Preventing Surgical Site Infections

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Duke Center for Antimicrobial Stewardship and Infection Prevention

Disclosures

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- Owner, Infection Control Education for Major Sports, LLC

Outline

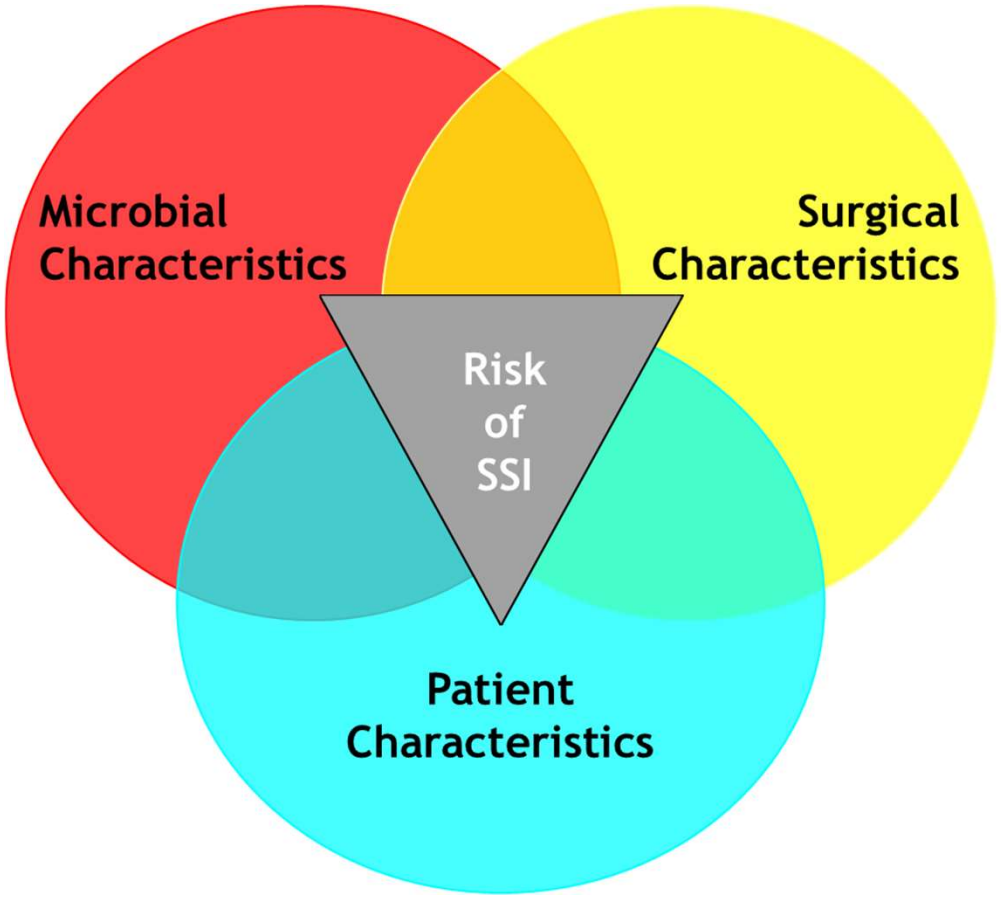
- Impact of SSI
- Surveillance for SSIs
- Strategies for Prevention
  - Essential practices
  - Supplemental strategies – to do or not to do?

Impact of SSI

- SSIs are the most common and most costly HAI
- An estimated 16 million operations were performed in acute care hospitals in 2010
- Prevalence
  - 2-5% of surgical patients develop an SSI
  - ~160,000-300,000 SSIs per year in US
  - SSI is now the most common and costly HAI
- Impact
  - Each SSI results in 7-11 additional hospital days
  - Patients with SSI have a 2-11 times higher risk of death
  - 77% of deaths among patients with SSI are directly due to SSI
  - Cost (2007 dollars): $3.5 to $10 billion annually

www.cdc.gov/nhsn/pdfs
Anderson D, et al ICHE 2014

Risk of SSI



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Risk Factors

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Table 3. Selected Risk Factors for and Recommendations to Prevent Surgical Site Infection (SSI)

Risk Factor	Recommendation	Quality of Evidence
Intrinsic, patient-related (preoperative)		
Unmodifiable		
Age	No formal recommendation: relationship to increased risk of SSI may be secondary to comorbidities or immunosenescence[343–345]	N/A
History of radiation	No formal recommendation. Prior irradiation at the surgical site increases the risk of SSI, likely due to tissue damage and wound ischemia.[184]	N/A
History of skin and soft-tissue infections	No formal recommendation. History of a prior skin infection may be a marker for inherent differences in host immune function.[346]	N/A
Modifiable		
Glucose control	Control serum blood-glucose levels for all surgical patients including patients without diabetes.[347]	HIGH
Obesity	Increase dosing of prophylactic antimicrobial agent for morbidly obese patients.[73,348]	HIGH
Smoking cessation	Encourage smoking cessation within 30 days of procedure.[4,349–353]	HIGH
Immunosuppressive medications	Avoid immune-suppressive medications in perioperative period if possible	LOW
Hypoalbuminemia	No formal recommendation. Though a noted risk factor,[354] do not delay surgery for use of total parenteral nutrition.	N/A
S. aureus nasal colonization	Decolonize patients with nasal mupirocin or povidine-iodine prior to surgery	MODERATE
Preparation of patient		
Hair removal	Do not remove unless hair will interfere with the operation[4]; if hair removal is necessary, remove outside of the operating room by clipping. Do not use razors.	HIGH
Preoperative infections	Identify and treat infections remote to the surgical site (eg, urinary tract infection in the presence of prior to elective surgery.[4,355] Do not routinely test or treat for asymptomatic bacteriuria except in urologic procedures.[4,355]	MODERATE
Operative characteristics		
Surgical scrub (surgical team members' hands and forearms)	Use appropriate antiseptic agent to perform preoperative surgical scrub.[4,356] For most products, scrub the hands and forearms for 2–5 minutes.	MODERATE
Skin preparation	Wash and clean skin around incision site. Use a dual agent skin prep containing alcohol unless contraindications exist.[4]	HIGH
Antimicrobial prophylaxis	Administer only when indicated.[4] Select appropriate agents based on surgical procedure, most common pathogens causing SSI for a specific procedure, and published recommendations.[73] Administer within 1 hour of incision to maximize tissue concentration.[73] Discontinue antimicrobial agents after incisional closure in the operating room.[a]	HIGH
Blood transfusion	Blood transfusions increase the risk of SSI by decreasing macrophage function. Reduce blood loss and need for blood transfusion to greatest extent possible.[357–359]	MODERATE
Surgeon skill/technique	Handle tissue carefully and eradicate dead space.[4]	LOW
Appropriate gloving	All members of the operative team should double glove and change gloves when perforation is noted.[360]	LOW
Asepsis	Adhere to standard principles of operating room asepsis.[4]	LOW
Operative time	No formal recommendation in most recent guidelines; minimize as much as possible without sacrificing surgical technique and aseptic practice.	HIGH
Operating room characteristics		
Ventilation	Follow American Institute of Architects' recommendations for proper air handling in the operating room.[4,361]	LOW
Traffic	Minimize operating room traffic.[4,208,209]	LOW
Environmental surfaces	Use an Environmental Protection Agency (EPA)–approved hospital disinfectant to clean visibly soiled or contaminated surfaces and equipment in accordance with manufacturer's instructions.[4]	LOW
Sterilization of surgical equipment	Sterilize all surgical equipment according the device manufacturer's validated parameters: cycle type, time, temperature, pressure, and dry time. Minimize the use of immediate use steam sterilization.[4,362]	MODERATE

Prevention - Recent Guidelines

- WHO – 2016
- ACS – 2016
- CDC – 2017
- ASHP – 2013*

**currently being revised*

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SHEA Expert Guidance

Strategies to prevent surgical-site infections in acute-care hospitals: 2022 Update

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Summary Table

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Table 1. Summary of Recommendations to Prevent Surgical Site Infections (SSIs)

Essential practices
1. Administer antimicrobial prophylaxis according to evidence-based standards and guidelines.[73,75] (Quality of evidence: HIGH)
2. Use a combination of parenteral and oral antimicrobial prophylaxis prior to elective colorectal surgery to reduce the risk of SSI.[116,117] (Quality of evidence: HIGH)
3. Decolonize surgical patients with an anti-staphylococcal agent in the preoperative setting for orthopedic and cardiothoracic procedures. (Quality of evidence: HIGH) Decolonize surgical patients in other procedures at high risk of staphylococcal SSI, such as those involving prosthetic material. (Quality of evidence: LOW)
4. Use antiseptic-containing preoperative vaginal preparation agents for patients undergoing cesarean delivery or hysterectomy. (Quality of evidence: MODERATE)
5. Do not remove hair at the operative site unless the presence of hair will interfere with the surgical procedure. [4,120] (Quality of evidence: MODERATE)
6. Use alcohol-containing preoperative skin preparatory agents in combination with an antiseptic. (Quality of evidence: HIGH)
7. For procedures not requiring hypothermia, maintain normothermia (temperature > 35.5°C) during the perioperative period. (Quality of evidence: HIGH)
8. Use impervious plastic wound protectors for gastrointestinal and biliary tract surgery. (Quality of evidence: HIGH)
9. Perform intraoperative antiseptic wound lavage.[172] (Quality of evidence: MODERATE)
10. Control blood-glucose level during the immediate postoperative period for all patients.[94] (Quality of evidence: HIGH)
11. Use a checklist and/or bundle to ensure compliance with best practices to improve surgical patient safety. (Quality of evidence: HIGH)
12. Perform surveillance for SSI. (Quality of evidence: MODERATE)
13. Increase the efficiency of surveillance by utilizing automated data. (Quality of evidence: MODERATE)
14. Provide ongoing SSI rate feedback to surgical and perioperative personnel and leadership. (Quality of evidence: MODERATE).
15. Measure and provide feedback to HCP regarding rates of compliance with process measures.[94] (Quality of evidence: LOW)
16. Educate surgeons and perioperative personnel about SSI prevention measures. (Quality of evidence: LOW)
17. Educate patients and their families about SSI prevention as appropriate. (Quality of evidence: LOW)
18. Implement policies and practices to reduce the risk of SSI for patients that align with applicable evidence-based standards, rules and regulations, and medical device manufacturer instructions for use.[4,94] (Quality of evidence: MODERATE)
19. Observe and review operating room personnel and the environment of care in the operating room and in central sterile reprocessing. (Quality of evidence: LOW)
Additional approaches
1. Perform an SSI risk assessment. (Quality of evidence: LOW)
2. Consider use of negative pressure dressings in patients who may benefit. (Quality of evidence: MODERATE)
3. Observe and review practices in the preoperative clinic, postanesthesia care unit, surgical intensive care unit and/or surgical ward. (Quality of evidence: MODERATE)
4. Use antiseptic-impregnated sutures as a strategy to prevent SSI. (Quality of evidence: MODERATE)
Approaches that should not be considered a routine part of SSI prevention
1. Do not routinely use vancomycin for antimicrobial prophylaxis.[73] (Quality of evidence: MODERATE)
2. Do not routinely delay surgery to provide parenteral nutrition. (Quality of evidence: HIGH)
3. Do not routinely use antiseptic drapes as a strategy to prevent SSI. (Quality of evidence: HIGH)
Unresolved issues
1. Optimize tissue oxygenation at the incision site
2. Preoperative intranasal and pharyngeal CHG treatment for patients undergoing cardiothoracic procedures
3. Use of gentamicin-collagen sponges
4. Use of antimicrobial powder
5. Use of surgical attire

Surveillance

- Direct vs. indirect methods
  - Indirect method reliable (sensitivity, 84%–89%) and specific (specificity, 99.8%) compared with direct surveillance
- Indirect combines
  - Review of microbiology reports and patient medical records
  - Screening for readmission and/or return to the operating room
  - Other information, such as coded diagnoses, coded procedures, operative reports, or antimicrobials ordered
  - Surgeon and/or patient surveys

Baker et al. AJIC 1995.
Cardo et al. ICHE 1993.

