# Preventing Surgical Wound Infections: A funny thing happens on the way to the OR


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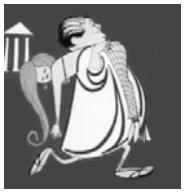


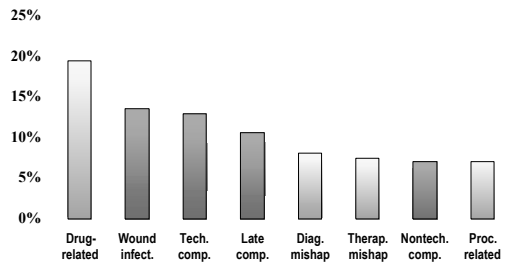
## Practical Meaning of Quality

"80%" Good"
- 36 million checks drawn on wrong account every day
- 9 million credit card transaction errors daily
- 1000 fold increase in aviation deaths

"99% Good"
- Unsafe drinking water 15 minutes each day
- No electricity for almost 7 hours each month

"99.9% Good"
- 16,000 lost articles of mail per hour
- 2 unsafe landings per day at most major airports

## Medical Mishaps




Source: Brennan et al. N Engl J Med. 1991;324:370-376

## Burden of Nosocomial Infections

| *Infection Type* | *Rate per 100 adm** | *No. Infections per Year* | *Extra Days per Case* [+] | *Extra Bed Days/Yr* | *Cost per Infection* [‡] | *Cost per Year* [§] *$000,000* |
|---|---|---|---|---|---|---|
| **Surgical Wound** | 1.39 | 53,421 | 8.2 | 438,052 | $4,100 | $219 |
| **Pneumonia** | 0.60 | 23,060 | 20.0 | 461,200 | $10,000 | $230 |
| **Bacteremia** | 0.27 | 10,377 | 24.0 | 249,048 | $12,000 | $125 |
| **Urinary** | 2.39 | 91,853 | 2.4 | 220,447 | $1,200 | $110 |
| **Other** | 1.07 | 41,123 | 4.8 | 197,390 | $2,400 | $97 |
| **Total** | | **219,834** | | **1,566,137** | | **$781** |

## History of SSI Prevention and Control

- Before the mid-19th century

  Surgery = purulent drainage, sepsis and often death

  - **1843 Oliver Wendell Holmes - "dirty hands" paper**
  - **1861 Ignaz Semmelweis - handwashing with chloride lime solutions**
  - **1863 Louis Pasteur - germ theory**
  - **1867 Joseph Lister - antiseptic principles**

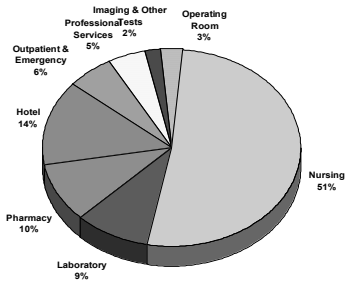
## Surgical Wound Infections Extra LOS

**Gross and Attributable Wound Infection Related Length of Stay**

| Time Period | Mean Days | Median Days |
|---|---|---|
| **Gross Infection LOS** | **13.6** | **7.0** |
| **Attributable Infection LOS** | **10.2** | **4.5** |

Zoutman et al Inf Contr Hosp Epi 1999

## Distribution of SSI Costs




Zoutman et al Inf Contr Hosp Epi 1999

## SSI Risk Factors

- Patient Risk Factors
  - Age
  - Nutritional status
  - Diabetes
  - Smoking
  - Steroids
  - Pre-op LOS
  - *Colonization with S. aureus
  - Peri-op transfusions
  - Remote infection

## SSI Risk Factors

- Operative Characteristics
  - Pre- op antiseptic showers
  - *Pre- op hair removal
  - Patient skin prep in the OR
  - Pre- op hand/arm antisepsis
  - Infected/colonized OR staff
  - *Antimicrobial prophylaxis

## SSI Risk Factors

- Operative Characteristics (Cont'd)
  - *OR Ventilation
  - Environmental cleaning in the OR
  - Microbial sampling of the OR
  - *Sterilization of equipment
    - Flash sterilization
  - Scrub suits, masks, caps, boots
  - Gowns and drapes

## SSI Risk Factors

- Operative Characteristics (Cont'd)
  - Asepsis in OR
  - Surgical technique
  - Drains
  - *Hypothermia <36°C
  - *Supplemental oxygen
  - Dressings
  - Discharge planning

