hospital stay by ~7-10 days & costs USD 2-3000 extra
• Overall costs of SSIs > USD 2 bn p.a.

Joseph Lord Lister (1827-1912)

• British surgeon
• Pioneer of antisepsis in surgery
• Observations re. surgical infections
• Approx. 50% of pts. died
• Use of carbolic acid spray

SSIs ranked second in a study of serious adverse events in hospitals in New York State


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Surgery in the 20th Century
- Listerian principles further developed into ‘aseptic surgery’ by German, then US surgeons
- Many achievements: sterile field, surgical attire, face masks, etc.
- Prominent surgeon in US: William Altemeier (Cincinnati)

Causes and risk factors of SSIs
- SSIs are complex multifactorial events!
- Many contributing & preventing factors
- Difficult or impossible to pinpoint cause of a given individual SSI
- In ‘clean’ surgery, patient skin is major source
- In surgery - through mucous membranes - intestinal surgery - contaminated/infected surgery . . . other sources assume a greater role

Risk factors for SSI

Host Factors
- Old age
- Severe underlying illness
- Obesity
- Malnutrition
- Diabetes mellitus
- Smoking
- Immunocompromising diseases or therapies
- Presence of other infections
- Skin diseases

Preoperative Factors
- Remote Infection
- Prolonged pre-op. stay
- Shaving the skin
- Inadequate antib. prophylaxis
- Staph. aureus & MRSA carriage

Surgical Factors
- Inadequate skin antiseptics
- Emergency procedure
- Surgical volume
- Prosthetic implants
- Prolonged procedure
- Use of drains
- Poor surgical technique
- Unexpected contamination
- Lack of surveillance

Environmental Factors
- Inadequate attire
- Excessive activity
- Inadequate ventilation
- Inadequately sterilised items

The ‘Puzzle Model’ of SSI Causation
- There can be contributing or preventing pieces
- They can be of vastly unequal sizes (strong/weak factors)
- The relative amount of contribution is often unknown
- Some factors are suspected, but unproven

ASA Score
(American Society of Anesthesiologists: Physical Status Classification) and the risk of SSIs

<table>
<thead>
<tr>
<th>Code</th>
<th>Patient’s Preoperative Physical Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normally healthy patient</td>
</tr>
<tr>
<td>2</td>
<td>Patient with mild systemic disease</td>
</tr>
<tr>
<td>3</td>
<td>Patient with severe systemic disease that is not incapacitating</td>
</tr>
<tr>
<td>4</td>
<td>Patient with an incapacitating systemic disease that is a constant threat to life</td>
</tr>
<tr>
<td>5</td>
<td>Moribund patient who is not expected to survive for 24 hours with or without operation</td>
</tr>
</tbody>
</table>

*Reference 406.
Note: The above is the version of the ASA Physical Status Classification System that was current at the time of development of, and still is used in, the NNIS Risk Index. Meanwhile, the American Society of Anesthesiologists has revised their classification system: the most recent version is available at http://www.asahq.org/portalinfo/physical-status.html.

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Types of SSIs

- Superficial Incisional SSI
- Deep Incisional SSI
- Organ/Space SSI

Mangram AJ et al. 1999 ('CDC Guideline')

Diagnosis of SSIs

- Purulent drainage from wound +/- dehiscence
- Organisms isolated from aseptically obtained fluid or tissue
- Pain, swelling, redness, heat +/- fever
- Diagnosis by surgeon or attending physician
- After follow-up for 30 days, if no implant
  - 1 year with implant

(Strongly abbreviated version)

Example of an SSI

Conlon CP, Snydman DR. Color Atlas and Text of Infect. Dis. 2002

Pathogens involved in SSIs

- Cardiac, orthopaedic, neurosurgical, vascular surgery: Staph. aureus & coag.-neg. staph common
- Gastrointestinal: Gram-negatives & anaerobes common
- Obstetric & gynaecologic: Gram-negatives, anaerobes, B-streptococci, enterococci common

Mangram et al. 1999 ('CDC Guideline')

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus aureus</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Coag. neg. staph</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Enterococcus spp.</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Streptococcaceae</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Enterobacter spp.</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Klebsiella spp.</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Streptococcus spp.</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Candida spp.</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Surgical site classification