Surveillance – Electronic Data Helps

- Strategy 1 – antibiotics and readmissions
  - Improve the sensitivity and reduce effort
- Strategy 2 – diagnosis codes
  - Medicare claims data can be used to enhance traditional surveillance methods for SSI and to identify hospitals with unusually high or low rates of SSI

Chalfine et al ICHE 2006.
Calderwood et al. ICHE 2013.
Huang et al. ICHE 2011.

Surveillance – Post-Discharge

- Important for internal review
- Not useful for hospital comparisons

Rates and Reporting

- Rate
  - Number of infections/100 procedures
- SIR – Standardized Infection Ratio
  - Number of observed infections/number of expected infections
    - >1 is bad
- Methods for risk adjustment exist, but are not very good

Example

- SSI following colon=10
  - Number of procedures=250
- NHSN says rate of colon SSI=2.0
  - So expected number of SSIs for 250 procedures would be 5 (5/250=2 SSI/100 procedures)
- SIR = 10/5 = 2

Basic Practices

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Essential Practices

- Timing
- Dose
  - Re-dose?
- Duration
- Post-op glucose control
  - 110-150 mg/dL
  - Cardiac and non-cardiac
  - 24-48 hours after end of anesthesia *(uncertainty exists…)*

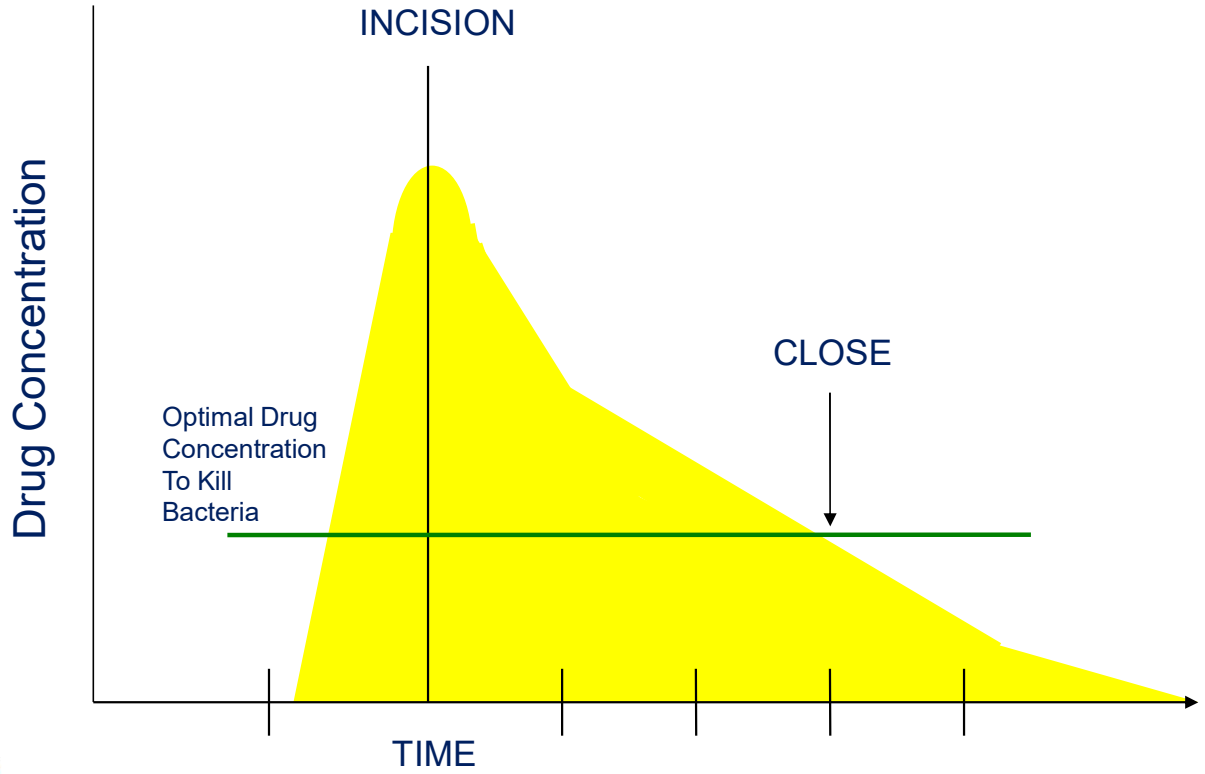
Timing and Dose - GOALS

1. Optimize serum and tissue concentration at the time of incision

2. Provide dose that ensure sufficient concentration during the procedure

3. Use agents that cover likely pathogens for the procedure

Prophylaxis: Ideal Scenario



Timing

- For most agents (e.g., beta lactams), administer within 60 minutes prior to incision
  - Mixed data on more specificity
    - Some data suggest improved outcomes if within 15-30 minutes
  - Allow for 2 hours for fluoroquinolones and vancomycin
- Unique scenarios
  - Administer prior to skin incision rather than after cord clamping for CSEC
  - Administer prior to inflating tourniquet

Can Timing be Optimized?

- Cohort study
  - 158 Swiss hospitals
  - 538,967 patients (11 procedures)
- Timing of administration of cefuroxime and rate of SSI
- Mixed effects logistic regression
- Administration 10-25 minutes prior to incision was associated with decreased risk

Figure 2. Crude Surgical Site Infection (SSI) Rate Relative to Timing of Surgical Antimicrobial Prophylaxis (SAP)

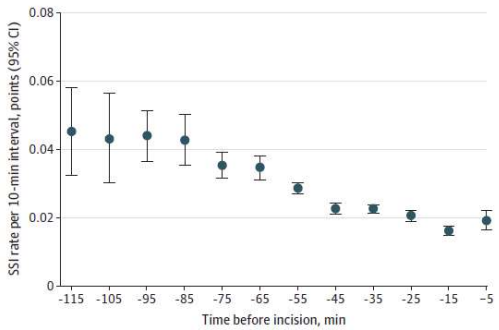


Table 3. Fully Adjusted Mixed Effects Logistic Regression Models With Surgical Site Infection as the Dependent Variable[a]

Variable	aOR (95% CI)	*P* value
Timing of cefuroxime surgical antimicrobial prophylaxis administration prior to incision		
0-30 min	0.85 (0.78-0.93)	<.001
31-60 min	0.91 (0.84-0.98)	.01
61-120 min	1 [Reference]	NA

Sommerstein et al. JAMA Netw Open 2023;6:e2317370

Weight-based Dosing

- Cefazolin
  - 2g if <120 kg
  - 3g if ≥120 kg
  - 30 mg/kg for pediatric patients
- Vancomycin 15 mg/kg
- Gentamicin 5 mg/kg
  - For morbidly obese patients, use the ideal weight plus 40% of the excess weight for dose calculation
  - NOTE: Use of single dose for prophylaxis **not** associated with renal injury

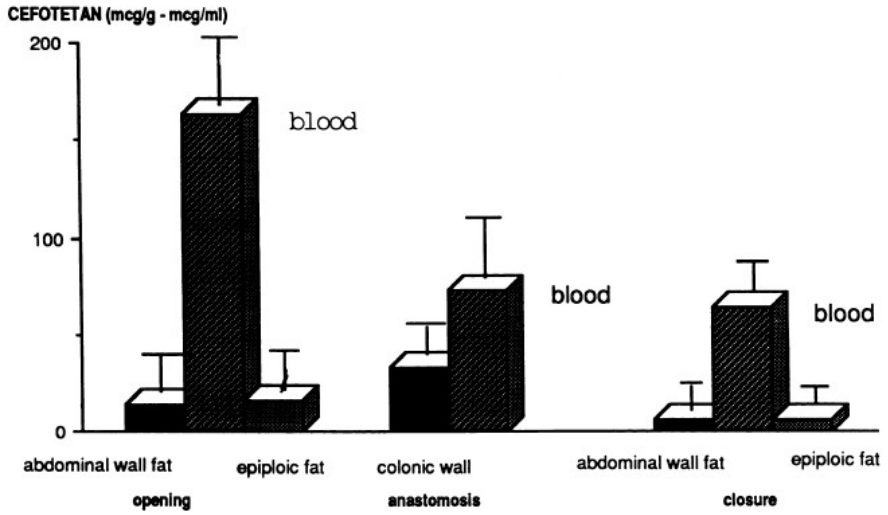
Obesity is a Risk Factor for SSI

- Numerous studies have shown that obesity is an independent risk factor for SSI
  - Increased rates of SSI of 2 to 6 times higher than non-obese patients
- Why? Likely combination of technical and pharmacologic factors
  - Poorly vascularized tissue
    - Strong correlation between amount of SQ/intra-abdominal fat and risk of SSI
    - Decreased tissue oxygenation among obese patients
  - Creation of dead space
    - Fat > 3.4 cm
  - Patients often have other co-morbid illnesses such as diabetes mellitus and CV disease

Choban et al. *Am Surg*. 1995;61(11):1001-5.
Nagachinta et al. *J Infect Dis*. 1987;156(6):967-73.