## Surgical Techniques & SSI Risk

- **Maintaining effective hemostasis**
- **Preventing hypothermia**
- **Gently handling tissues**
- **Avoiding inadvertent entries into a hollow viscus**
- **Removing devitalized tissues**
- **Using drains and suture material appropriately**
- **Eradicating dead space**
- **Managing the postoperative incision**

## Perioperative Complications following CABG

| | |
|---|---|
| • Atrial fibrillation | 19.4% |
| • Ventilation >1 day | 5.5% |
| • Readmission within 30 days | 5.2% |
| • Surgical site infection | 2.6% |
| • Delirium | 2.6% |
| • Pneumonia | 2.5% |
| • Stroke | 2.4% |
| • UTI | 1.5% |

**Society of Thoracic Surgeons Database, 1999**

## NNIS Risk Index for SSI Surveillance

| Patient-specific Risk Score | Total 0-3 points |
|---|---|

- ◆Wound class class III or IV — 1 point
- ◆ASA score 3, 4, 5 — 1 point
- ◆Duration of surgery > cutpoint — 1 point

## SSI Rates* by Surgery Type and Risk Index Category

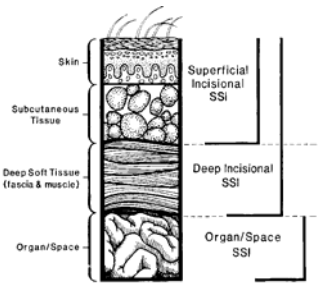
| | Duration Cutpoint | Risk 0 | 1 | 2 | 3 |
|---|---|---|---|---|---|
| Abd Hysterectomy | **2 hr** | **1.5** | **2.5** | **6.1** | ** |
| Knee Prosthesis | **2 hr** | **0.9** | **1.2** | **2.0** | ** |
| Small Bowel Surgery | **3 hr** | **5.6** | **7.5** | **9.8** | **14.8** |
| CABG (chest & leg) | **5 hr** | **0.7** | **3.5** | **5.8** | **17.5** |

*** Infections per 100 procedures**
**** Risk index categories 2 & 3 combined**
**Source: NNIS Semiannual Report, June 1999**

## Surgical Wound Surveillance

- Of Proven Efficacy
- Risk Stratification
  - NNIS= 1 point for each of:
    - ASA Score>2
    - Wound class contaminated/dirty
    - Procedure duration > 75th %ile
- Case finding methods
- Post-Discharge surveillance, day surgery
- Reporting Rates to surgeons

## Cross Section of Abdominal Wall Depicting CDC Classification of SSI




## Supplemental Perioperative $O_2$

- DESIGN: Randomized controlled trial, double blind
- POPULATION: Colorectal surgery (N=500)
- INTERVENTION: 30% vs 80% inspired oxygen during and up to 2 hours after surgery
- RESULTS: SSI incidence 5.2% (80% $O_2$) vs 11.2% (30% $O_2$), p=0.01

**Greif, R, et al , NEJM, 2000**

## Antimicrobial Prophylaxis: 4 Principles

- **Use AMP agent for operations where use reduced SSI rates or for operations where an SSI would be catastrophic**
- **Use AMP agent that is safe, inexpensive, and bactericidal for likely contaminants**
- **Time initial dose of AMP agent such that bactericidal concentration is in serum and tissues by time skin incised**
- **Maintain therapeutic levels during operation**

## Prophylaxis: Agents, Timing

- **1st and 2nd generation cephalosporins most commonly used AMP agents**
- **Administration of AMP agent ≤ 2 hours before incision reduced SSI risk (0.59% vs ≥ 3.3%)(Classen, 1992)**
- **General consensus: Administer AMP no more than 30 min before incision**
  - **Except CSEC, after cord clamping**
  - **Except vancomycin, about 1 hour before incision**

## Optimal Surgical Antimicrobial Prophylaxis

Includes 3 factors:

- Appropriate choice of antimicrobial agent
- Proper timing of administration of anti-microbial agent prior to surgical incision
- Limiting duration of antimicrobial administration following surgery

## Impact of Timing of Antimicrobial Prophylaxis (AP)

- DESIGN: Prospective study
- POPULATION: Clean and clean contaminated procedures (N=2847)

