CURRENT CONCEPTS IN THE PREVENTION OF SURGICAL SITE INFECTIONS

Walter L. Biffl, M.D.

Director, Surgical Quality

Denver Health Medical Center

Professor of Surgery

University of Colorado

SURGICAL INFECTIONS - OUTLINE

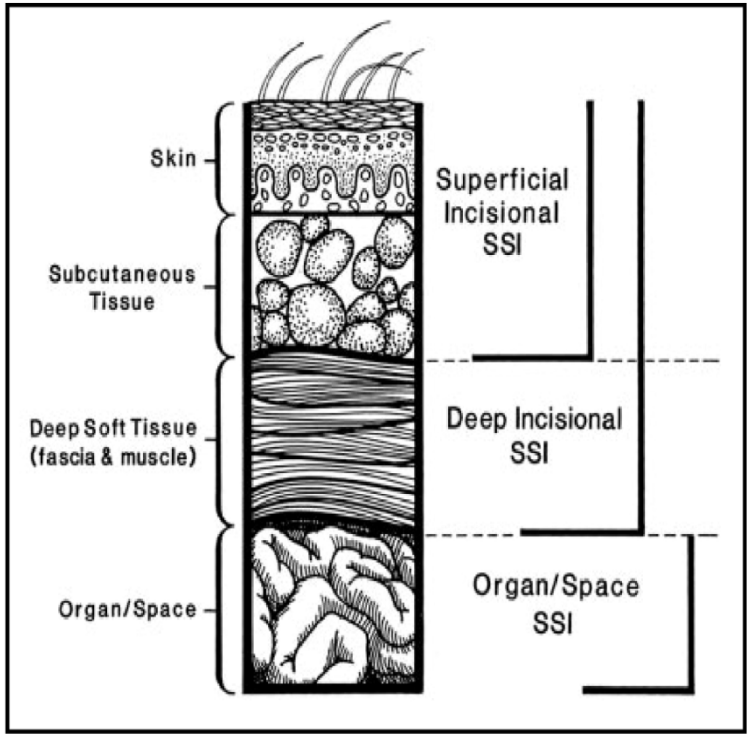
- Surgical Site Infection (SSI) Basics
- Why You Should Care
- SSI Prevention

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 in 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

Horan TC et al. Infect Control Hosp Epidemiol 1992; 13:606

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

National Nosocomial Infections Surveillance System (NNIS) System Report: Data summary from January 1992–June 2001. Am J Infect Control 2001; 29:404.

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

Cruse et al, Surg Clin North Am 1980; 60:27

WOUND INFECTION RATES

	1967-1977 62,939 pts	1993-1998 20,007 pts
Clean	1.5	2.6
Clean-Contaminated	7.7	3.6
Contaminated	15.2	10.5
Dirty / Infected	40.0	-

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

	0	1	2	3	All
Clean	1.0	2.3	5.4	-	2.1
Clean-Contaminated	2.1	4.9	9.5	-	3.3
Contaminated	-	3.4	6.6	13.2	6.4
Dirty / Infected	-	3.1	8.1	12.8	7.1
All	1.5	2.9	6.8	13.0	2.8

National Nosocomial Infections Surveillance (NNIS) System Report: Data summary from January 1992–June 2001. Am J Infect Control 2001; 29:404.

WOUND INFECTION RATES

	M	0	1	2	3
Cholecystectomy	.45	.68	1.8	3.3	5.7
Colon	-	4.0	5.7	8.5	11.3
Appendectomy	.67	1.3	2.6	4.9	
Gastric	.68	2.6	4.7	8.3	

"M" = 0 risk, laparoscopic

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

National Nosocomial Infections Surveillance (NNIS) System Report: Data summary from January 1992–June 2004. Am J Infect Control 2004; 32:470

Laparoscopic vs Open Approach Significantly Decreases SSI Risk in Colorectal Surgery

Kiran RP et al. J Am Coll Surg 2010; 211:232

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

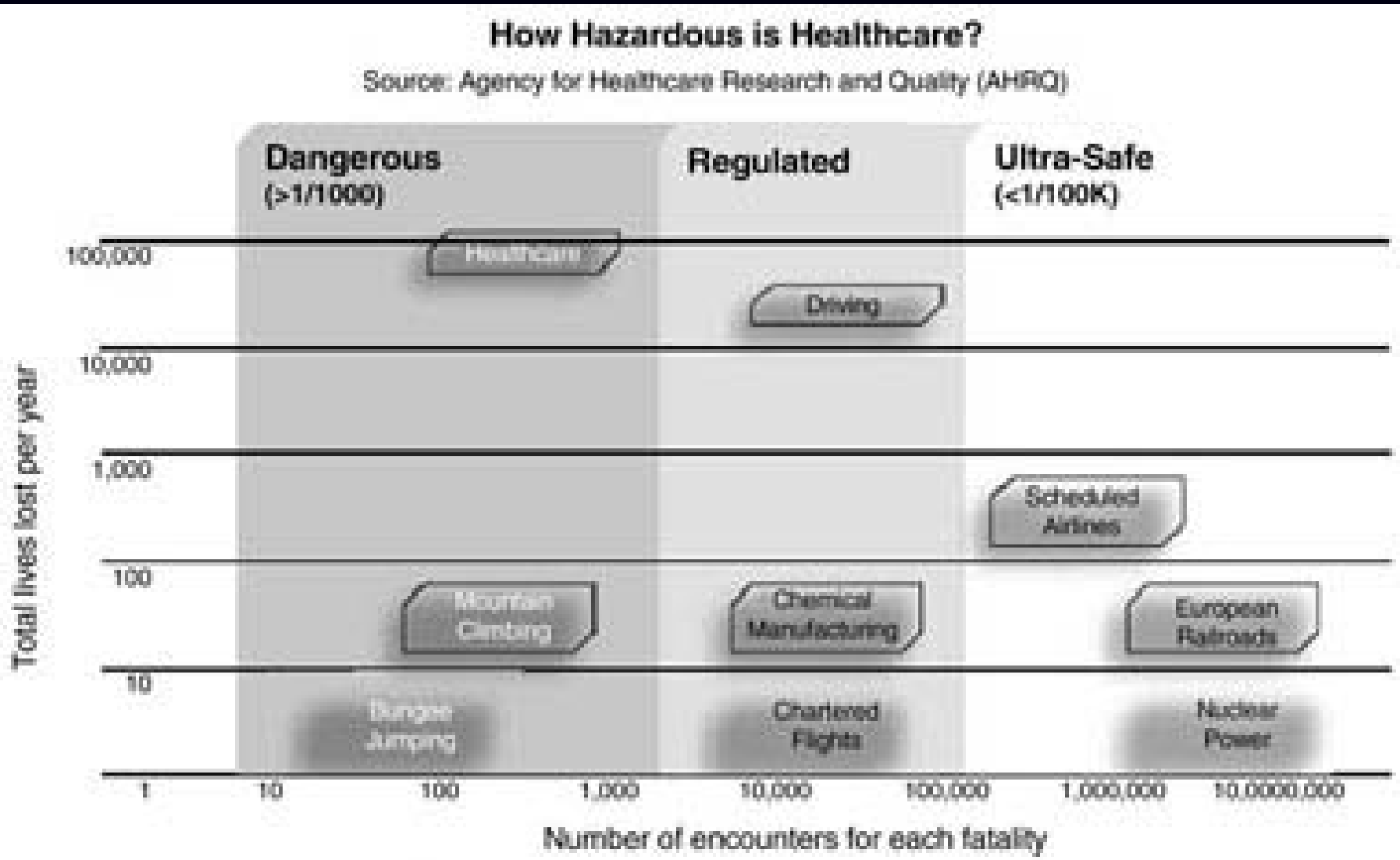


FIG. 1. Relative riskiness of various human activities considered dangerous.