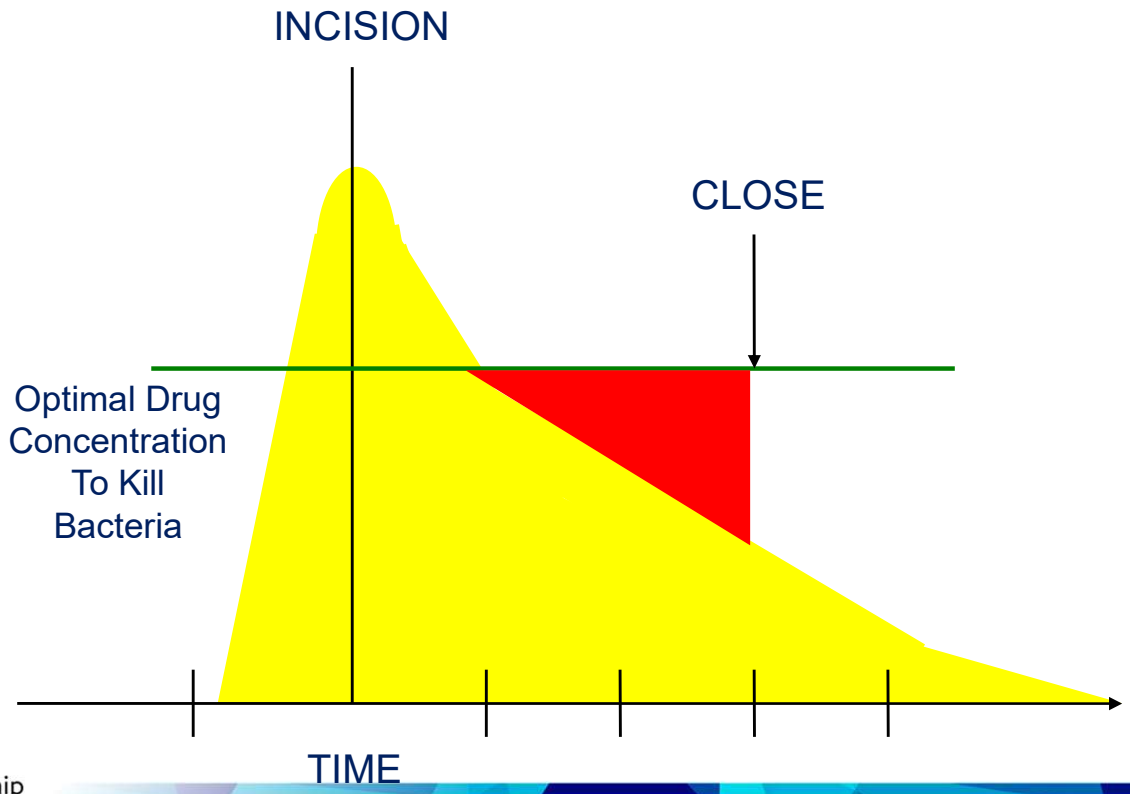
Tissue Concentration

- Adipose tissue has far smaller concentration of antibiotic than blood
  - 10% of blood concentration
  - The more adipose tissue, the smaller the concentration
- Administered 2g of cefotetan prior to colorectal surgery (n=16)
  - Measured antibiotic concentration in serum, skin fat and gut fat



Martin et al. Antimicrob Agent Chemother 1992;36:1115-8.

Prophylaxis: Obesity



3g v. 2g Cefazolin: Outcomes

- Review of >38,000 hip procedures
  - >2000 patients >120 kg
  - 75% were underdosed (received 2g)
- Patients underdosed were >2-fold higher risk of SSI compared to appropriate dosing
- Excellent safety profile, even with higher dosing

Morris et al. AJHP 2020;77:434.

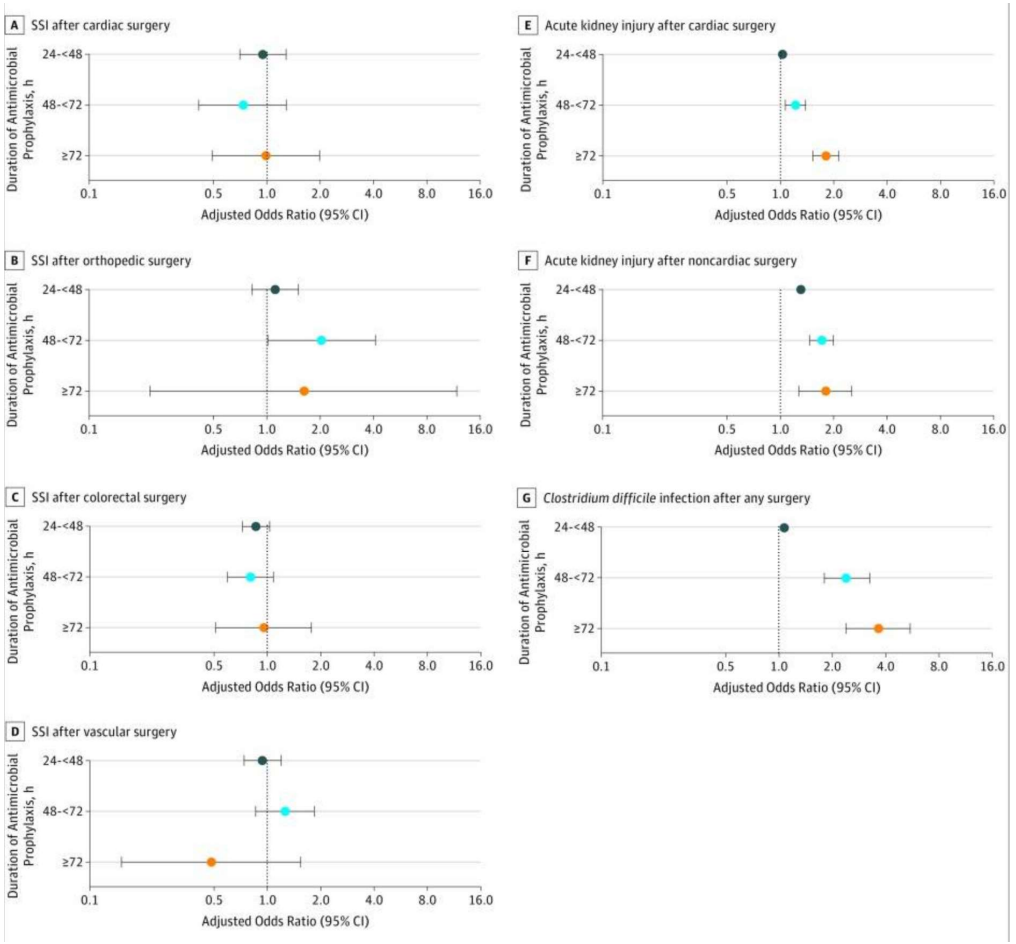
Duration

- OLD: stop within 24 hours of surgery
- Numerous meta-analyses fail to demonstrate any benefit of prolonged prophylaxis
  - Even if drain left in place
  - Systematic review: single dose vs. multiple dose (24 hour)
    - SSI OR 1.04 [0.86-1.25]
- No benefit, but increased risk of harm
  - *C. difficile*
  - Antibiotic resistance
  - AKI
- **NEW: stop at surgical closure**

McDonald et al. Aust NZ J Surg 1998. Miranda et al. JACS 2020;231:766. Takemoto et al. JBJS Am 2015

Increased Duration and Adverse Events

79,058 surgical patients in VA system



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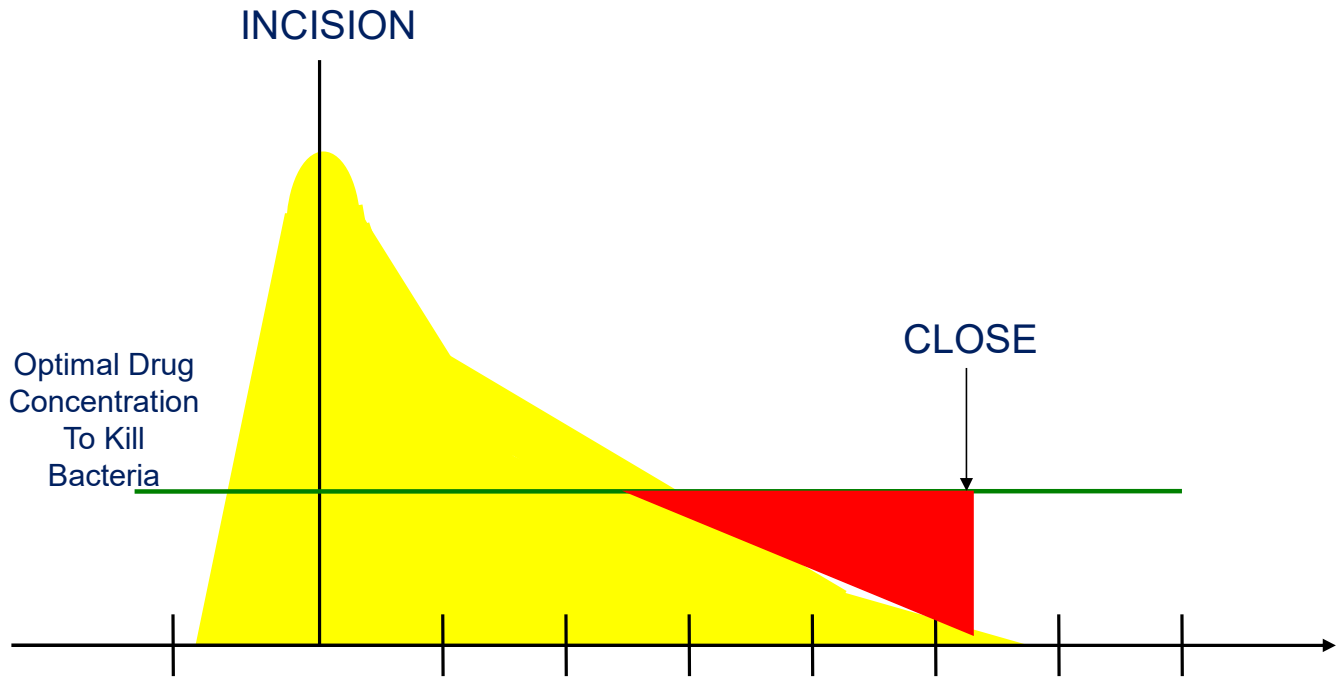
Branch-Elliman et al. JAMA Surgery 2019;154:590

Expand the Details – More Essential Practices (Part 2)

- Re-dosing for prolonged procedures
  - Prolonged surgical duration is risk factor for SSI
- Bowel prep
  - NEW: give a combination of parenteral and oral antimicrobial prophylaxis prior to elective colorectal surgery (HIGH)

Prophylaxis: Long Procedure



Re-Dosing: Outcomes

- Analysis of 801 patients undergoing clean-contaminated operations:
  - If procedure > 3 hours, then rate of SSI reduced from 6.1 to 1.3 with additional dosing

Table 1.
Recommended Doses and Redosing Intervals for Commonly Used Antimicrobials for Surgical Prophylaxis

Antimicrobial	Recommended Dose		Half-life in Adults With Normal Renal Function, hr[19]	Recommended Redosing Interval (From Initiation of Preoperative Dose), hr[c]
	Adults[a]	Pediatrics[b]		
Ampicillin–sulbactam	3 g (ampicillin 2 g/sulbactam 1 g)	50 mg/kg of the ampicillin component	0.8–1.3	2
Ampicillin	2 g	50 mg/kg	1–1.9	2
Aztreonam	2 g	30 mg/kg	1.3–2.4	4
Cefazolin	2 g, 3 g for pts weighing ≥120 kg	30 mg/kg	1.2–2.2	4
Cefuroxime	1.5 g	50 mg/kg	1–2	4
Cefotaxime	1 g[d]	50 mg/kg	0.9–1.7	3
Cefoxitin	2 g	40 mg/kg	0.7–1.1	2
Cefotetan	2 g	40 mg/kg	2.8–4.6	6
Ceftriaxone	2 g[e]	50–75 mg/kg	5.4–10.9	NA
Ciprofloxacin[f]	400 mg	10 mg/kg	3–7	NA
Clindamycin	900 mg	10 mg/kg	2–4	6

Scher KS. Am Surg 1997;63:59-62. ASHP Guidelines 2013.