**Classen DC, et al. NEJM, 1992**

## Impact of Timing of AP on SSI Risk

| TIMING | SSI INCIDENCE | RR | p value |
|---|---|---|---|
| 2-24 hours preop | 3.8% | -- | |
| <2 hours preop | 0.6% | 0.15 | <0.001 |
| 3 hours postop | 1.4% | 0.37 | 0.11 |
| 3-24 hours postop | 3.3% | 0.86 | 0.8 |

## Impact of Prolonged Surgical AP

- DESIGN: Prospective
- POPULATION: CABG patients (N=2641)
  Group 1: pts who received ≤ 48 hrs of AP
  Group 2: pts who received > 48 hrs of AP
- OUTCOMES:
  Incidence of SSI
  Isolation of a resistant pathogen

**Harbarth S, et al. Circulation, 2000**

### Impact of Prolonged Surgical AP

- RESULTS: 57% patients received AP ≤48 hr
  43% patients received AP >48 hr

SSI Incidence
- ≤48 hr group: 8.7% (131/1502) versus
- >48 hr group: 8.8% (100/1139), p=1.0

Antimicrobial resistant pathogen
- OR 1.6 (95% CI 1.1-2.6)

- Pseudolus: Wait!
- Hero: Yes?
- Pseudolus: A brilliant idea!
  Hero: Yes!
- Pseudolus: That's what we need, a brilliant idea.
  - From: "A Funny Thing Happened On The Way To The Forum"
    - By Stephen Sondheim

**The Study Setting**

- Kingston General Hospital
- 466 tertiary care center
- Hospital based prospective cohort study
- Data collected between 1994 and 2000 (6 years)
- 7,388 patients entered into study
- 669 cases excluded
- 6,719 cases left to be analyzed

### Surgical Wound Surveillance Methods

- **Full Time Infection Control Practitioner**
- **Receives OR list each day**
- **Reviews chart and examines wound every 48-72 hours or more often if suspicious of infection**
- **CDC's definition of wound infection used**
- **Details of prophylaxis and selected risk factors recorded**
- **Review of patient care computer system for readmits with infection**
- **Monthly reports to each surgeon/ICC**

**Inclusion/Exclusion Criteria**

**Included**
- CABG
- Cardiac Valves
- Lung Resection
- AAA
- Lower Limb Vascular
- Colonic Resection
- Abdo-Hysterectomy
- Hip/Knee Replacement

**Excluded**
- Emergency procedures
- Wound class of 3 or 4
- Patients <18 years
- Patient with 2 or more procedures requiring >1 incisions during the same operation
- Patient on antibiotics 24 hour pre-op for infections or endocarditis prophylaxis
- Incomplete data in chart

**Outcome Variables**

- **Effective First Prophylactic Dose (EFPD):**
  - **Correct Drug (guidelines)**
  - **Correct Dose (guidelines)**
  - **Correct Route**
  - **Correct Timing (within 120 minutes pre-op)**
- **Surgical Wound Infection**
  - **CDC 1996 criteria**

### Hospital and Patient Variables

**Hospital**

- Where the FPD given (OR/floor)
- Same day surgery
- Time between FPD and incision
- Procedure Duration
- Net Duration of post-op SPA
- Calendar Year
- Class of Wound
- Order Written
- Effective First Prophylactic Dose

**Patient**

- Age
- Gender
- NNIS risk level
- Beta-lactam allergy
- Pre-op days
- Pre-op critical care days
- Procedure category
- IV drugs given the day before surgery

## Surgical Prophylactic Antibiotic Protocol

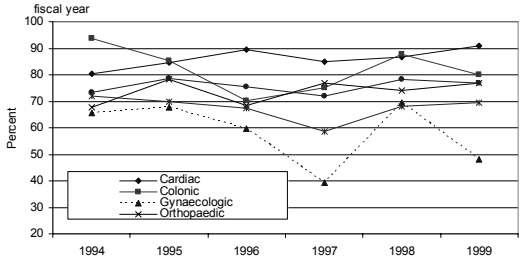
| Procedure | 1st Choice | Alternative |
|---|---|---|
| Coronary artery bypass grafting or valve replacement | cefazolin | vancomycin |
| Vascular surgery of abdominal aorta, groin vessels, or insertion of a prosthetic graft | cefazolin | vancomycin |
| Total joint replacement | cefazolin | vancomycin |
| Colorectal surgery | neomycin + erythromycin orally and/or metronidazole + gentamicin | neomycin + erythromycin orally and/or cefotetan |
| Thoracotomy for lung resection | cefazolin | vancomycin |
| Hysterectomy, abdominal | cefazolin | Doxycycline IV one dose or metronidazole + gentamicin |