<table>
<thead>
<tr>
<th>Class</th>
<th>Surgical Procedure</th>
<th>Approx. Infection Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Clean</td>
<td>Uninfected wound; gastrointestinal tract &amp; other body cavities not entered; wound primarily closed</td>
<td>1-2%</td>
</tr>
<tr>
<td>II Clean-contaminated</td>
<td>Respiratory, gastrointestinal, genital or urinary tract entered under controlled conditions w/out unusual contamination</td>
<td>5-10%</td>
</tr>
<tr>
<td>III Contaminated</td>
<td>Fresh, traumatic wounds; spillage from GI tract; acute, non-purulent inflammation</td>
<td>10-20%</td>
</tr>
<tr>
<td>IV Dirty-infected</td>
<td>Gross peritoneal soiling; perforated</td>
<td>&gt;20%</td>
</tr>
</tbody>
</table>
**Rates of SSIs in different wound classes**

<table>
<thead>
<tr>
<th>Wound classification</th>
<th>Cruse &amp; Foorold (n=63,000) 1970-75</th>
<th>SENIC (n=69,000) 1975-78</th>
<th>Olson &amp; Lee (n=36,500) 1980-85</th>
<th>Culver et al (n=65,000) 1987-90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td>1.5</td>
<td>2.9</td>
<td>1.3</td>
<td>2.1</td>
</tr>
<tr>
<td>Clean-contaminated</td>
<td>7.7</td>
<td>3.9</td>
<td>2.4</td>
<td>3.3</td>
</tr>
<tr>
<td>Contaminated</td>
<td>15.2</td>
<td>8.5</td>
<td>7.9</td>
<td>6.4</td>
</tr>
<tr>
<td>Dirty (established infection)</td>
<td>40.0</td>
<td>12.8</td>
<td>7.1</td>
<td>6.6</td>
</tr>
</tbody>
</table>

- Risk of infection increases from Class I to IV
- Greatest relative improvements in last 20-30 years in Classes III & IV (surg. antibiotic prophylaxis)

**Surgical hand antisepsis (‘Scrubbing’)**

- Goal is to reduce number of microorganisms transferred from the surgical team to the patient during surgery by:
  - Unrecognised puncture(s) in the surgical glove (ca. 35%)
  - Accidental touching of the wound after removal of gloves
  - Tiny holes in approx. 0.3-1% in new sealed gloves
- Infectious doses in implant surgery:
  - 100 bacteria (CFU) for Staph. aureus
  - 1000 bacteria (CFU) for coag.-neg. staphylococci
- Surgical hand antisepsis has never been tested in randomised controlled trials...
- But numerous empirical data & case reports (of infections when protocols were breached) & microbiological data strongly support its use


**Advantages of alcohol-based scrubbing**

- Significantly greater reduction of microorganisms (~10-100 x)
- Shorter scrubbing times (~3 min vs. ~5 min)
- Highly active formulations can do 1.5 min
- Gentler to skin (added emollients)

**Pre-surgical skin antisepsis (‘skin prep’)**

Activity of antiseptic agents

From Mangram AJ et al. 1999 (‘CDC guideline’)

- Alcohols are generally the most rapid-acting & most effective skin antiseptics
- Combination of alcohol plus chlorhexidine or iodine can add residual activity
- Alcohol is unsuitable for mucous membrane antisepsis (e.g. oral, ENT, eye, vaginal surgery)
Recent clinical trial


- Setting: clean-contaminated surgery in 6 hospitals
- One alcohol-containing vs. one aqueous prep: (1) 70% isopropanol plus 2% CHG; (2) Aqueous PVP-I
- Significantly lower infection rates with (1) than (2), including deep incisional but not org/sp SSIs

Another clinical study

Swenson BR et al. Infect Control Hosp Epidemiol. 30: 964-71; 2009

- Setting: general surgery
- Three alcohol-containing preps: (1) Aqueous PVP-I alternating w. 70% isopropanol (2) 70% isopropanol plus 2% CHG (3) Iodine povacrylex in isopropanol
- Significantly lower infection rates with (1) & (3) but no difference in deep incisional and org/sp SSIs