Mechanical Bowel Prep + PO Abx

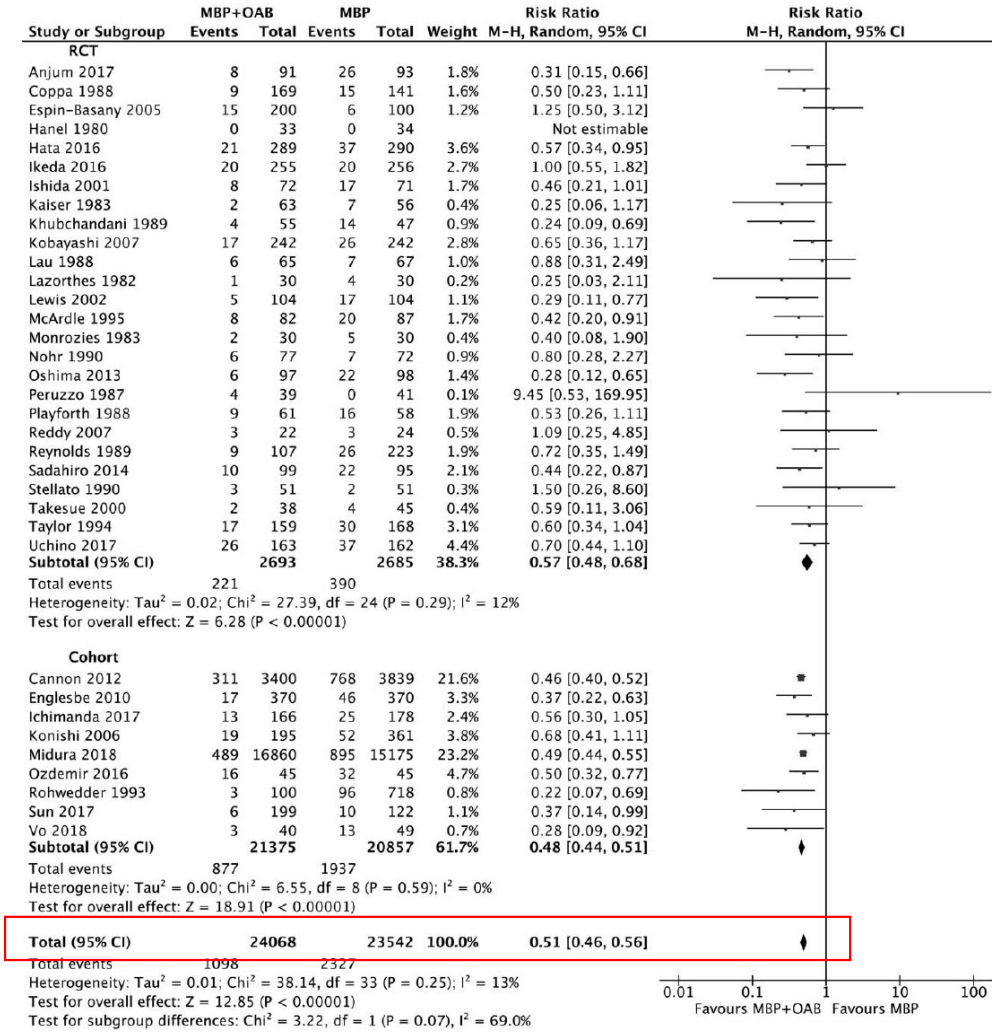
- Frequently overlooked
- Evidence based
  - Combine MBP + PO Abx + parenteral Abx
  - MBP alone does not reduce risk of SSI

Best Practice for SSI Prevention	Compliance with Best Practice, n/N (%)
Choice of prophylactic antibiotic(s)	578/643 (90%)
Timing of prophylactic antibiotic(s)	534/643 (83%)
Weight-based dose of prophylactic antibiotic(s)	557/643 (87%)
Re-dosing of prophylactic antibiotic(s)[a]	44/77 (57%)
Skin antisepsis with appropriate agent	528/643 (82%)
Maintenance of perioperative normothermia	467/643 (73%)
Operative and postoperative supplemental oxygen[b]	89/503 (18%)
Postoperative glucose monitoring and control	264/643 (41%)
Use of SSI prevention checklist	195/643 (30%)
Prophylactic oral antibiotics and mechanical bowel preparation[c]	28/217 (13%)

Baker et al. eClinicalMed 2022;54:101698.

MBP + PO Abx vs. MBP alone

Systematic Review of 40 studies



Study or Subgroup	MBP+OAB Events	Total	MBP Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
RCT						
Anjum 2017	8	91	26	93	1.8%	0.31 [0.15, 0.66]
Coppa 1988	9	169	15	141	1.6%	0.50 [0.23, 1.11]
Espin-Basany 2005	15	200	6	100	1.2%	1.25 [0.50, 3.12]
Hanel 1980	0	33	0	34		Not estimable
Hata 2016	21	289	37	290	3.6%	0.57 [0.34, 0.95]
Ikeda 2016	20	255	20	256	2.7%	1.00 [0.55, 1.82]
Ishida 2001	8	72	17	71	1.7%	0.46 [0.21, 1.01]
Kaiser 1983	2	63	7	56	0.4%	0.25 [0.06, 1.17]
Khubchandani 1989	4	55	14	47	0.9%	0.24 [0.09, 0.69]
Kobayashi 2007	17	242	26	242	2.8%	0.65 [0.36, 1.17]
Lau 1988	6	65	7	67	1.0%	0.88 [0.31, 2.49]
Lazorthes 1982	1	30	4	30	0.2%	0.25 [0.03, 2.11]
Lewis 2002	5	104	17	104	1.1%	0.29 [0.11, 0.77]
McArdle 1995	8	82	20	87	1.7%	0.42 [0.20, 0.91]
Monrozies 1983	2	30	5	30	0.4%	0.40 [0.08, 1.90]
Nohr 1990	6	77	7	72	0.9%	0.80 [0.28, 2.27]
Oshima 2013	6	97	22	98	1.4%	0.28 [0.12, 0.65]
Peruzzo 1987	4	39	0	41	0.1%	9.45 [0.53, 169.95]
Playforth 1988	9	61	16	58	1.9%	0.53 [0.26, 1.11]
Reddy 2007	3	22	3	24	0.5%	1.09 [0.25, 4.85]
Reynolds 1989	9	107	26	223	1.9%	0.72 [0.35, 1.49]
Sadahiro 2014	10	99	22	95	2.1%	0.44 [0.22, 0.87]
Stellato 1990	3	51	2	51	0.3%	1.50 [0.26, 8.60]
Takesue 2000	2	38	4	45	0.4%	0.59 [0.11, 3.06]
Taylor 1994	17	159	30	168	3.1%	0.60 [0.34, 1.04]
Uchino 2017	26	163	37	162	4.4%	0.70 [0.44, 1.10]
Subtotal (95% CI)		**2693**		**2685**	**38.3%**	**0.57 [0.48, 0.68]**
Total events	221		390			
Heterogeneity: Tau² = 0.02; Chi² = 27.39, df = 24 (P = 0.29); I² = 12%						
Test for overall effect: Z = 6.28 (P < 0.00001)						
Cohort						
Cannon 2012	311	3400	768	3839	21.6%	0.46 [0.40, 0.52]
Englesbe 2010	17	370	46	370	3.3%	0.37 [0.22, 0.63]
Ichimanda 2017	13	166	25	178	2.4%	0.56 [0.30, 1.05]
Konishi 2006	19	195	52	361	3.8%	0.68 [0.41, 1.11]
Midura 2018	489	16860	895	15175	23.2%	0.49 [0.44, 0.55]
Ozdemir 2016	16	45	32	45	4.7%	0.50 [0.32, 0.77]
Rohwedder 1993	3	100	96	718	0.8%	0.22 [0.07, 0.69]
Sun 2017	6	199	10	122	1.1%	0.37 [0.14, 0.99]
Vo 2018	3	40	13	49	0.7%	0.28 [0.09, 0.92]
Subtotal (95% CI)		**21375**		**20857**	**61.7%**	**0.48 [0.44, 0.51]**
Total events	877		1937			
Heterogeneity: Tau² = 0.00; Chi² = 6.55, df = 8 (P = 0.59); I² = 0%						
Test for overall effect: Z = 18.91 (P < 0.00001)						
Total (95% CI)		**24068**		**23542**	**100.0%**	**0.51 [0.46, 0.56]**
Total events	1098		2327			
Heterogeneity: Tau² = 0.01; Chi² = 38.14, df = 33 (P = 0.25); I² = 13%						
Test for overall effect: Z = 12.85 (P < 0.00001)						
Test for subgroup differences: Chi² = 3.22, df = 1 (P = 0.07), I² = 69.0%						