## Analyses

- Univariate analysis:
  - Produce frequencies and rates
  - Assess distributions, normality, skewness
- Bivariate analysis:
  - Evaluation of associations (2 x 2 tables)
  - Unadjusted odds ratios
  - Stratified frequencies and rates
- Multivariate analysis:
  - Enter statistically significant variables into multiple logistic regression model
    - EFPD, SSI as outcomes

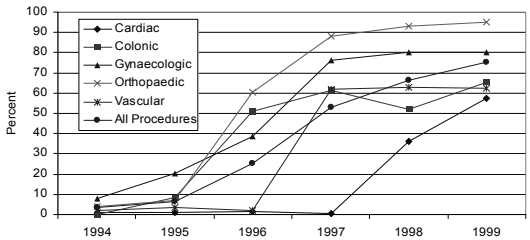
## Effective First Prophylactic Dose Success Rate over 6 Years

Fig. 6. Surgical procedure category Effective First Prophylactic Dose rates by fiscal year

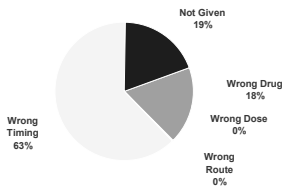



## Proportion of Same Day Surgical Cases over 6 Years

Fig. 5. Percentage of patients who had same day surgery for the 5 procedure categories over six fiscal years




### EFPD Component Errors




Note: 86 % of "Not Given" were from gynaecology

## Risk Factors for SSI

| Effective First Prophylactic Dose | *Procedure Duration* | *NNIS Risk Index* | *Time of first Prophylactic dose* | *Procedure Category* |
|---|---|---|---|---|
| 0.69 | *1.0 (< 100 minutes)*[R] | *1.0 (0)*[R] | *1.0 (0-2 hours)*[R] | *1.0 (Orthopaedics)*[R] |
| | 1.4 (100-139)* | 1.9 (1) | 1.3 (>2h early)* | 1.4 (Cardiothoracic)* |
| | 2.0 (140-199) | 1.4 (2)* | 1.4 (Post-Incision)* | 10.1 (Colonic) |
| | 3.6 (≥ 200) | | 2.8 (Not given) | 1.8 (Gynaecologic) |
| | | | | 2.9 (Vascular) |

R= Reference Group *=Not significant (p>.05)

## Summary of Factors Predicting for EFPD

| Procedure | Order Written | SPA Given in OR | ß lactam allergy | Same Day Admit |
|---|---|---|---|---|
| Cardiothoracic | – | + | – | – |
| Vascular | + | + | – | – |
| Colonic | + | + | – | – |
| Hysterectomy | + | – | – | – |
| Joint Replacement | + | + | – | + |

## Results: Adjusted predictors of an SSI

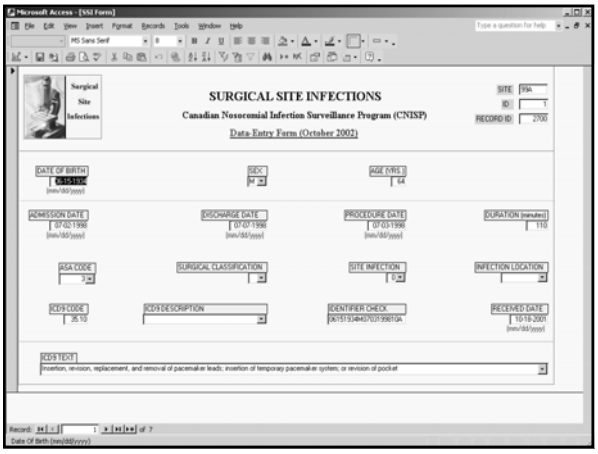
- EFPD: OR= 0.63 (p= 0.005)
- Procedure Duration over 200 minutes: OR= 3 (p< 0.001)
- NNIS Risk score of 1 OR= 2 (p< 0.004)
- Time of first dose relative to incision: For those that were given none, OR=2.9 (p=0.002)
- Procedure category (when compared to orthopaedics):
  - Colonic OR=11.1 (p< 0.001)
  - Vascular OR= 3.6 (p< 0.001)
  - Gynaecologic OR= 2.6 (p = 0.005)