Cakmakci M. Surg Infect 2010; 11:1

HEALTHCARE-ASSOCIATED INFECTIONS (HAIs)

- **Surgical Site Infections (SSIs)**
- **Central Line Associated Bloodstream Infections (CLABSIs)**
- **Catheter-Associated Urinary Tract Infections (CAUTIs)**
- **Ventilator-Associated Pneumonias (VAPs)**
- **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**

Kaye KS et al, J Am Geriatr Soc 2009; 57:46

CONSEQUENCES OF SSIs

7020 Colectomy Pts, 2002-2008

SSI 10.3%

Obese 14.5 vs 9.5%

	SSI	No SSI
Mean LOS	9.5	8.1
Costs	$31933	$14608
Readmission	28%	7%

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

Stone et al, Am J Infect Control 2005; 33:501

Roberts et al, Clin Infect Dis 2003; 36:1424

WHO PAYS FOR SURGICAL COMPLICATIONS?

Hospital Reimbursement ($)	Costs of Care ($)	Profit ($)	Profit Margin (%)
14,266 (uncomplicated)	10,978	3288	23.0
21,911 (complicated)	21,156	755	3.4

Dimick JB et al. J Am Coll Surg 2006; 202:933

MEDICAL "ERRORS"

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**

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*

Patient Safety Indicators	Excess LOS, d	*P* Value	Excess Charge, $	*P* Value	Excess Mortality, %	*P* Value
Accidental puncture or laceration	1.34 (0.08)	<.001	8271 (344)	<.001	2.16 (0.20)	<.001
Birth trauma, injury to neonate	−0.09 (0.08)	.27	298 (295)	.32	−0.08 (0.07)	.27
Complications of anesthesia	0.17 (0.90)	.26	1598 (660)	.02	0.24 (0.36)	.51
Decubitus ulcer	3.98 (0.10)	<.001	10 845 (368)	<.001	7.23 (0.23)	<.001
Foreign body left during procedure	2.08 (0.68)	.002	13 315 (3329)	<.001	2.14 (1.06)	.04
Iatrogenic pneumothorax	4.38 (0.24)	<.001	17 312 (1091)	<.001	6.99 (0.73)	<.001
Obstetric trauma, cesarean birth	0.43 (0.14)	.003	2718 (551)	<.001	−0.02 (0.02)	.32
Obstetric trauma, vaginal birth with instrumentation	0.07 (0.02)	<.001	220 (104)	.03	0.00	.32
Obstetric trauma, vaginal birth without instrumentation	0.05 (0.01)	<.001	−93 (66)	.16	0.00	>.99
Postoperative hemorrhage or hematoma	3.94 (0.27)	<.001	21 431 (1257)	<.001	3.01 (0.46)	<.001
Postoperative hip fracture	5.24 (0.69)	<.001	13 441 (1945)	<.001	4.52 (1.34)	<.001
Postoperative physiologic and metabolic derangement	8.89 (0.75)	<.001	54 818 (5099)	<.001	19.81 (2.27)	<.001
Postoperative pulmonary embolism or deep vein thrombosis	5.36 (0.15)	<.001	21 709 (747)	<.001	6.56 (0.33)	<.001
Postoperative respiratory failure	9.08 (0.57)	<.001	53 502 (3121)	<.001	21.84 (1.46)	<.001
Postoperative sepsis #4	10.89 (0.90)	<.001	57 727 (3077)	<.001	21.92 (1.47)	<.001
Postoperative wound dehiscence	9.42 (0.72)	<.001	40 323 (3467)	<.001	9.63 (1.55)	<.001
Selected infection due to medical care	9.58 (0.23)	<.001	38 656 (1026)	<.001	4.31 (0.35)	<.001
Transfusion reaction	3.44 (1.94)	.09	18 929 (10 068)	.07	−1.04 (1.04)	.33

*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

IMPACT OF “ERRORS”