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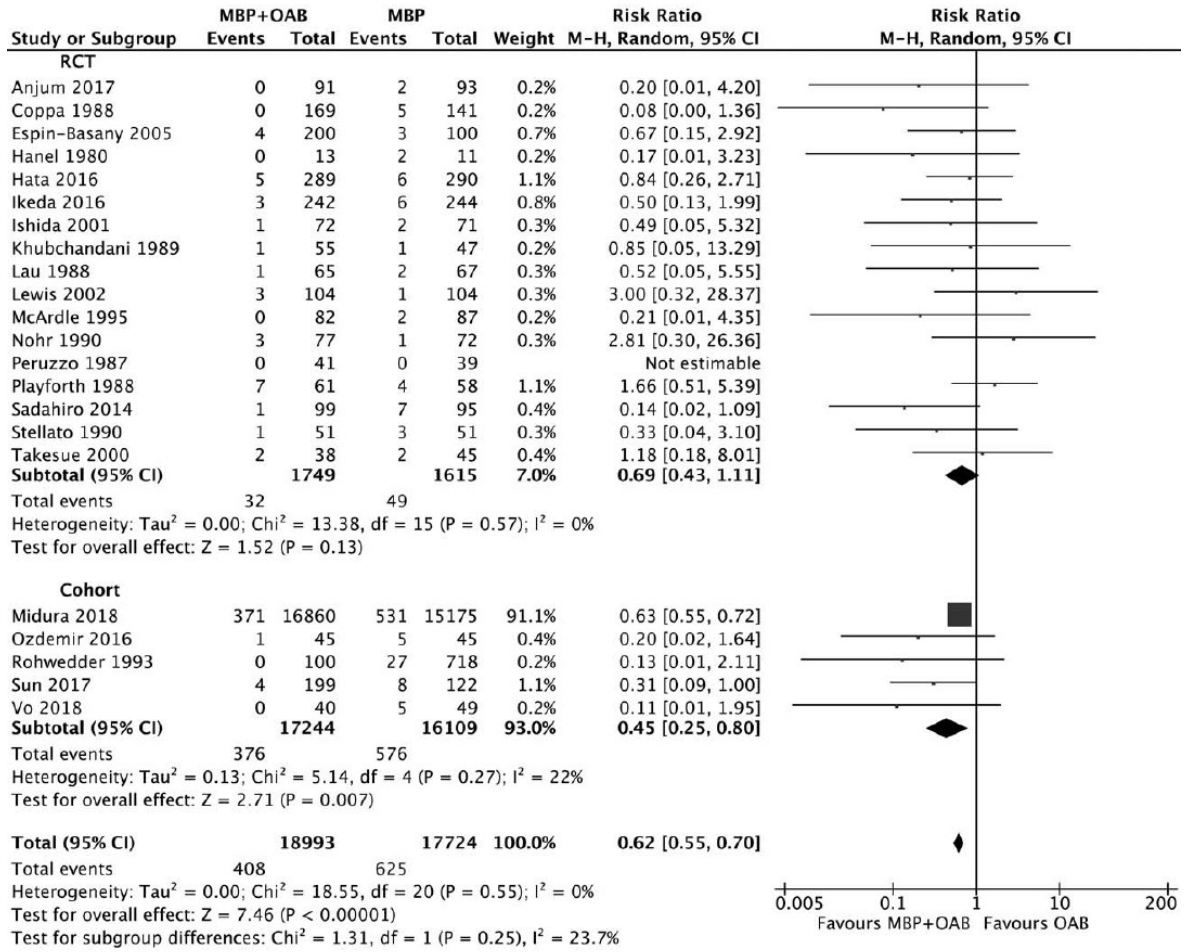
Rollins et al. Ann Surg 2019; 270:43-58.

Harm?

Decreased risk of anastomotic leak with MBP + PO Abx



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McArdle 1995	0	82	2	87	0.2%	0.21 [0.01, 4.35]
Nohr 1990	3	77	1	72	0.3%	2.81 [0.30, 26.36]
Peruzzo 1987	0	41	0	39		Not estimable
Playforth 1988	7	61	4	58	1.1%	1.66 [0.51, 5.39]
Sadahiro 2014	1	99	7	95	0.4%	0.14 [0.02, 1.09]
Stellato 1990	1	51	3	51	0.3%	0.33 [0.04, 3.10]
Takesue 2000	2	38	2	45	0.4%	1.18 [0.18, 8.01]
Subtotal (95% CI)		**1749**		**1615**	**7.0%**	**0.69 [0.43, 1.11]**
Total events	32		49			
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 13.38$, df = 15 (P = 0.57); $I^2 = 0\%$						
Test for overall effect: Z = 1.52 (P = 0.13)						
Cohort						
Midura 2018	371	16860	531	15175	91.1%	0.63 [0.55, 0.72]
Ozdemir 2016	1	45	5	45	0.4%	0.20 [0.02, 1.64]
Rohwedder 1993	0	100	27	718	0.2%	0.13 [0.01, 2.11]
Sun 2017	4	199	8	122	1.1%	0.31 [0.09, 1.00]
Vo 2018	0	40	5	49	0.2%	0.11 [0.01, 1.95]
Subtotal (95% CI)		**17244**		**16109**	**93.0%**	**0.45 [0.25, 0.80]**
Total events	376		576			
Heterogeneity: $Tau^2 = 0.13$; $Chi^2 = 5.14$, df = 4 (P = 0.27); $I^2 = 22\%$						
Test for overall effect: Z = 2.71 (P = 0.007)						
Total (95% CI)		**18993**		**17724**	**100.0%**	**0.62 [0.55, 0.70]**
Total events	408		625			
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 18.55$, df = 20 (P = 0.55); $I^2 = 0\%$						
Test for overall effect: Z = 7.46 (P < 0.00001)						
Test for subgroup differences: $Chi^2 = 1.31$, df = 1 (P = 0.25), $I^2 = 23.7\%$						

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Rollins et al. Ann Surg 2019; 270:43-58.

In fact, Consensus Recommendation!

- Three major guidelines recommend the use of MBP + PO antibiotics + Parenteral Abx for colorectal procedures
  - SHEA/IDSA
  - WHO
  - ACS/SIS

(not discussed in CDC/HICPAC)

Post-op Glycemic Control

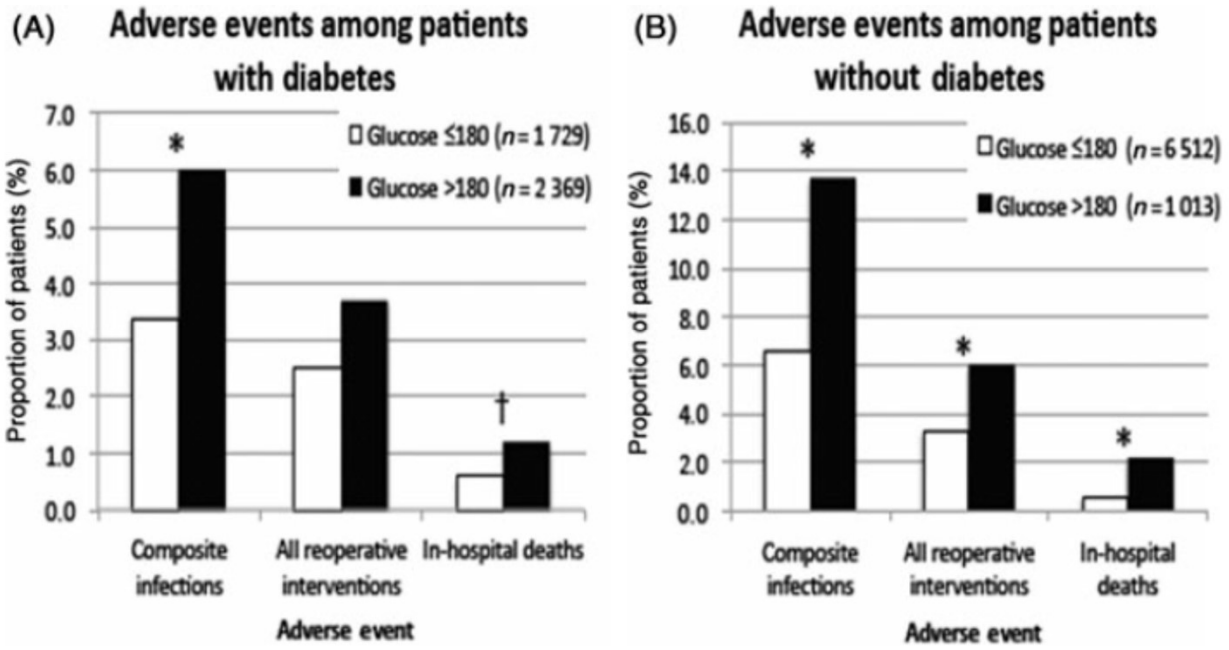
- New recommendations:
  - Emphasize REGARDLESS of diabetes diagnosis
  - Lower target to 110-150 mg/dL

Post-op Glycemic Control

- Surgical Care and Outcomes Assessment Program in Washington State
  - 11,633 patients (57% colorectal)
- Notes
  - 25% had glucose>180
  - Hyperglycemia = 2-fold increase in SSI risk
    - Adjusted

Kwon et al. Ann Surg 2013;257:8-14.

Post-op Glycemic Control



Kwon et al. Ann Surg 2013;257:8-14.

How?

- RCT of basal-bolus insulin vs. SS insulin
  - 211 general surgery patients with diabetes
- Results
  - 3.4-fold decrease in composite outcome
    - SSI, pneumonia, BSI, resp/renal failure
  - Average post-op glucose 145 v. 172 ($p<0.01$)
  - No statistically significant difference in patients with BG<40, but close (4 v. 0, $p=0.06$)

Umpierrez et al. Diabetes Care 2011;34:256-61.

Essential Practices – Part 3

- Antiseptic prep
- Wound lavage
- WHO checklist
- Bundles
- Screening and decolonization for *S. aureus*

Antiseptic Prep

- Use alcohol-containing skin prep (when possible)
- Add a disinfectant
  - CHG likely superior to PI
    - 4 RCTs

- NEW: use antiseptic-containing preoperative vaginal preparation agents for patients undergoing CSEC or HYST
  - PI or CHG
  - No alcohol

CHG Uses in Infection Control

Application	*Evidence*
Skin antisepsis	
CVC site preparation	50% better than povidone-iodine (catheter colonization)
Surgical hand scrub	86-92% reduction in flora
Source control in ICUs	Reduction in skin flora; reduce risk of CLABSI 6-fold
Preoperative scrub	Superior to other antiseptics in reducing skin flora at surgical site
Impregnated devices	
Vascular catheter dressings	Reduction in catheter colonization (40-50%); decrease rate of CLABSI
Vascular catheters	Reduction in catheter colonization (55%); in BSI (40%) in high-risk groups

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and Infection Prevention

Milstone et al, *Clin Infect Dis* 2008; 46:274–81.
Bleasdale et al, *Arch Intern Med* 2007; 167:2073-9.
Timsit et al. JAMA 2009; 301:1231-41.