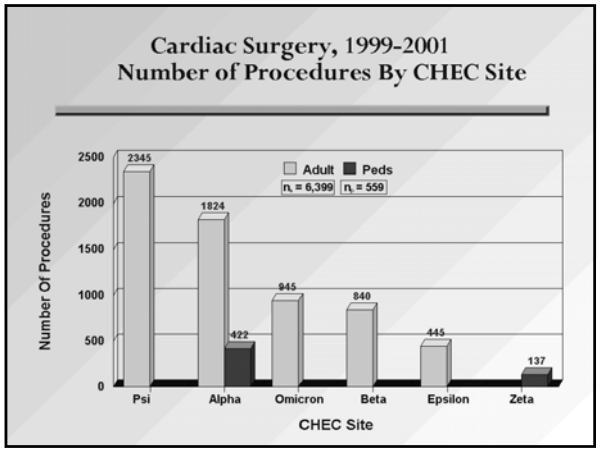
## Interventions

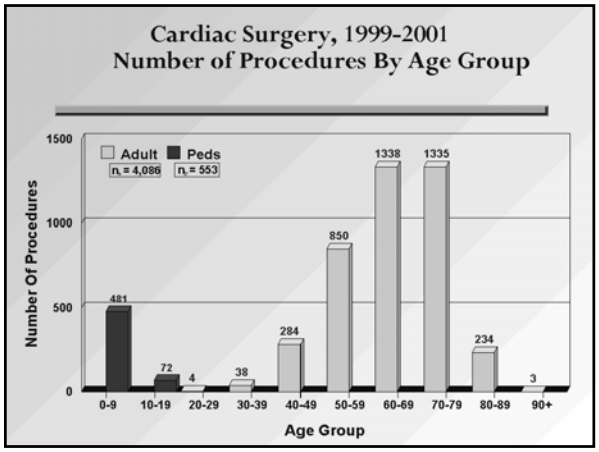
- Improving Awareness
  - Feedback EFPD rates to surgeons, OR Staff
- Analysis of workflow
  - Preop assessment of "allergies"
  - Start IV's in one location preoperatively
  - OR stock of approved antibiotics
- Responsibility to write the order for SPA
  - Anesthesiology vs surgery

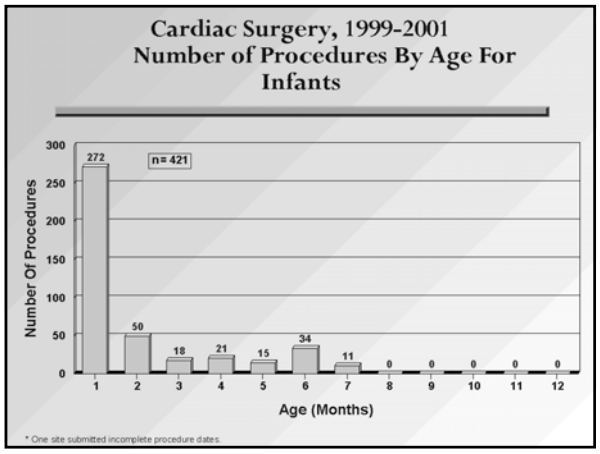
## Application

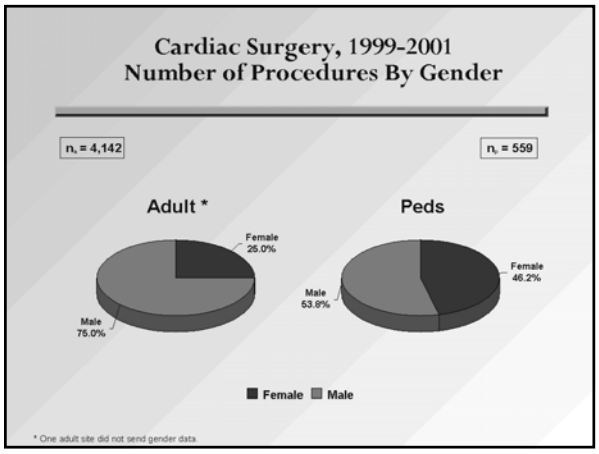
- Results only applicable to KGH
- Determined patient and process variables detrimental and beneficial to administering an EFPD
- Using focal points can devise intervention
  - Educational materials
  - Feedback of practice info to physicians
  - Physical structure of administering environment