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

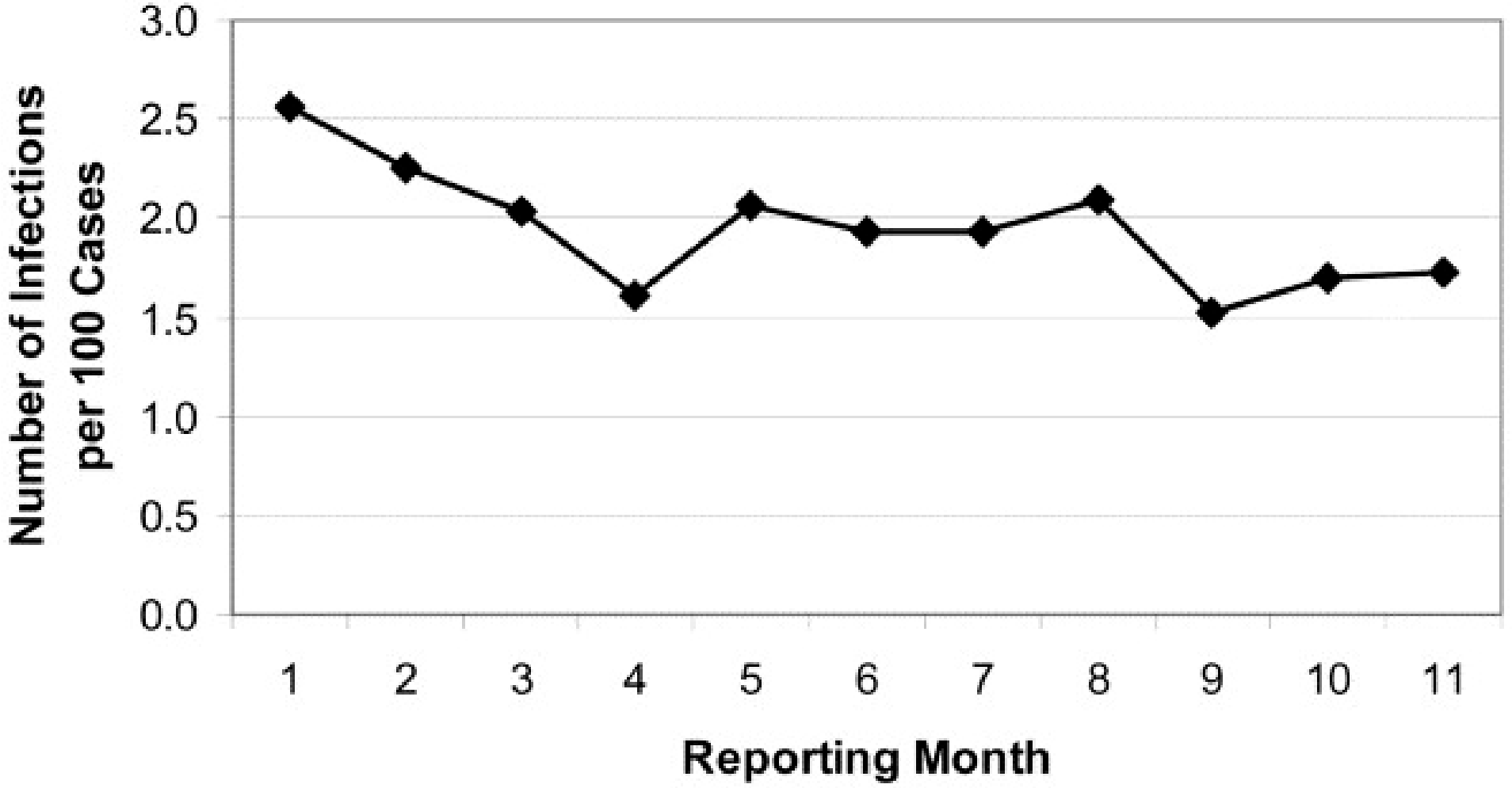
2002 SURGICAL INFECTION PREVENTION PROJECT (SIP)

- Prophylactic Antibiotic <1 hr Prior to Incision
- Appropriate Prophylactic Antibiotic
- Prophylactic Antibiotic Discontinued w/i 24 hr

Surgical Infection Prevention Collaborative

Process measure	Median performance, by quarter			
	1st	2nd	3rd	4th
Antibiotic timing within 1 h	72	82	89	92
Appropriate antibiotic selection	90	94	95	95
Discontinuation of antibiotic within 24 h	67	69	74	85
Normothermia	57	64	69	74
Avoid shaving surgical site	59	83	90	95
Oxygenation	75	81	84	94
Glucose control	46	49	53	54

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



Monthly (April 2002 - February 2003) surgical infection rates in the National Surgical Infection Prevention Collaborative.

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

- American College of Surgeons
- American Hospital Association
- American Society of Anesthesiologists
- Association of peri-Operative Registered Nurses
- Agency for Healthcare Research and Quality (AHRQ)
- Centers for Medicare & Medicaid Services
- Centers for Disease Control and Prevention
- Department of Veteran's Affairs
- Institute for Healthcare Improvement
- Joint Commission on Accreditation of Healthcare Organizations

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

Ultimate Goal: Reduce Surgical Complications 25% by 2010

SCIP INITIATIVES

Prevent:

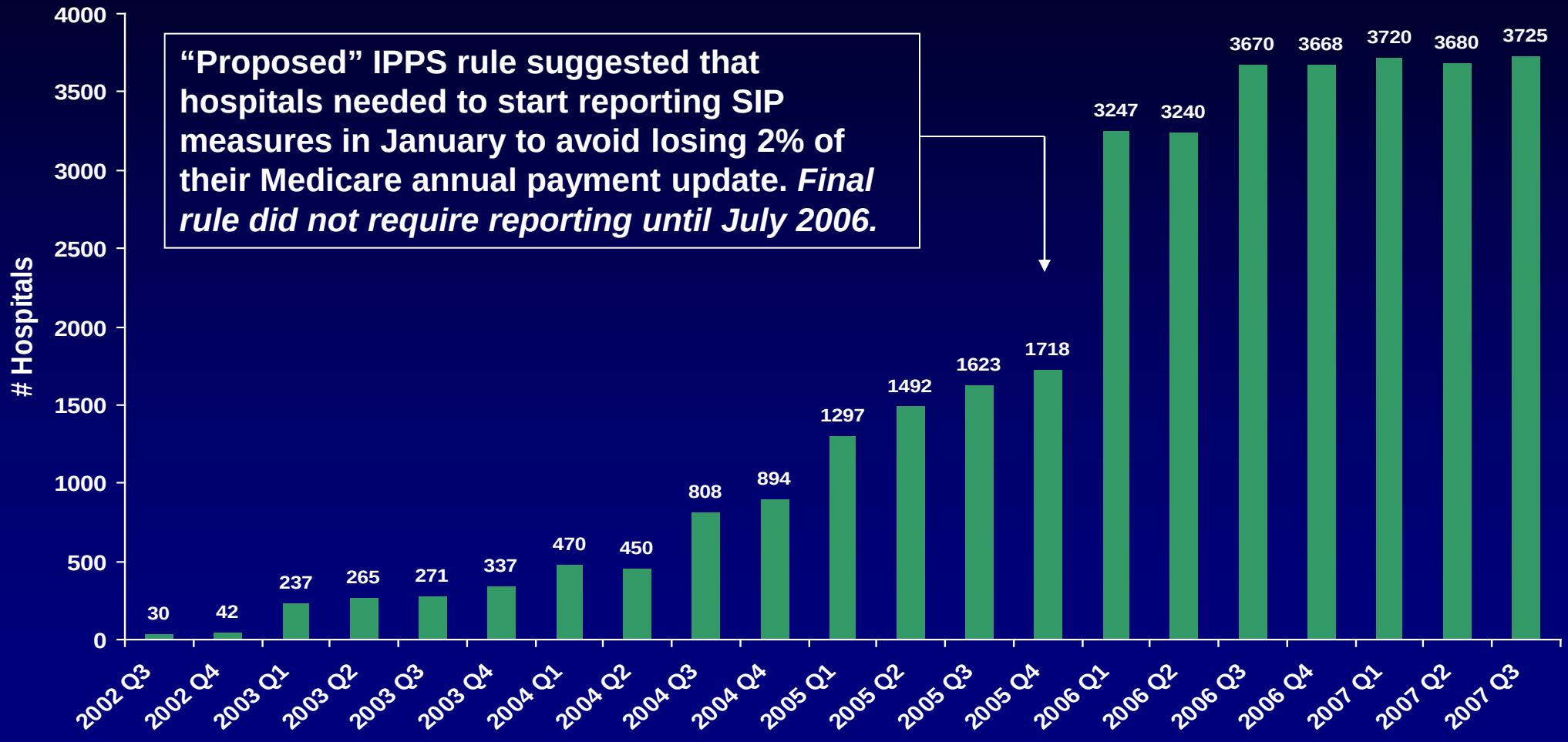
- **Surgical Site Infections**
- **Perioperative Myocardial Infarction**
- **Postoperative Pneumonia**
- **Venous Thromboembolism**