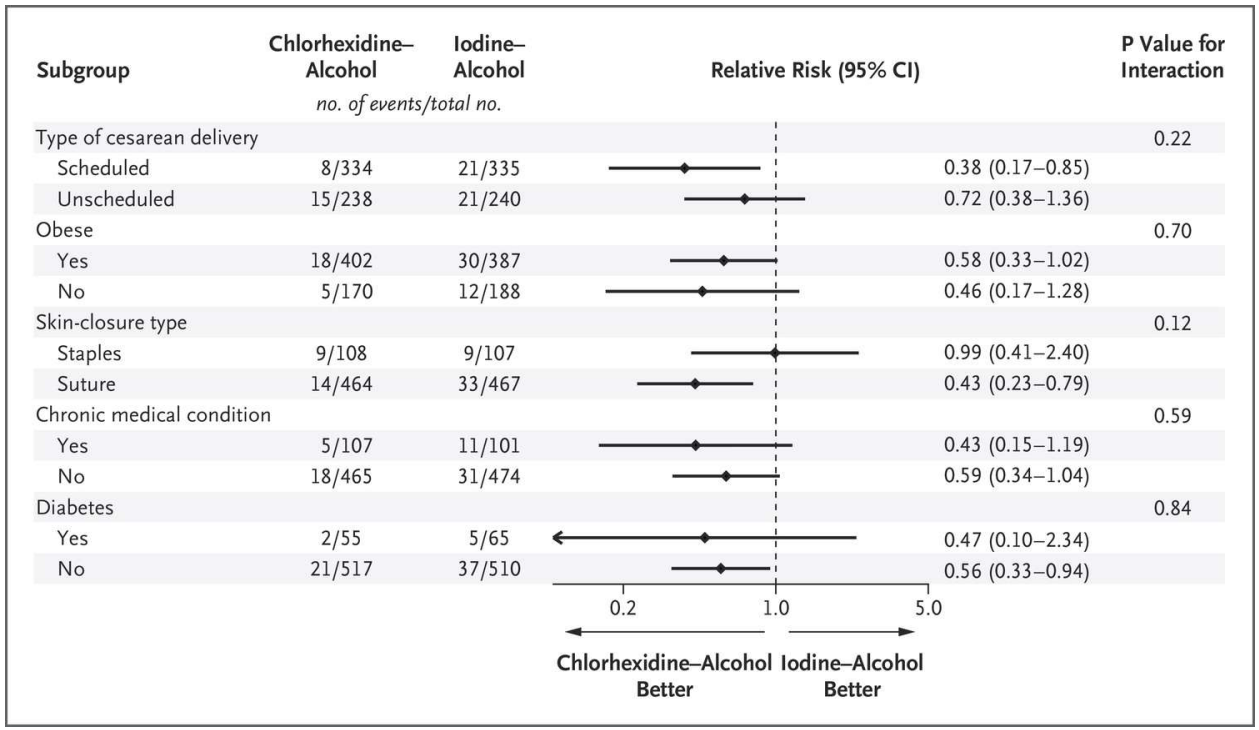
CHG v. PI?

- RCT comparing CHG-ETOH vs. PI-ETOH
- 1,147 women undergoing CSEC
- Rate of SSI lower with CHG/EtOH (p=0.02)
  - CHG/EtOH – SSI rate=3.0
  - PI/EtOH – SSI rate=4.9

Tuuli et al. NEJM 2016;374:647.

CHG v. PI

RCT of 1,147 women



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Tuuli et al. NEJM 2016;374:647

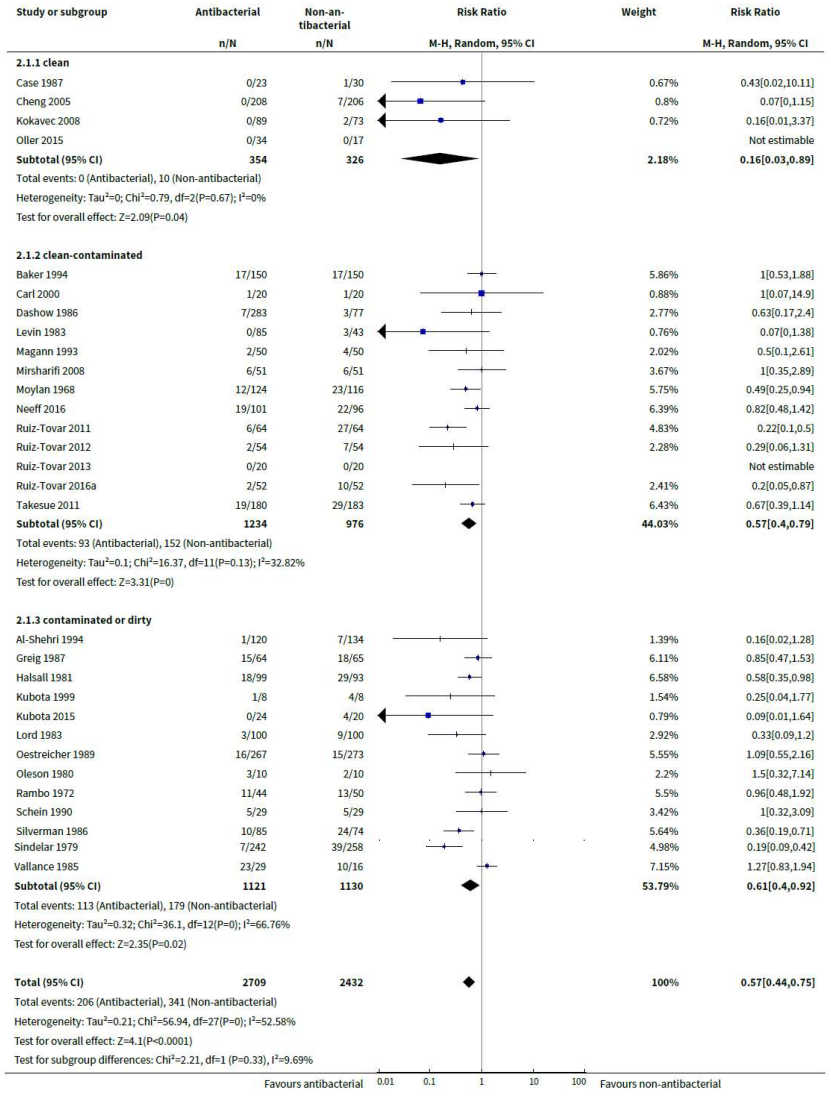
Wound Lavage

- Commonly performed, little standardization
  - Lots of papers, but most reviews still consider evidence to be “low quality”
- What to use?
  - Saline - NO
  - Antiseptic - YES
  - Antibiotic - MAYBE (but not preferred)
- Bacitracin contraindicated
  - FDA requested withdrawal from market

Antibacterial vs. Saline irrigation

Antibacterial (either antiseptic OR abx) lavage decreased risk of SSI

Norman et al. Cochrane Database Syst Review 2017;10:CD012234.



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Antiseptic vs. Antibiotic Lavage

- Systematic review and meta-analysis of 21 RCTs
  - Dilute povidone-iodine decreased risk of SSI
    - OR=0.31, 95% CI 0.13-0.73
  - No benefit from antibiotic lavage
- More recent, larger review (n=42 RCTs)
  - Dilute PI decreased risk (OR 0.57 [95% CI 0.32-0.95])
  - Abx lavage decreased risk (OR 0.44 [95% CI 0.28-0.67])
- Benefit of antibiotic irrigation may be limited to clean-contaminated or contaminated procedures
- Take Away: prefer use of PI
  - Weight of data supports its use
  - Avoid further antibiotic exposure
- POINT of EMPHASIS: How to obtain “STERILE” PI?

De Jonge et al. Surg Infect 2017;18:508. Thom H et al. Surg Infect 2021;22:144.

Checklists and Bundles

- Should we use them? YES
- What are the best components to include?
  - Not well known

Surgical Safety Checklist

- Checklists
  - Proven method for prevention of complications
    - Change system AND individual behavior
  - CLABSI
- New checklist for surgical care
  - 19 item surgical safety checklist
    - Sign in, Time out, Sign out
  - 8 institutions throughout world
  - Prospective, quasi-experimental study of patients before (n=3733) and after (n=3955) implementation
  - Non-cardiac surgery
  - During “Time-Out,” OR team had to confirm that prophylactic antibiotics have been administered ≤60 min before incision is made or that antibiotics are not indicated

Pronovost et al. N Engl J Med 2006;355:2725-32.
Haynes et al. N Engl J Med 2009;360:491-9.

Surgical Safety Checklist

Table 2. Characteristics of Participating Hospitals.

Site	Location	No. of Beds	No. of Operating Rooms	Type
Prince Hamzah Hospital	Amman, Jordan	500	13	Public, urban
St. Stephen's Hospital	New Delhi, India	733	15	Charity, urban
University of Washington Medical Center	Seattle, Washington	410	24	Public, urban
St. Francis Designated District Hospital	Ifakara, Tanzania	371	3	District, rural
Philippine General Hospital	Manila, Philippines	1800	39	Public, urban
Toronto General Hospital	Toronto, Canada	744	19	Public, urban
St. Mary's Hospital*	London, England	541	16	Public, urban
Auckland City Hospital	Auckland, New Zealand	710	31	Public, urban

Haynes et al. N Engl J Med 2009;360:491-9.

Surgical Safety Checklist

Site No.	No. of Patients Enrolled		Surgical-Site Infection		Prophylactic Antibiotics Given Appropriately (N=6802)		Death		Any Complication	
	Before	After	Before	After	Before	After	Before	After	Before	After
					percent					
1	524	598	**4.0**	**2.0**	98.1	96.9	**1.0**	**0.0**	**11.6**	**7.0**
2	357	351	2.0	1.7	56.9	76.9	1.1	0.3	7.8	6.3
3	497	486	5.8	4.3	83.8	87.7	0.8	1.4	13.5	9.7
4	520	545	3.1	2.6	80.0	81.8	1.0	0.6	7.5	5.5
5	370	330	**20.5**	**3.6**	29.8	96.2	**1.4**	**0.0**	**21.4**	**5.5**
6	496	476	4.0	4.0	25.4	50.6	3.6	1.7	10.1	9.7
7	525	585	**9.5**	**5.8**	42.5	91.7	2.1	1.7	**12.4**	**8.0**
8	444	584	4.1	2.4	18.2	77.6	1.4	0.3	6.1	3.6
Total	3733	3955	**6.2**	**3.4**	56.1	82.6	**1.5**	**0.8**	**11.0**	**7.0**
P value			<0.001		<0.001		0.003		<0.001	