Important issues for skin antisepsis

1. Good antimicrobial activity of antiseptic
   - Alcohol compounds generally best for superficial skin
   - Aqueous compounds for mucous membranes
2. Repeated application with friction (e.g. 3 x)
3. Sufficient contact time to exert antimicrobial kill
   - Commonly recommended: about 5 minutes total
   - Rationale: time-kill characteristics of antiseptics
4. Be aware of fire risk when using alcohols
   - Let the antiseptic dry before surgery
   - Avoid pooling (e.g. under the patient) & wetting of drapes

Antimicrobial prophylaxis

- Empirical choice of antibiotic(s) for type of operation
- Many studies showed reduction of SSIs
- The antibiotic(s) should be given as a single (but full therapeutic) dose before the operation, so that drug levels are sufficient during the operation
- Timing: about 30-60 min before incision
- Extra doses only for extended operations or contamination (e.g. spillage of intestinal content)
- Post-operative doses should not be given
  - No benefit, but bacterial resistance development
Other Measures to Prevent SSIs

- Surveillance program with surgeon feedback
  - Incl. post-discharge surveillance
- Screening for Staph. aureus carriage & decolonization before critical elective surgery
  - Recent study: Bode LGM et al. NEJM 362; 9-17; 2010
- Preoperative antiseptic showering (e.g. day before)
  - Unresolved
- Preoperative hair removal
  - If possible, no hair removal, if necessary, clipping is best
- Operating room ventilation & personnel movement
  - Recent discussion whether laminar flow is necessary or not
- Operating room attire and face masks
  - Discussion of face masks in anesthetists
- Avoidance of intraop. hypothermia & hyperglycemia
- Supplemental oxygen (e.g. 80%) respiration
  - Still controversial
- Listing is incomplete; several other measures

WHO Safe Surgery Saves Lives Campaign

- Guideline & Checklist
- However, focused more on general surgical safety, less on SSIs prevention

Bundle and Checklist Approaches

- Bundle: set of 3-5 defined practices that should be performed collectively
- Checklist: set of specific measures to be checked against a list (e.g. WHO)

WHO Checklist was used

Both studies: focus on general surgical safety, infections only part

Checklist developed by a Dutch team de Vries et al. Qual Saf Health Care 2009;18:121-126

Caution: Bundles are no Guarantee

- Implementation of a bundle of measures for which moderately good evidence exists, but all are not widely adopted
- Result: increased SSI rate
- Commentary speculated on distraction (multitasking problem)
- Personal interpretation: not only good EBM evidence is required, but also good scientific judgement & experience

The ‘Chlorhexidine Myth’

Background: several clinical trials showed better outcomes with pre-surgical skin antisepsis with (a) alcohol plus chlorhexidine vs. (b) povidone-iodine alone


Two recent Systematic Reviews

Conclusion: “Chlorhexidine is better than Povidone-Iodine for surgical skin antisepsis”

Systematic Review and Cost Analysis Comparing Use of Chlorhexidine with Use of Iodine for Preoperative Skin Antisepsis to Prevent Surgical Site Infection Infect Control Hosp Epidemiol 2010;31(12):1219-1229

Two recent Systematic Reviews

Conclusion: "Chlorhexidine is better than Povidone-Iodine for surgical skin antisepsis"

Example: "Survey Shows One-Third of HCWs Don’t Follow Evidence-Based Guidelines for Skin Antisepsis (mention of alcohol only further down in text)"
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### What is wrong?