SCIP PROCESS AND OUTCOME MEASURES RELATED TO SSI - 2010

- Prophylactic Antibiotic <1 hr Prior to Incision
- 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

"VOLUNTARY" REPORTING

DEFICIT REDUCTION ACT OF 2005

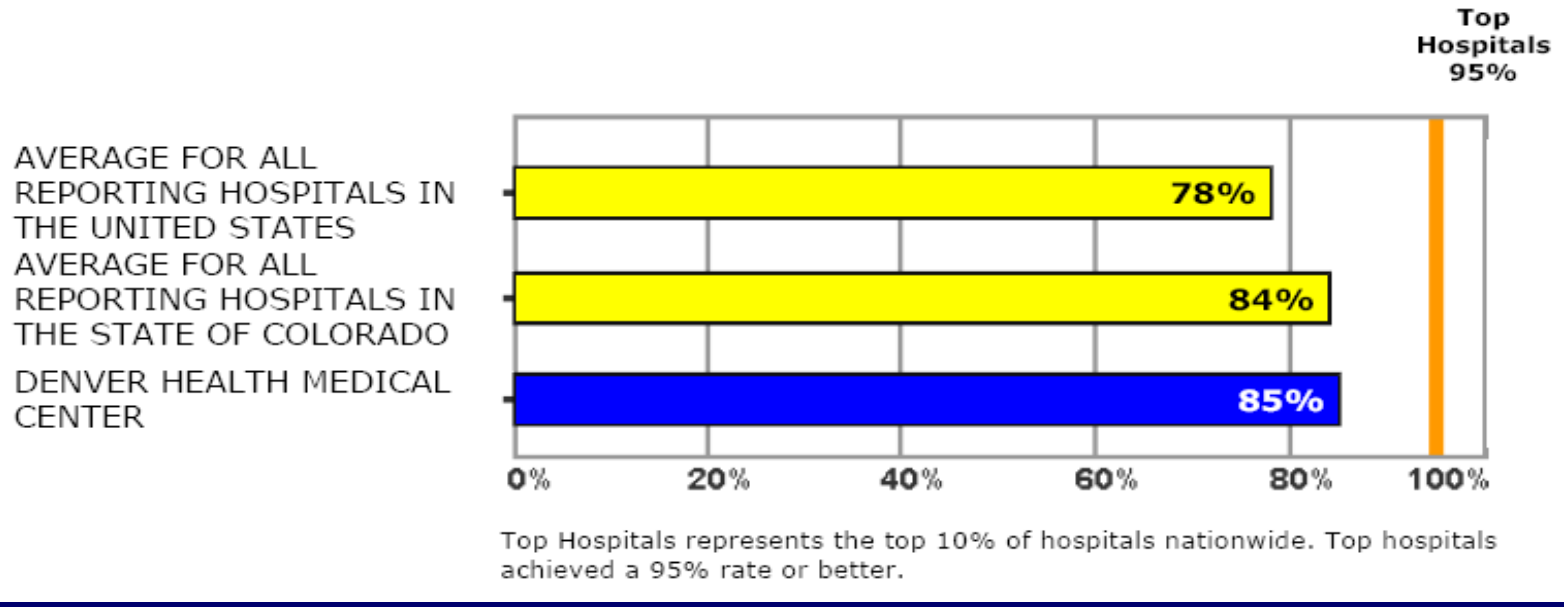


Hospital Interventions
Quality Improvement Organization
Support Center

HOSPITAL COMPARE

Percent of Surgery Patients Who Received Preventative Antibiotic(s) One Hour Before Incision

The rates displayed in this graph are from data reported for discharges January 2006 through December 2006.



Top Hospitals represents the top 10% of hospitals nationwide. Top hospitals achieved a 95% rate or better.

- **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

FINAL INPATIENT PAYMENT RULE

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**

FINAL INPATIENT PAYMENT RULE

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

Ingraham AM et al. J Am Coll Surg 2010; 211:705

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%

Anthony T et al. Arch Surg 2011; 146:263

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

Hawn MT et al. J Am Coll Surg 2011; 254:494

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?

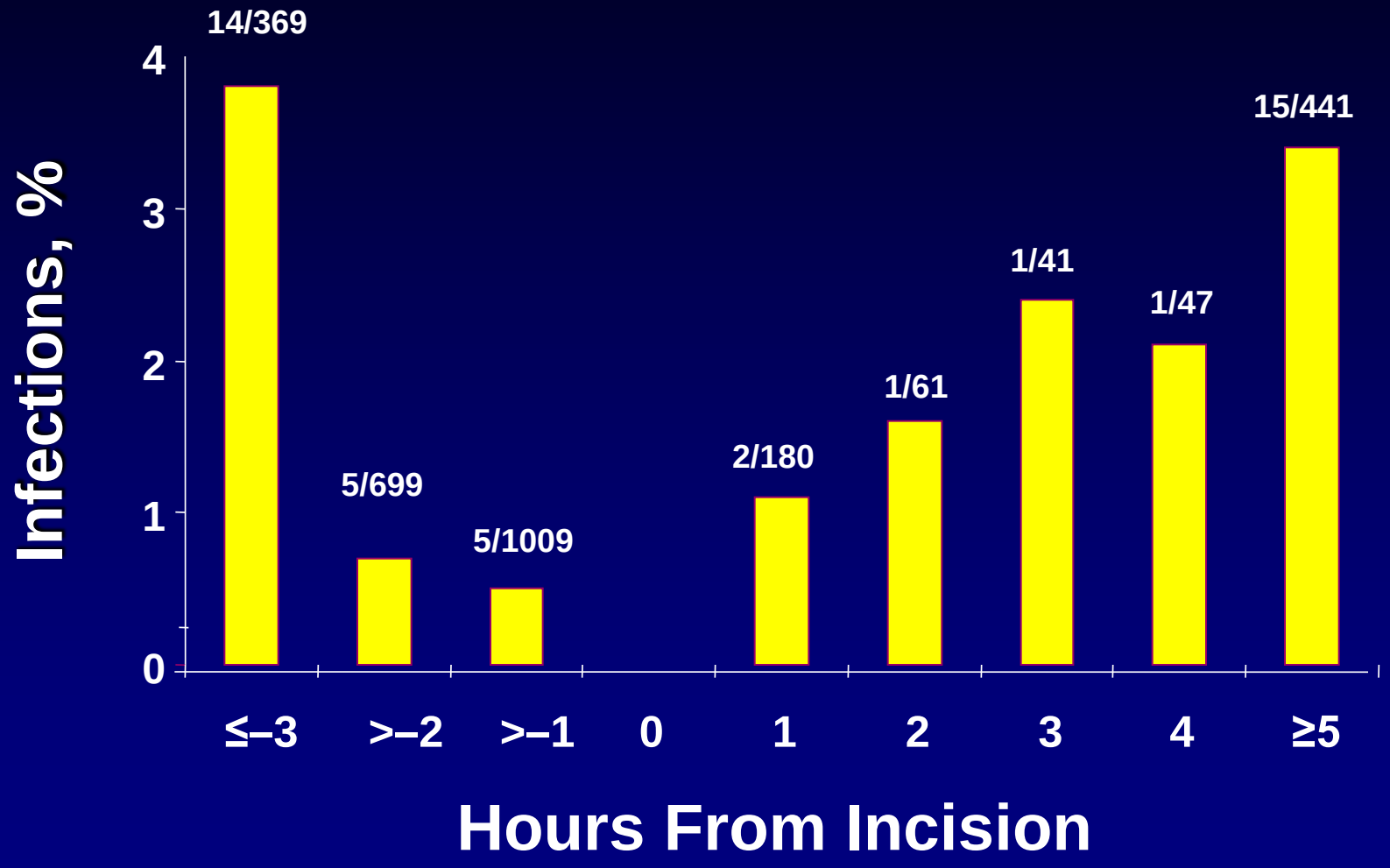
- **PFP Should not be Linked to Process Measures Until they Are Proven to Improve Outcomes**
- **Using These Measures to Compare Hospital Quality is Misleading**
- **Further Research is Warranted**