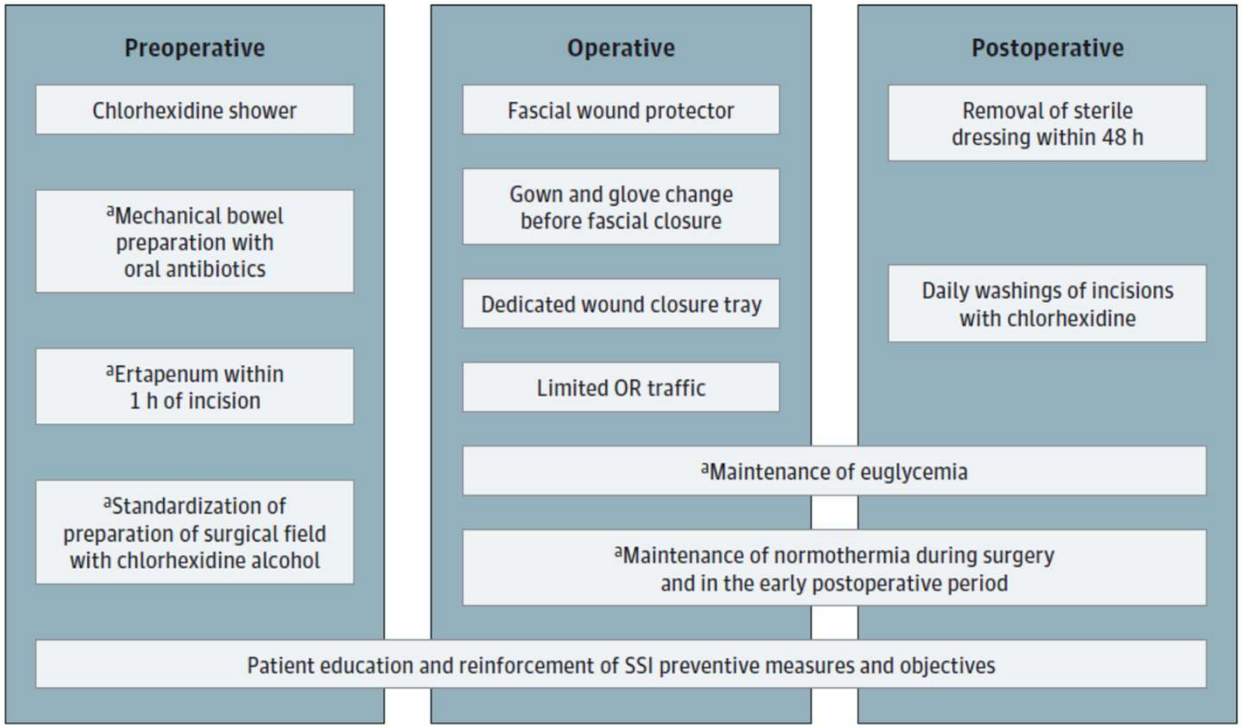
Haynes et al. N Engl J Med 2009;360:491-9.

Colorectal Bundle

- High adverse outcomes following colorectal procedures (>20%)
  - ACS-NSQIP data
- Created and implemented a “bundle” of evidence-based and “common sense” interventions
  - Multidisciplinary
  - Monthly review meetings
  - Items included on a “checklist”

Keenan et al. JAMA Surg 2014;149:1045.

Bundle Components



Keenan et al. JAMA Surg 2014;149:1045.

Results

- Retrospective analysis of 559 randomly selected patients from 2008 through 2012
  - Propensity matched on multiple potential confounders (age, sex, BMI, DM, chemo, XRT, total op time, lap approach, rectal)
  - 212 patients in each group
    - No major differences in patient characteristics

Keenan et al. JAMA Surg 2014;149:1045.

Results

	Prebundle (n=212)	Postbundle (n=212)	p-value
Superficial-incisional SSI	41 (19.3)	12 (5.7)	<0.001
Deep-incisional SSI	3 (1.4)	0	0.25
Organ-Space SSI	11 (5.2)	6 (2.8)	0.32
Wound disruption	5 (2.4)	3 (1.4)	0.72
Postop sepsis	18 (8.5)	5 (2.4)	0.009
LOS – med (IQR)	5.5 (4-8)	5.0 (3-7)	0.05
30-d readmit	32 (15.1)	19 (9.0)	0.14

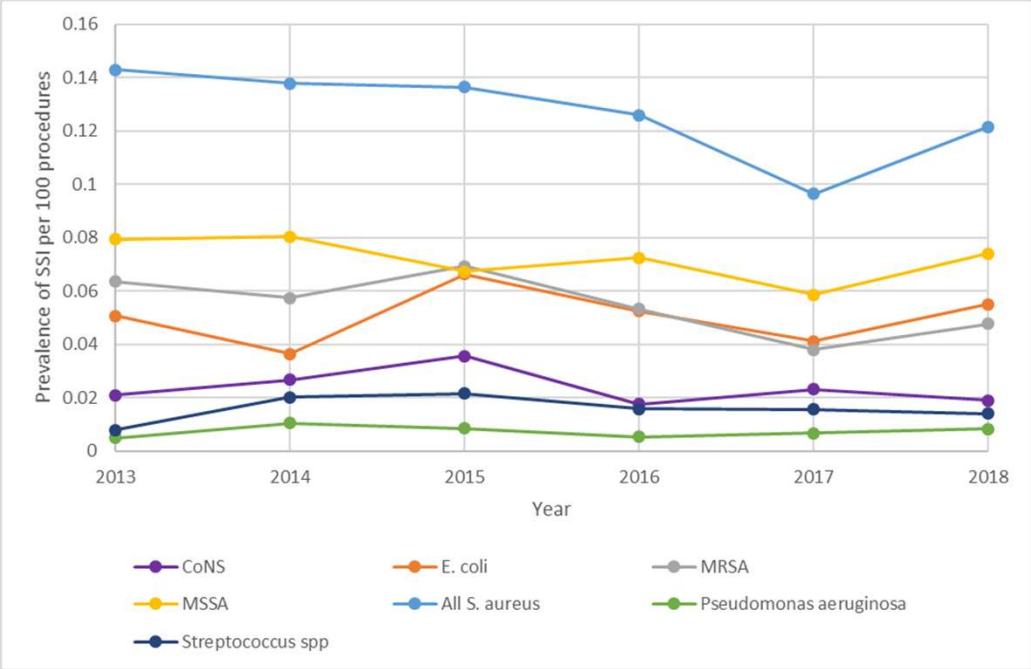
Keenan et al. JAMA Surg 2014;149:1045.

Glove/Instrument Change

- ACS/SIS recommended changing gloves and instruments for closure in colorectal surgery
- Based on expert consensus
- Frankly, not a bad idea

S. aureus Screening/Decolonization

- MRSA gets the attention, but emphasis should be on both MSSA and MRSA
- If known to be colonized, should decolonize
  - ASHP, WHO, ACS, SHEA
- BUT - Should you screen??
  - Controversial!



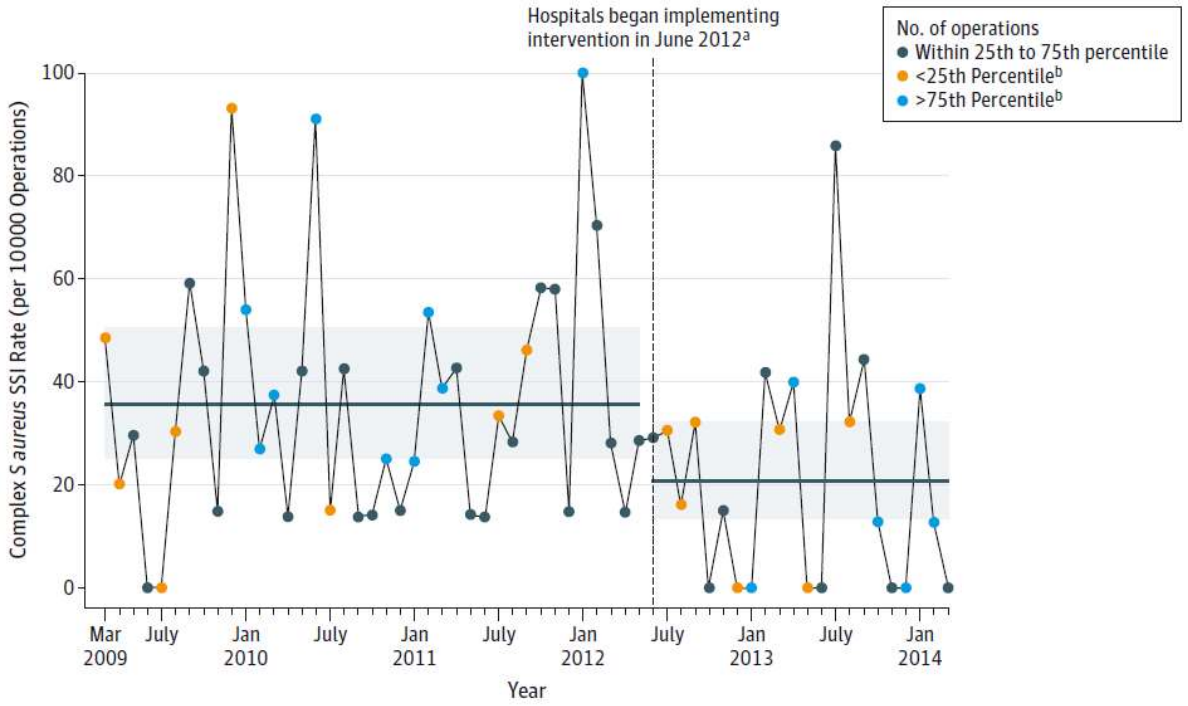
S. aureus Decolonization

- Standard decolonization: intranasal mupirocin + CHG bathing
  - Alternatives exist
- Most support from orthopedic and cardiothoracic literature
  - Clean procedures
  - Meta-analysis of 17 studies concluded that decolonization strategies prevent *S. aureus* SSI
  - At least two RCTs
- Not as much support when other procedures studied
- New recommendation:
  - Decolonize ortho and CT procedures
  - Decolonize other procedures at high risk of staph SSI (i.e., prosthetic material)

S. aureus Decolonization

20 hospital study, using a bundle to reduce risk of S. aureus SSI

Included screening and decolonization



Schweizer et al. JAMA 2015;313:2162.

Screening/Decolonization Considerations

- Many factors to consider
  - Baseline rate of *S. aureus* SSI
  - Ability to follow up culture results
  - Resources to implement protocol
  - How to screen? How to decolonize?
  - Create mupirocin resistance? Availability?
- Some modeling data suggest universal decolonization may be more cost effective than screening and treating

Stambough et al. J Arthoplasy 2017;32:728.

Intranasal Povidone Iodine

- Alternative approach with antiseptic agent instead of antibiotic
  - Won't drive antibiotic (mupirocin) resistance
  - Still couple of skin antisepsis (chlorhexidine)
- Easier approach – can be given pre-operative setting instead of requiring 5 days prior to the procedure
  - Effect likely not as long lasting
- One single center RCT of 855 patients with spine or joint procedure
  - No difference in overall SSI rate or *S. aureus* SSI rate between mupirocin and intranasal PI

Phillips et al. ICHE 2014;35:826.

Essential Practices – Part 4

- Don’t shave skin
- Maintain normothermia
  - Devices make easier
  - Only in procedures with general anesthesia

Supplementary Strategies – To Do or Not?