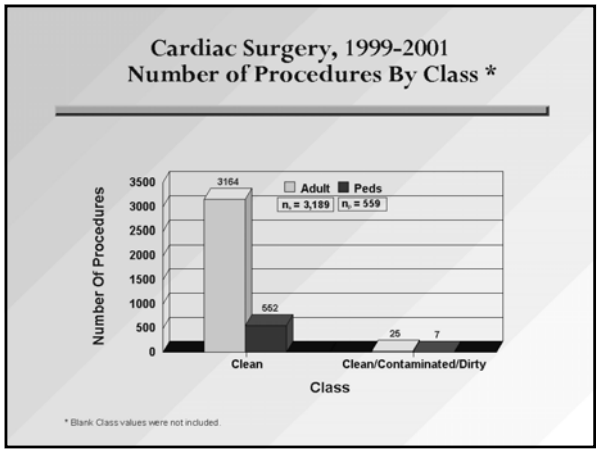


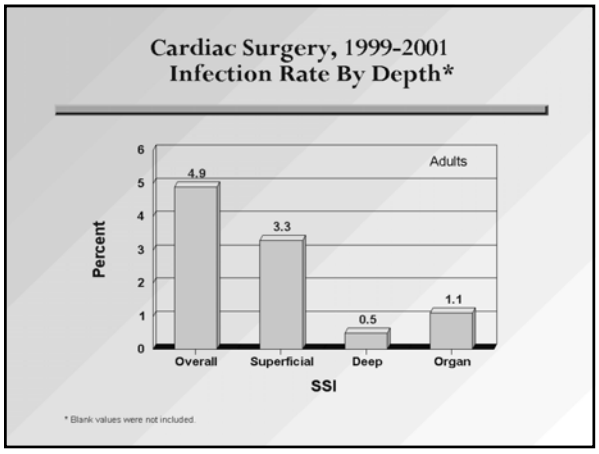

Cardiac Surgery, 1999-2001
Number of Procedures By CHEC Site
Adult
Peds
n, = 6,399
n, = 559
Number Of Procedures
2500
2000
1500
1000
500
0
2345
1824
422
945
840
445
137
Psi
Alpha
Omicron
Beta
Epsilon
Zeta
CHEC Site

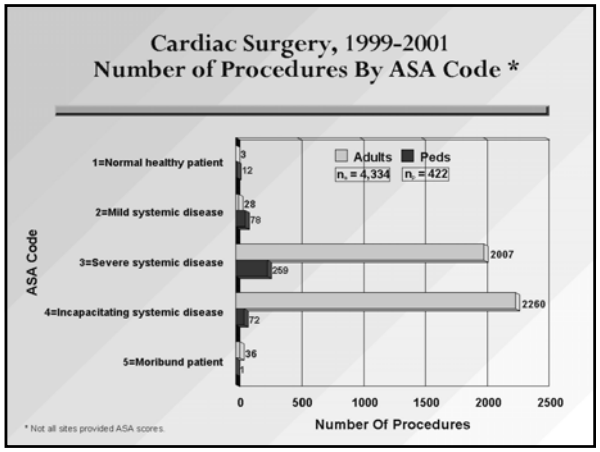

Cardiac Surgery, 1999-2001
Number of Procedures By Age Group
Adult
Peds
n, = 4,086
n, = 553
Number Of Procedures
1500
1000
500
0
481
72
4
38
284
850
1338
1335
234
3
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90+
Age Group

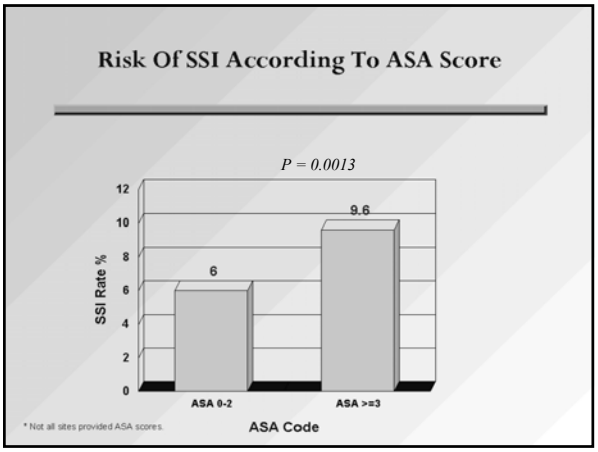

Cardiac Surgery, 1999-2001
Number of Procedures By Age For Infants
n= 421
Number Of Procedures
300
250
200
150
100
50
0
272
50
18
21
15
34
11
0
0
0
0
0
1
2
3
4
5
6
7
8
9
10
11
12
Age (Months)
* One site submitted incomplete procedure dates.