?

SCIP PROCESS AND OUTCOME MEASURES RELATED TO SSI - 2010

- **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 Prophylactic Antibiotics: Timing Of Administration



Classen DC et al. N Engl J Med 1992; 326:281

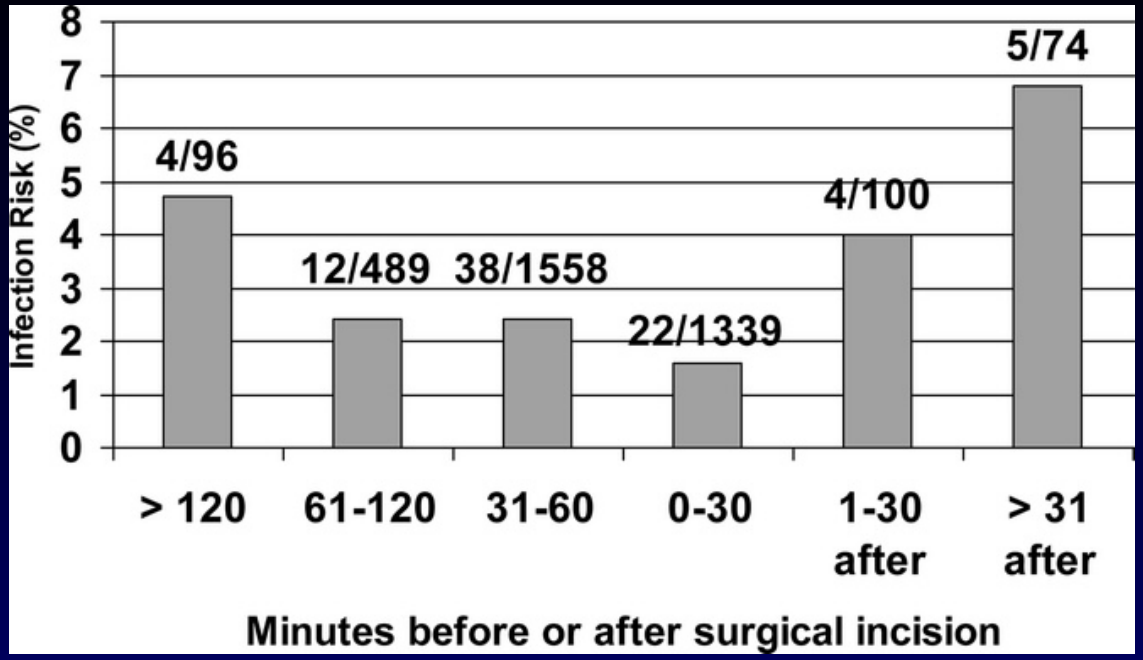


TABLE 3. Association Between Timing of Prophylaxis and Infection Risk

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

*Test for overall association between timing and infection risk, $P = 0.04$.
†Adjusted for duration of surgery and procedure type.
‡Non cephalosporin antibiotics compromised <5% of those designated to be given with short infusion times and are included.

Steinberg JP et al. Ann Surg 2009; 250:10

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

RELATIVE BENEFIT FROM ANTIBIOTIC PROPHYLAXIS

Operation	Prophylaxis (%)	Placebo (%)	NNT
Colon	4-12	24-48	3-5
Other (mixed) GI	4-6	15-29	4-9
Vascular	1-4	7-17	10-17
Cardiac	3-9	44-49	2-3
Hysterectomy	1-16	18-38	3-6
Craniotomy	0.5-3	4-12	9-29
Total joint repl	0.5-1	2-9	12-100
Breast & hernia	3.5	5.2	58