- Negative pressure wound therapy
- Supplemental oxygen
- Use of vancomycin
  - Vancomycin powder
- Antimicrobial sutures

Negative Pressure Wound Therapy

- Routine use of prophylactic negative pressure wound therapy has not been shown to decrease SSIs
- Prophylactic negative pressure wound therapy on primarily-closed, high-risk surgical wounds may decrease SSI risk vs. standard wound dressings
  - Low quality evidence cited in ACS and WHO guidelines
  - High-risk wounds: surrounding soft tissue damage, poor blood flow, hematoma, or intraoperative contamination
- The pressure level or duration of negative pressure therapy needed to maximize SSI risk reduction is not known

Negative Pressure Wound Tx

- Large, randomized clinical trial of SSI after CSEC
- Enrolled 1624, stopped due to futility

Table 3. Primary and Secondary Outcomes by Randomization Group

Outcome	No. (%) Negative pressure (n = 806)	Standard dressing (n = 802)	Absolute risk difference (95% CI)[a]	Relative risk (95% CI)[b]	*P* value[c]
Primary outcome					
Superficial or deep surgical-site infection	29 (3.6)	27 (3.4)	0.36 (−1.46 to 2.19)	1.05 (0.63 to 1.76)	.70
Prespecified secondary outcomes					
Infection type					
Superficial surgical site	18 (2.2)	16 (2.0)	0.34 (−0.86 to 1.53)	1.12 (0.57 to 2.18)	.58
Deep surgical-site[d]	11 (1.4)	11 (1.4)	−0.18 (−1.20 to 0.84)	0.96 (0.42 to 2.20)	.73
Organ space surgical-site[d]	2 (0.3)	2 (0.3)	0.00 (−0.49 to 0.49)	0.97 (0.14 to 6.84)	>.99
Other wound complications	21 (2.6)	25 (3.1)	−0.53 (−1.93 to 0.88)	0.83 (0.47 to 1.47)	.46
Skin separation	11 (1.4)	9 (1.1)			
Seroma	5 (0.6)	6 (0.8)			
Hematoma	4 (0.5)	8 (1.0)			
Cellulitis	1 (0.1)	4 (0.1)			

Tuuli et al. JAMA 2020;1180-1189.

Oxygen and SSI: Basic Science

- O_2 is important for wound healing
- O_2 correlated with collagen deposition
- Tissue hypoxia is a risk factor for wound infection and dehiscence
- Superoxide production by leukocytes proportional to P_{O2}
- Many antibiotics require oxygen to exert lethal effects on bacteria

Hunt and Pai. Surg Gynecol Obstet. 1972;135:561-7.
Hartmann et al. Eur J Surg. 1992;158:521-6.
Hopf et al. *Arch Surg*. 1997;132:997-1004.
Allen et al. Arch Surg 1997;132:997-1005. Kohanski et al. Cell 2007;130:797-810.

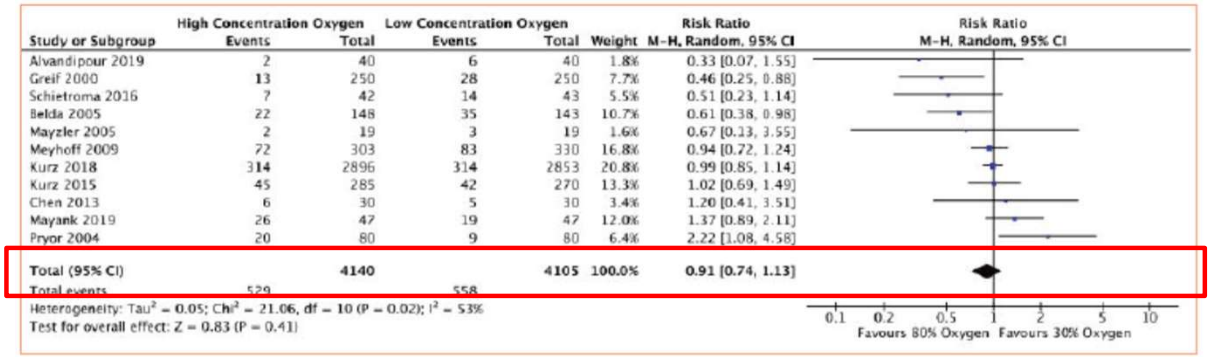
High Inspired O_2 Fraction

- Meta-analysis reviewed 5 RCTs
  - Variation in methods noted
    - 3 included nitrous oxide mixture
    - 1 provided O2 for 6 hours
    - 3 colorectal
    - Antibiotic prophylaxis not controlled for in all
- By fixed-effects method, data supports use of 80% FiO2 for prevention of SSI
- Previous guidelines – Essential Practice

Qadan et al. Arch Surg 2009;144:359-66.
Napolitano L. Arch Surg 2009;144:366-67.

Supplemental Oxygen: What Happened After 2014?

- 2022 Compendium: Unresolved
  - Optimize tissue oxygenation at the incision site
- Meta-analyses performed including additional studies
  - No significant impact of supplemental oxygen
  - Although “trend” towards SSI prevention still there



Study or Subgroup	High Concentration Oxygen Events	Total	Low Concentration Oxygen Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Alvandipour 2019	2	40	6	40	1.8%	0.33 [0.07, 1.55]
Greif 2000	13	250	28	250	7.7%	0.46 [0.25, 0.88]
Schietroma 2016	7	42	14	43	5.5%	0.51 [0.23, 1.14]
Belda 2005	22	148	35	143	10.7%	0.61 [0.38, 0.98]
Mayzler 2005	2	19	3	19	1.6%	0.67 [0.13, 3.55]
Meyhoff 2009	72	303	83	330	16.8%	0.94 [0.72, 1.24]
Kurz 2018	314	2896	314	2853	20.8%	0.99 [0.85, 1.14]
Kurz 2015	45	285	42	270	13.3%	1.02 [0.69, 1.49]
Chen 2013	6	30	5	30	3.4%	1.20 [0.41, 3.51]
Mayank 2019	26	47	19	47	12.0%	1.37 [0.89, 2.11]
Pryor 2004	20	80	9	80	6.4%	2.22 [1.08, 4.58]
Total (95% CI)		**4140**		**4105**	**100.0%**	**0.91 [0.74, 1.13]**
Total events	529		558			

Heterogeneity: $Tau^2 = 0.05$; $Chi^2 = 21.06$, $df = 10$ ($P = 0.02$); $I^2 = 53\%$
Test for overall effect: $Z = 0.83$ ($P = 0.41$)

Risk Ratio M-H, Random, 95% CI
0.1 0.2 0.5 1 2 5 10
Favours 80% Oxygen Favours 30% Oxygen

Figure 2. Forest Plot of the Incidence of Surgical Site Infection Comparing High Concentration (80% inspired) Versus Low Concentration (30-35% inspired) Oxygen for Colorectal Surgery
Abbreviations: CI, confidence interval; M-H, Mantel-Haenszel; Random, random-effects model

Shaffer et al, AANA Journal, 2021, Vol. 89, No. 3

What about IV Vancomycin?

- Discouraged
  - Indication for need significantly reduced
    - May have value during proven outbreak of MRSA SSI
    - No head-to-head comparison with decolonization strategy previously described
- Previously, “high rate” of MRSA SSI was potential indication
  - Retrospective cohort of 79,092 surgical patients
    - Perceived high rate of MRSA SSI was primary reason for use of vancomycin
      - Rate of colonization no higher
      - Rate of SSI no different
      - AKI higher
- Other studies also point to increased adverse events

Strymish et al. CID 2020;71:2732. Branch-Elliman et al. JAMA Surg

What about IV Vancomycin?

- Even though “covers” MRSA, vancomycin has decreased coverage compared to beta-lactams
  - No Gram negative activity
  - Reduced MSSA activity
- Some experts argue that should **add** vancomycin to standard agents when needed
  - Cohort study of 70,101 VA surgical patients receiving beta lactam, vanco, or both for prophylaxis
    - Combination led to higher rates of AKI than either alone
    - Combination led to lower SSI rate for cardiac procedures but not for ortho, vascular, GYN, or colorectal procedures

Branch-Elliman et al. PLOS Med 2017;14:e1002340

Vancomycin Powder?

- "Unresolved" issue
  - Several single center quasi-experimental studies found a lower rate of SSI in spinal surgery with the use of vancomycin powder
  - Others noted significant increase in the proportion of SSI with polymicrobial and Gram-negative pathogens
- RCT of 907 spinal procedures
  - Prophylactic abx vs. prophylactic abx + vancomycin powder
  - No difference in SSI outcomes
  - Small numbers
- Overall, no high quality data to support

Tubaki et al. Spine 2013;38:2149.

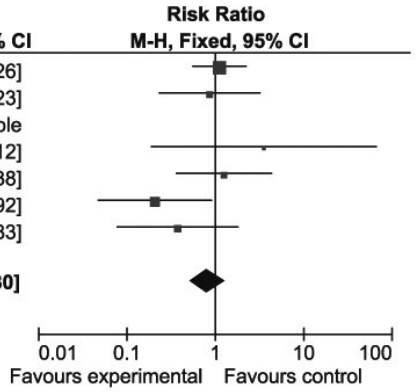
Antiseptic-Impregnated Sutures

- Presence of sutures decreases bacterial inoculum needed to cause SSI
  - 1,000,000 -> 100
- But data not convincing

Study or Subgroup	Abx suture Events	Total	Control Events	Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Baracs	14	153	14	170	36.7%	1.11 [0.55, 2.26]
Defazio 2005	4	50	4	43	11.9%	0.86 [0.23, 3.23]
Deliaert 2009	0	26	0	26		Not estimable
Ford 2005	3	98	0	49	1.8%	3.54 [0.19, 67.12]
Mingmalairak 2009	5	50	4	50	11.1%	1.25 [0.36, 4.38]
Rozelle 2008	2	46	8	38	24.2%	0.21 [0.05, 0.92]
Zhang	2	46	5	43	14.3%	0.37 [0.08, 1.83]
Total (95% CI)		**443**		**393**	**100.0%**	**0.82 [0.51, 1.30]**
Total events	30		35			

Heterogeneity: $Chi^2 = 6.33$, df = 5 (P = 0.28); $I^2 = 21\%$

Test for overall effect: Z = 0.85 (P = 0.39)



Chang et al. Ann Surg 2012;255:854

Supplementary Strategies – To Do or Not?

- Negative pressure dressings
  - Can be used as an Additional Practice
- Supplemental oxygen
  - *Don't know ("unresolved")*
    - *Now demoted*
- Use of vancomycin – expanded discussion
  - Not routine; try to avoid
  - May have special indications
  - Powder? *Unresolved*
- Antimicrobial sutures
  - Can be used as an Additional Practice

Take Home Points

- SSI is the most costly HAI
- Many different strategies are required to reduce SSI risk to lowest extent possible
- IPs play a critical role
- Not every hospital needs to approach SSI prevention the same way
  - But all hospitals need to review and use the essential strategies

Questions?

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