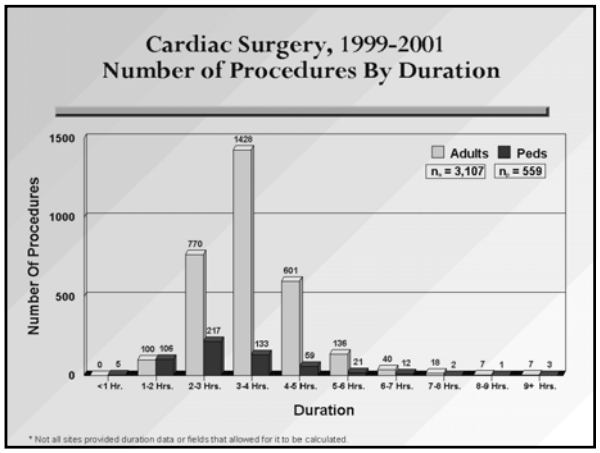

Cardiac Surgery, 1999-2001
Number of Procedures By Gender
n, = 4,142
n, = 559
Adult *
Peds
Female
25.0%
Male
75.0%
Female
46.2%
Male
53.8%
Female
Male
* One adult site did not send gender data.

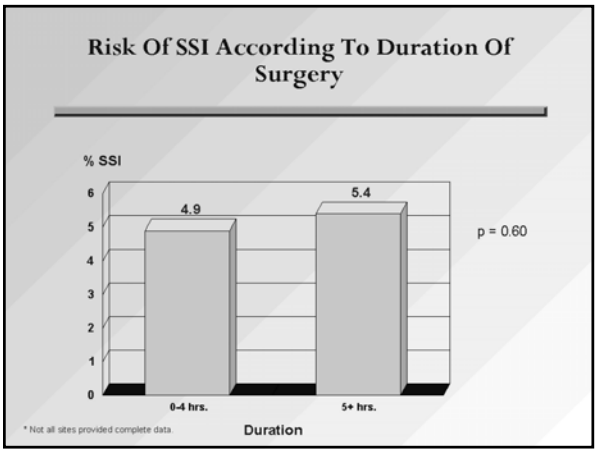

Cardiac Surgery, 1999-2001
Number of Procedures By Class *
Adult
Peds
n, = 3,189
n, = 559
Number Of Procedures
3500
3000
2500
2000
1500
1000
500
0
3164
552
25
7
Clean
Clean/Contaminated/Dirty
Class
* Blank Class values were not included.

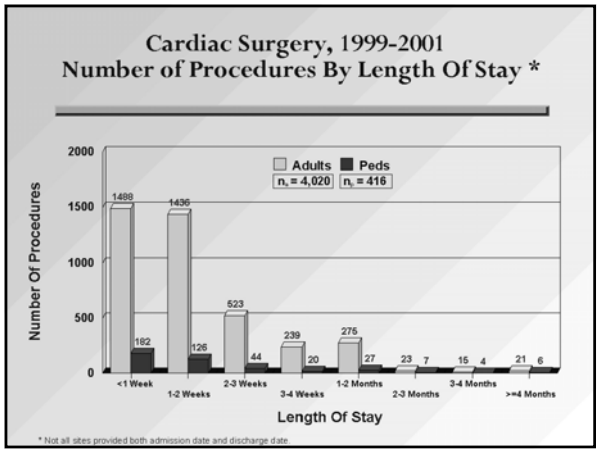

Cardiac Surgery, 1999-2001
Infection Rate By Depth*
Adults
Percent
6
5
4
3
2
1
0
4.9
3.3
0.5
1.1
Overall
Superficial
Deep
Organ
SSI
* Blank values were not included.