NNT = number needed to treat; repl = replacement

ANTIBIOTIC CHOICE

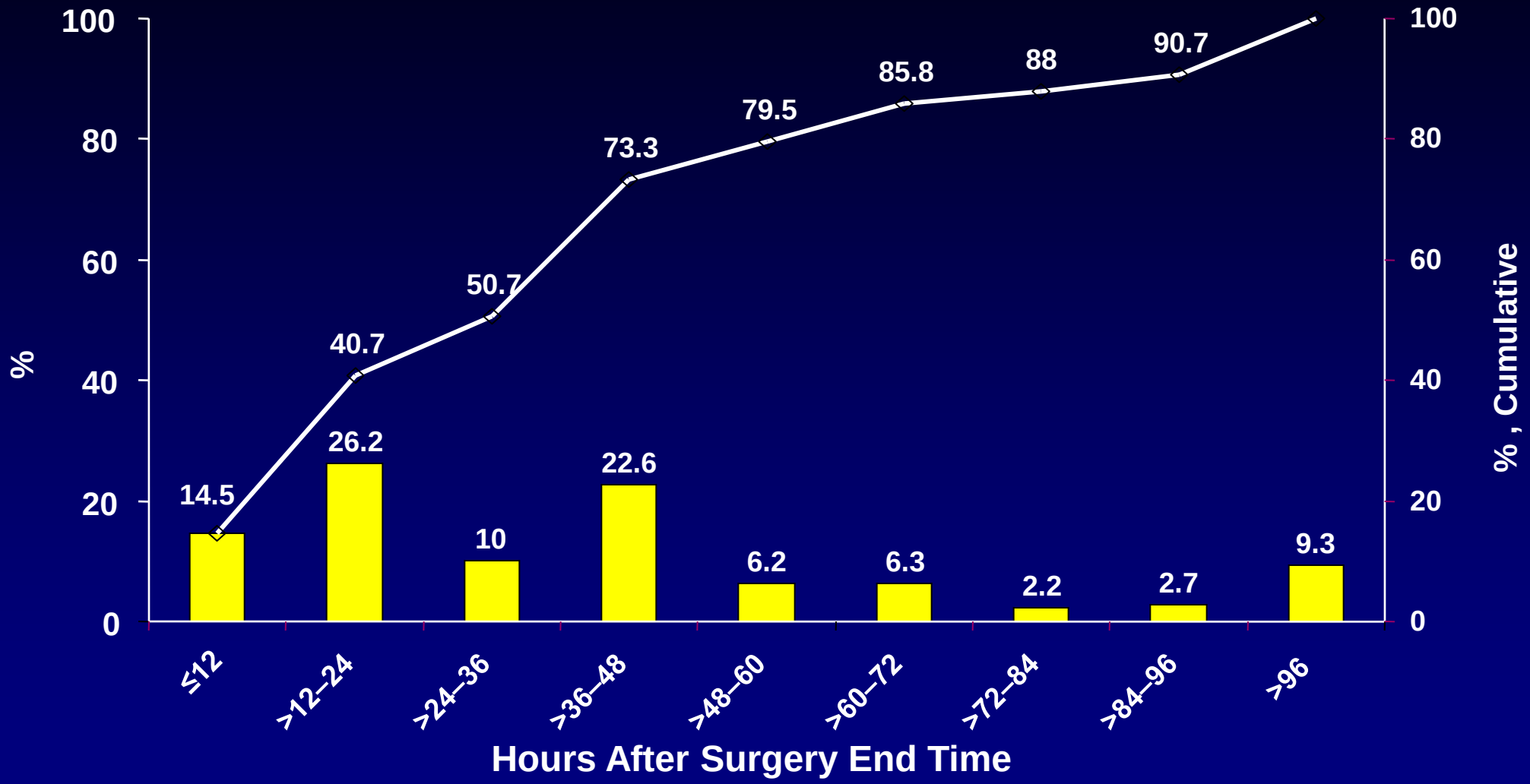
- 605 Colorectal Surgery Pts
- Use of a “Nonstandard” Abx Regimen (ie, Non-SCIP-Compliant) was Assoc with Increased Risk of SSI (OR 2.069, 1.078-3.969)

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

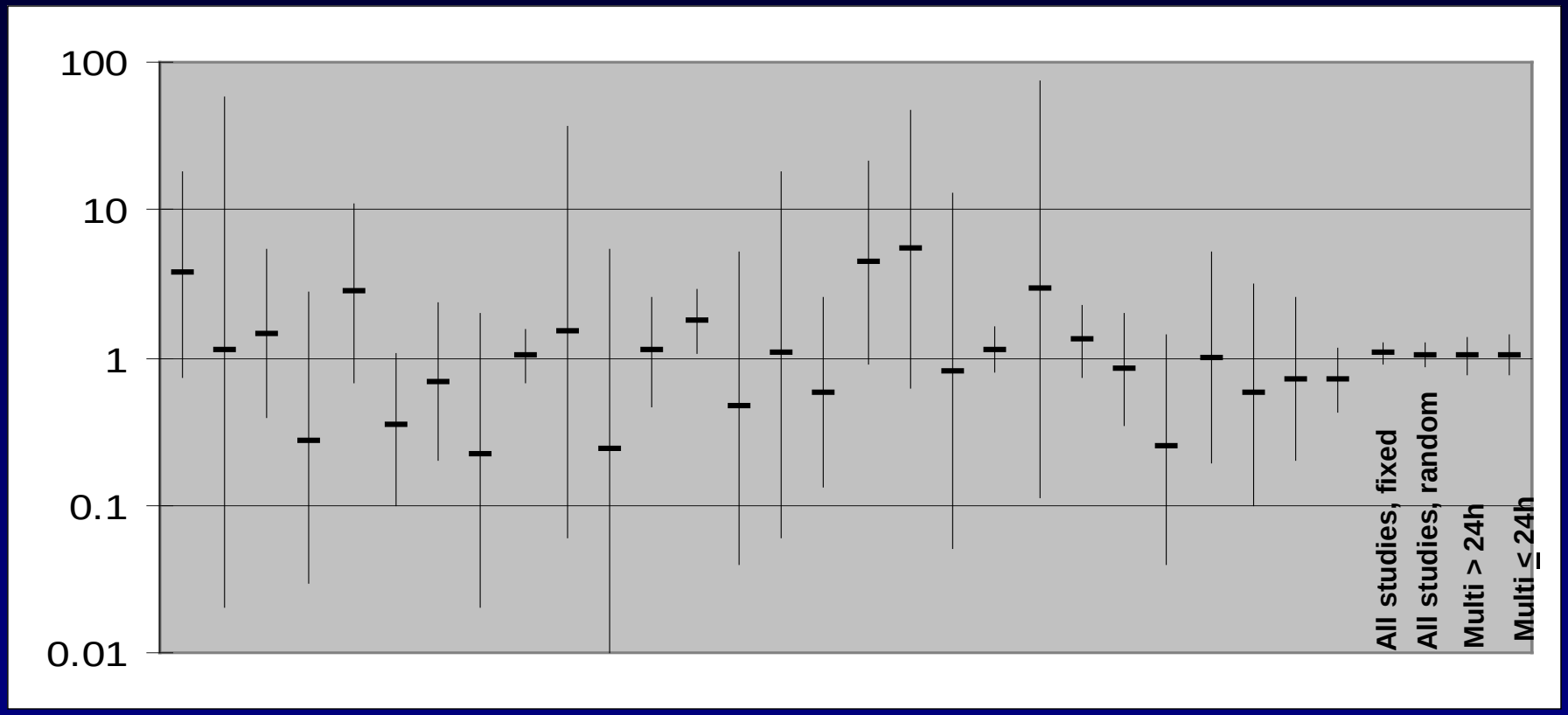


Bratzler et al, Arch Surg 2005; 140:174

ANTIBIOTIC PROPHYLAXIS
DURATION

- **Most studies have confirmed efficacy of ≤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



McDonald M et al, Aust NZ J Surg 1998; 68:388

DURATION OF PROPHYLAXIS: INFECTION AND ANTIBIOTIC RESISTANCE IN CARDIAC SURGERY

	<48 Hr Short	>48 Hr Long	Odds Ratio
Number	1502	1139	
SSI	131 (8.7%)	100 (8.8%)	1.0 (0.8-1.3)
Acq Ab Res	6%		1.6 (1.1-2.6)