- Most (but not all) chlorhexidine preparations for skin antisepsis are mixtures of alcohol plus chlorhexidine
- Alcohols are about 10 times (~1 log) more rapid and effective than chlorhexidine (multiple tests since 1970s)
- Combination of alcohol plus CHG or PVP-I is indeed useful because of immediate plus sustained effect
- In the Systematic Reviews:
  - Majority of studies used (a) Alcohol plus CHG vs. (b) Povidone-Iodine alone (i.e. 2 active ingredients vs. 1)
  - Only few studies of CHG alone vs. PVP-I alone or alc. CHG vs. alc. PVP-I; they are inconclusive or methodologically flawed
- Conclusions are made solely for CHG, alcohol is ignored
- **Assessment:** Reviews and conclusions are seriously flawed by way of ignoring the alcohol component

### Addressing the ‘Chlorhexidine Myth’

**British Journal of Surgery**  
Letters (web & print) by:  
- N. Nesser, Y. Launey, Y. Maldant,  
Pontchaillou University Hospital, Rennes, France  
- M. Maiwald, M. Widmer, M. Roter, M.  
KK Women’s and Children’s Hospital, Singapore; University of Basel, Switzerland; University of Vienna, Austria  
- G. Kampf, A. Kramer,  
Bode Chemie, Hamburg, Germany; University of Greifswald, Germany  
- K. Turza Campbell, B. Swenson, R. Sawyer,  
University of Virginia, Charlottesville, USA

**Conclusions:**

- This myth can put patients at serious risk of infections
- It may take years to reverse it

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### Flammable Skin Antiseptics and Risk of Surgical Fires

- Concern about fire risk in operating rooms when using alcohol skin antisepsis (several publications)
- However, OR fires are rare
- In USA: ~ 100 fires p.a., 10 severe, 1-2 deaths (Bruley ME. Qual Saf Health Care 2004)
- Majority due to anaesthetic gases & flammable items around airways
- Minority due to skin preps; these almost always due to inadvertent misuse: pooling, wetting of drapes

### The ‘fire triangle’

Salmon L. AORN J. 80: 41-54; 2004

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### Some Facts and Calculations (US Data)

- In US, 30 million operations p.a.
- 2.5% SSIs (1/3 deep, severe)
- Result --> 249,000 deep organ/space SSIs
- If skin antisepsis reduces SSI rate 2.5% --> 2.4%  
  --> 240,000 deep SSIs
- --> 9,000 deep SSIs avoided
- Contrast: 10 severe surgical fires p.a.
- **Conclusions:**
  - Fire risk is real, but avoidable w. good practices
  - Benefit in SSI prevention outweighs risks

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### Campaigns & Tools for SSI Surveillance & Prevention

- US Centers for Disease Control, Collection of Guidelines  
- US Institute of Healthcare Improvement (IHI)  
  - http://www.ihi.org
- UK Surgical Site Infection Surveillance Service (SSISS)  
  - http://www.hpa.org.uk/infections/topics_az/surgical_site_infection/SSISS.htm
- UK NICE Surgical Site Infection Prevention Guidelines  
  - http://www.nice.org.uk/CG74
- German Krankenhaus-Infections-Surveillance-System (KISS)  
  - http://www.nrz-hygiene.de/
- Note: listing is not intended to be complete!
### COMING SOON …

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Speaker/Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 Apr. 11</td>
<td>Healthcare-Associated Infection Prevention Bundles – Preventing The Preventable</td>
<td>Speaker: Dr. William Jarvis, Jason &amp; Jarvis Associates</td>
</tr>
<tr>
<td>28 Apr. 11</td>
<td>The Spaulding Classification for Disinfection and Sterilization Is It Time to Reconsider?</td>
<td>Speaker: Dr. Gerry McDonnell, Steris Inc.</td>
</tr>
<tr>
<td>05 May 11</td>
<td>The Importance of Worldwide Hand Hygiene Events and Activities</td>
<td>Speaker: Prof. Didier Pittet, University of Geneva Hospitals</td>
</tr>
<tr>
<td></td>
<td>(Free WHO Teleclass)</td>
<td>Sponsored by: WHO Patient Safety Challenge (<a href="http://www.who.int/pacs/en">www.who.int/pacs/en</a>)</td>
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<tr>
<td>09 May 11</td>
<td>Voices of the Australian Infection Control Association</td>
<td>Speaker: AICA Board</td>
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<tr>
<td>12 May 11</td>
<td>The Faecal Quandary – Bedpan Management in a Modern Age</td>
<td>Speaker: Gertie van Knippenberg-Gordebeke, The Netherlands</td>
</tr>
<tr>
<td></td>
<td>Sponsor: MEIKO Maschinenbau GmbH &amp; CO.KG</td>
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