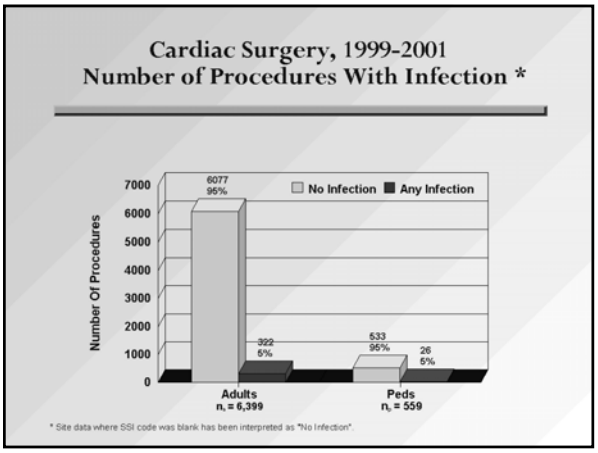

Cardiac Surgery, 1999-2001
Number of Procedures By ASA Code *
Adults
Peds
n = 4,334
n = 422
1=Normal healthy patient
2=Mild systemic disease
3=Severe systemic disease
4=Incapacitating systemic disease
5=Moribund patient
ASA Code
3
12
28
78
2007
259
2260
72
36
1
0
500
1000
1500
2000
2500
Number Of Procedures
* Not all sites provided ASA scores.

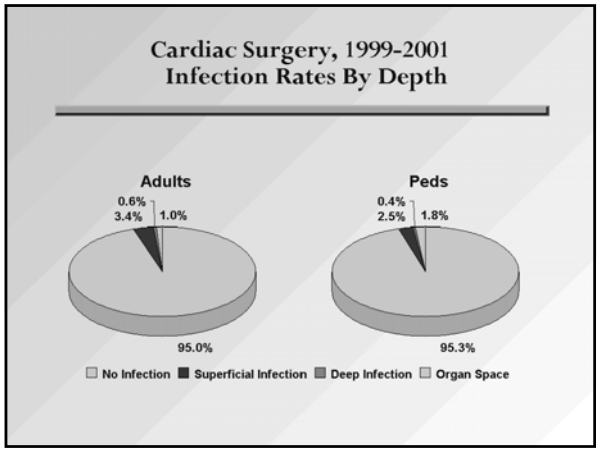

Risk Of SSI According To ASA Score
P = 0.0013
SSI Rate %
12
10
8
6
4
2
0
6
9.6
ASA 0-2
ASA >=3
ASA Code
* Not all sites provided ASA scores.


Cardiac Surgery, 1999-2001
Number of Procedures By Duration
Adults
Peds
n = 3,107
n = 559
Number Of Procedures
1500
1000
500
0
0
5
100
106
770
217
1428
133
601
59
136
21
40
12
18
2
7
1
7
3
<1 Hr.
1-2 Hrs.
2-3 Hrs.
3-4 Hrs.
4-5 Hrs.
5-6 Hrs.
6-7 Hrs.
7-8 Hrs.
8-9 Hrs.
9+ Hrs.
Duration
* Not all sites provided duration data or fields that allowed for it to be calculated.


Risk Of SSI According To Duration Of Surgery
% SSI
6
5
4
3
2
1
0
4.9
5.4
p = 0.60
0-4 hrs.
5+ hrs.
Duration
* Not all sites provided complete data.


Cardiac Surgery, 1999-2001
Number of Procedures By Length Of Stay *
Adults
Peds
n = 4,020
n = 416
Number Of Procedures
2000
1500
1000
500
0
1488
182
1436
126
523
44
239
20
275
27
23
7
15
4
21
6
<1 Week
1-2 Weeks
2-3 Weeks
3-4 Weeks
1-2 Months
2-3 Months
3-4 Months
>=4 Months
Length Of Stay
* Not all sites provided both admission date and discharge date.


Cardiac Surgery, 1999-2001
Number of Procedures With Infection *
No Infection
Any Infection
Number Of Procedures
7000
6000
5000
4000
3000
2000
1000
0
6077
95%
322
5%
533
95%
26
5%
Adults
n = 6,399
Peds
n = 559
* Site data where SSI code was blank has been interpreted as "No Infection".





## Other Winter 2005 Teleclasses

**For more information, refer to www.webbertraining.com/schedule.cfm**

- *February 15* – **Endemic Influenza, Pandemic Influenza, and Avian Flu** with Dr. Stephano Lazzari
- *February 17* – **Sad Cows and Englishmen, Predicaments and Predictions for Spongiform Encephalopathies** with Dr. Corrie Brown
- *February 24* – **Sneezes, Coughs and Drips: Respiratory and GI Outbreaks in Long Term Care** with Dr. Chesley Richards
- *March 10* – **Biocide Use in a Healthcare Environment** with Dr. Jean-Yves Mailard
- *March 17* - **WHO's Global Patient Safety Challenge 2005/2006 Preventing Healthcare Associated Infection; A Worldwide Strategy** with Dr. Didier Pittet

*Questions? Contact Paul Webber paul@webbertraining.com*