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

  Latham R et al, Infect Control Hosp Epidemiol 2001; 22:607
- 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

HAIR REMOVAL

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

WARMING

Hypothermia is Common in Surgery

- Impaired Thermoregulation
- Altered Heat Distribution, Exposure

WARMING

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

WARMING

Kurz A et al, NEJM 1996; 334:1209

200 Colorectal Surgery Pts

Routine Care (Hypothermia) vs

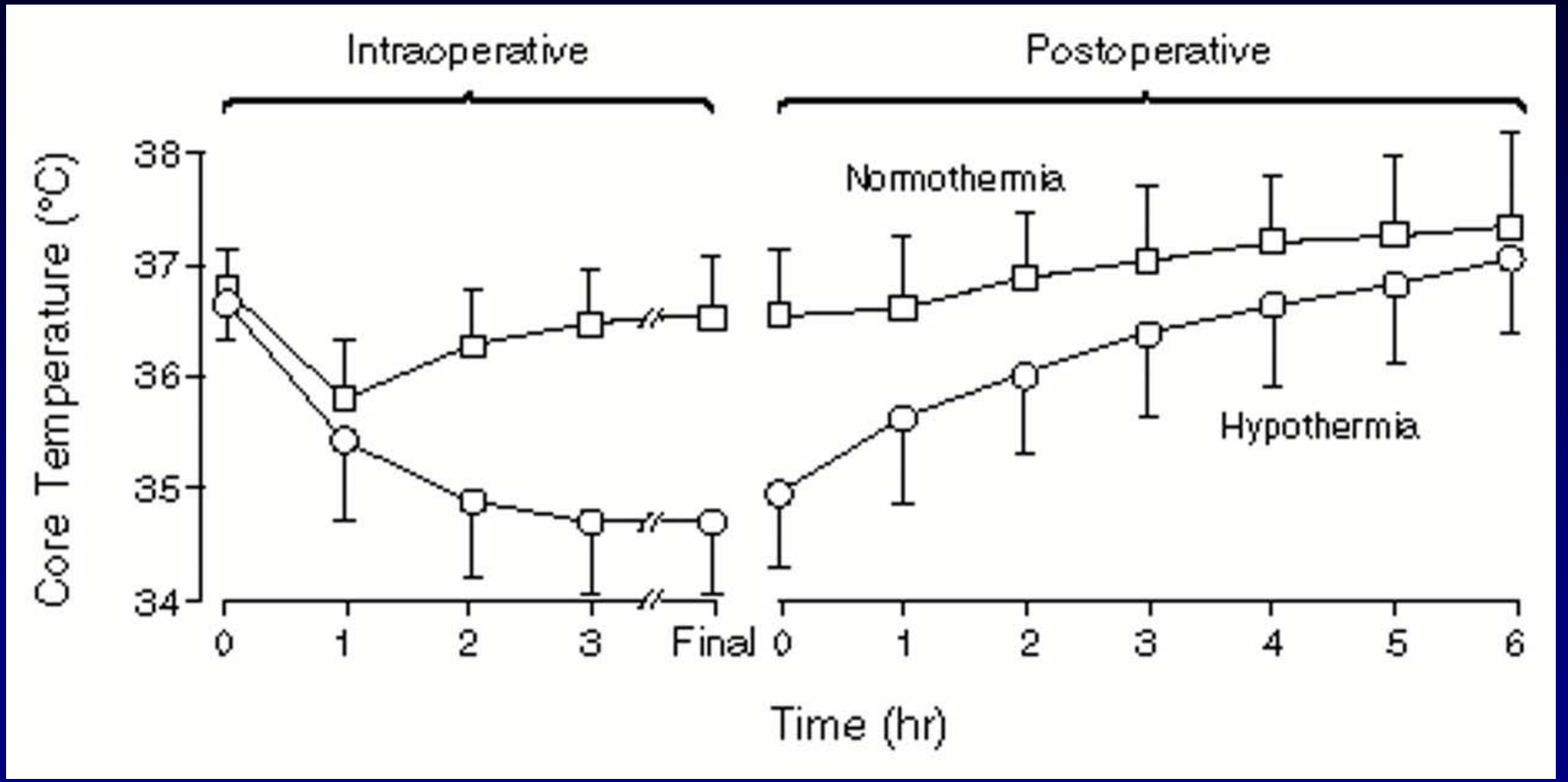
Warming (Normothermia)

- I.V. Abx, Hydration, O_2 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

Variable	Warm	Hypo	p
n	104	96	-
Infection	6 (6%)	18 (19%)	.009
ASEPSIS Score	7 ± 10	13 ± 16	.002
Collagen μg/cm	328 ± 135	254 ± 114	.04
Days to Solids	6 ± 3	7 ± 2	.006
Days to SR	10 ± 3	11 ± 2	.002
Hospital LOS	12 ± 4	15 ± 7	.001

Kurz A et al, NEJM 1996; 334:1209

RISK FACTORS

Multivariate Analysis

Risk Factor	Odds Ratio
Tobacco Use	10.5
Hypothermia	4.9
Rectum vs Colon	2.7
NNISS Score	2.5
Age	1.6

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

WARMING

Response to SCIP-10

Matched Case Control Study- 146 Cases with SSI, 323 Controls without SSI

No Association Between Warming and SSI

Lehtinen SJ et al, Ann Surg 2010: 252:696

OTHER PREVENTION STRATEGIES

- Preoperative
- Intraoperative
- Postoperative

Mangram et al, HICPAC Guidelines 1999
Alexander JW et al. Ann Surg 2011; 253:1082

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)

PATIENT BATHING

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)

SKIN PREP

PRCT, 234 pts

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

Save OR time and cost

Ellenhorn JDI et al. J Am Coll Surg 2005; 201:737

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).

Type of Infection	Chlorhexidine–Alcohol (N=409)	Povidone–Iodine (N=440)	Relative Risk (95% CI)*	P Value†
	no. (%)			
Any surgical-site infection	39 (9.5)	71 (16.1)	0.59 (0.41–0.85)	0.004
Superficial incisional infection	17 (4.2)	38 (8.6)	0.48 (0.28–0.84)	0.008
Deep incisional infection	4 (1.0)	13 (3.0)	0.33 (0.11–1.01)	0.05
Organ-space infection	18 (4.4)	20 (4.5)	0.97 (0.52–1.80)	>0.99
Sepsis from surgical-site infection	11 (2.7)	19 (4.3)	0.62 (0.30–1.29)	0.26

* 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.

Darouiche RO et al. N Engl J Med 2010;362:18

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)

Noorani A et al. Br J Surg 2010; 97:1614

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- AII)

COLORECTAL SURGERY- MECHANICAL BOWEL PREP (MBP)

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

Slim K et al. Ann Surg 2009; 249:203

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)

OXYGEN

- Bactericidal Activity of Neutrophils is Oxygen-Dependent
- Subcutaneous Wound Oxygen Tension is Inversely Correlated with Wound Infection Rates

Hopf et al, Arch Surg 1997; 132:997

Hypothesis: Supplemental Oxygen Decreases Wound Infections

OXYGEN

500 Colorectal Surgery Pts

30% O_2 / 70% N_2

vs

80% O_2 / 20% 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

OUTCOMES

Variable	30%	80%	p
n	250	250	-
SQ O2 Tension	59	109	<.01
Infection	28 (11%)	13 (5%)	.01
ASEPSIS Score	5 ± 9	3 ± 7	.01
Collagen μg/cm	267 ± 109	258 ± 118	.38
Days to Solids	4 ± 2	5 ± 2	.27
Hospital LOS	12 ± 4	12 ± 6	.26

Grief et al, NEJM 2000; 342:161

OXYGEN

Pryor et al, JAMA 2004; 291:79

165 Surgical Pts

35% O_2 vs 80% O_2

Intraop + 2 Hr Postop

OUTCOMES

Variable	35%	80%	p
n	80	80	-
Infection	9 (11%)	20 (25%)	.02
Reoperation	0	4 (5%)	.07
Hospital LOS	6.4	8.3	.06

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**

OXYGEN

Belda et al, JAMA 2005; 294:2035

291 Colorectal Surgery Pts

30% O_2 vs 80% O_2

Intraop + 2 Hr Postop

OUTCOMES

Variable	30%	80%	p
n	143	148	-
Infection	35 (24%)	22 (15%)	.04
Hospital LOS	10.5	11.7	.09

Belda et al, JAMA 2005; 294:2035

OXYGEN
The PROXI Trial

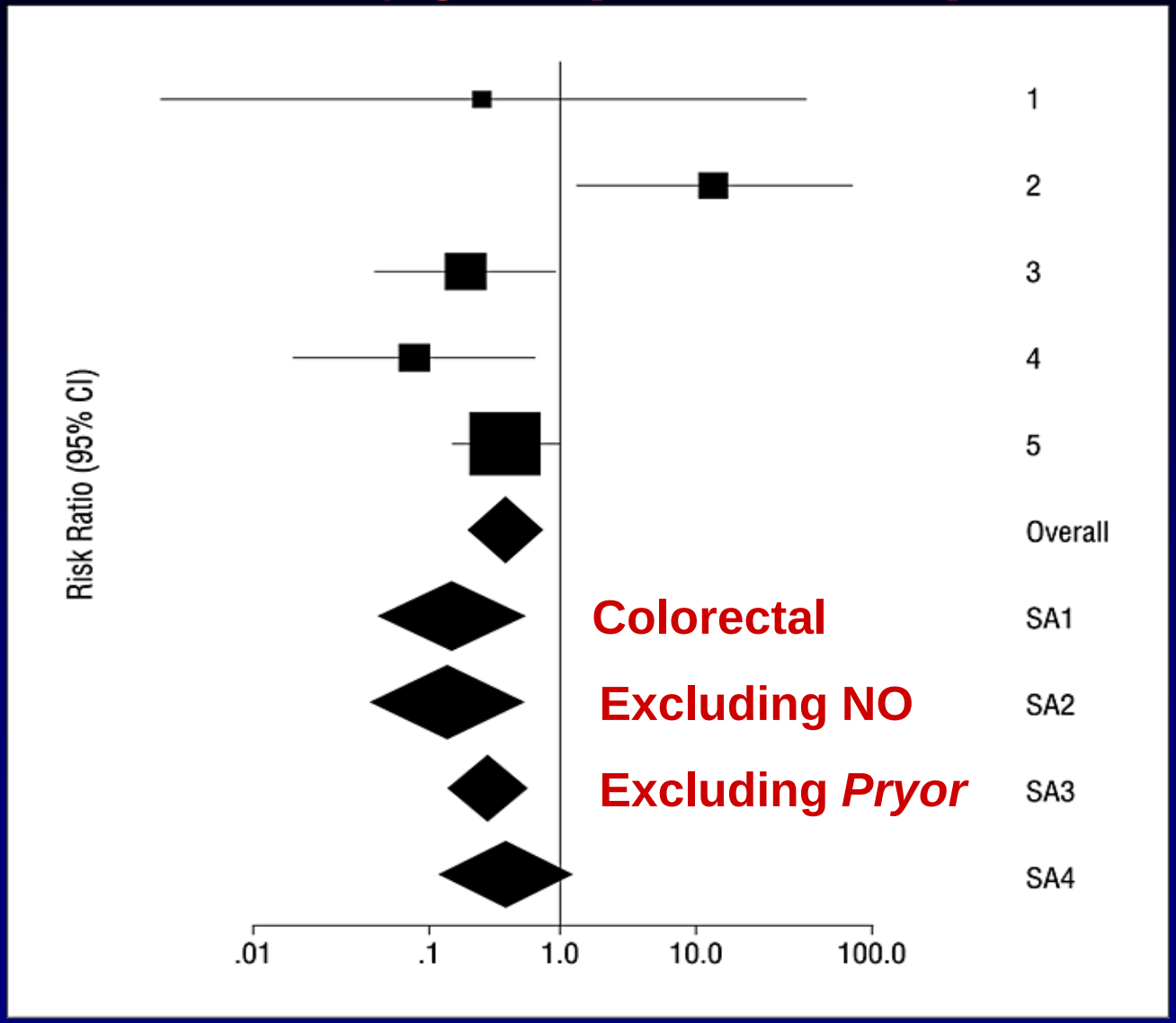
Meyhoff et al, JAMA 2009; 302:1543

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



ARCHIVES OF SURGERY

Qadan M et al. Arch Surg 2009; 144:359

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

Cimochowski GE et al, Ann Thorac Surg 2001; 71:1572

-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

Perl TM et al, N Engl J Med 2002; 346:1871

Potential cost-effective strategy

Farr BM, N Engl J Med 2002; 346:1905

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%*

Bode LGM et al, N Engl J Med 2010; 362:9

TRANSFUSIONS AND POSTOPERATIVE INFECTION

Transfusion is Associated with Increased Postop Infection Rates

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

Landers DF et al, Anesth Analg 1996; 82:187

BLOOD TRANSFUSION

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

Bernard AC et al. J Am Coll Surg 2009; 208:931

IMPACT OF LOW-VOLUME LEUKOREDUCED TRANSFUSION

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; $p \leq 0.05$) and was associated with increased risk for SSI (OR = 1.25; $p < 0.05$).

Bernard AC et al. J Am Coll Surg 2009; 208:931

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)

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%

Forbes SS et al, J Am Coll Surg 2008; 207:336

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%

Thompson KM et al. Ann Surg 2011; 254:430

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