Preventing Surgical Site Infections

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- Owner, Infection Control Education for Major Sports, LLC

Outline

- Impact of SSI
- Surveillance for SSIs
- Strategies for Prevention
  - Basic recommendations
  - 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

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

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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

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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

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Prevention - Recent Guidelines

- SHEA/IDSA – 2014*
- WHO – 2016
- ACS – 2016
- CDC – 2017
- ASHP – 2013*

**currently being revised*

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Basic Practices

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Basic Practices – First Tier

- Timing
- Dose
  - Re-dose?
- Duration
- Mechanical Bowel Prep
- Post-op glucose control
  - 180 mg/dL
  - Cardiac and non-cardiac
  - 18-24 hours after end of anesthesia

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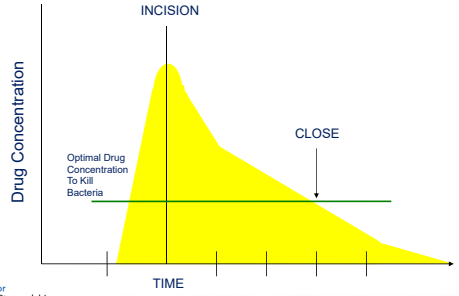
Timing and Dose - GOALS

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

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

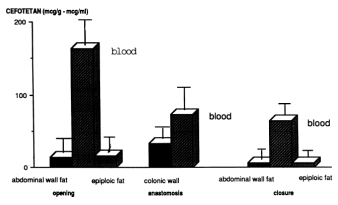
Obesity is a Risk Factor for SSI

- 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.

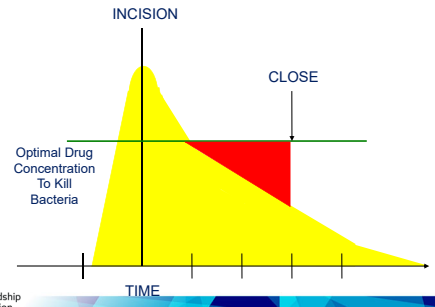
Tissue Concentration

- 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.

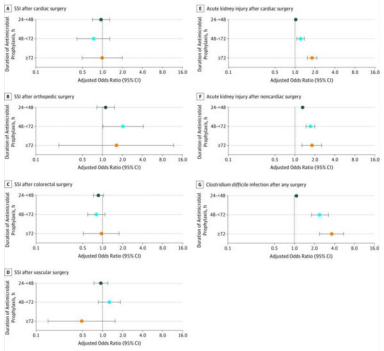
Duration

- Current: 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]
- Newer guidelines will promote stopping <u>after closure</u>
- No benefit, but increased risk of harm
  - *C. difficile*
  - Antibiotic resistance
  - AKI

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

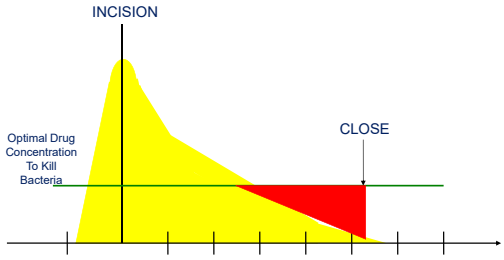


Branch-Elliman et al. JAMA Surgery 2019;154:590

Expand the Details - Basic Practices

- Re-dosing for prolonged procedures
  - Prolonged surgical duration is risk factor for SSI
- Bowel prep

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[b]	Recommended Redosing Interval (From Initiation of Preoperative Dose), hr[c]
	Adults[a]	Pediatrics[a]		
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[d]	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

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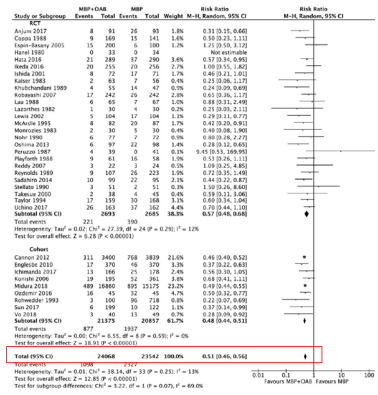
MBP + PO Abx vs. MBP alone

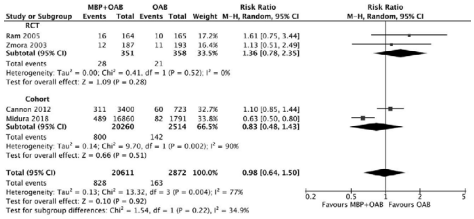
Systematic Review of 40 studies



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

MBP + PO Abx vs. PO Abx

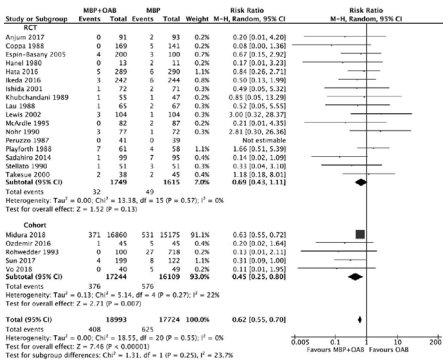
No difference



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

Harm?

Decreased risk of anastomotic leak with MBP + PO Abx



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)

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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.

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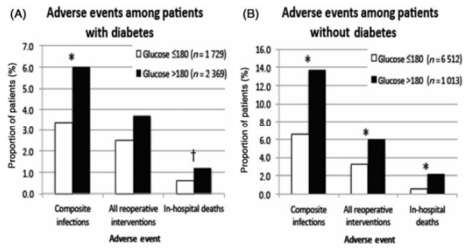

Kwon et al. Ann Surg 2013;257:8-14.

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.

Other First Tier Interventions

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

Basic Practices – Second Tier

- Oxygenation
- Skin prep
- WHO checklist

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

- Recent 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

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

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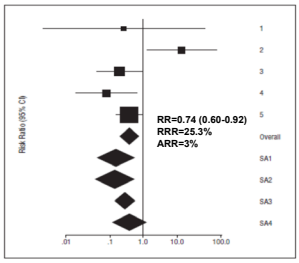

Qadan et al. Arch Surg 2009;144:359-66.
Napolitano L. Arch Surg 2009;144:366-67.

Harm?

- PROXI Trial
  - n=1400 patients undergoing acute or elective laparotomy
  - Randomized to 80% v. 30% FiO_2
  - SSI dx in 14 days
- No difference in rates of SSI for two groups
  - Approx 20% for each group
  - Adjusted RR=0.91 (0.69 to 1.20)
- No difference in adverse outcomes between two groups

Meyhoff et al. JAMA 2009;302:1543-50.
Hunt and Hopf. JAMA 2009;302:1588-9.

Implementation?

- Not easy
- Reasonable chance being given high FiO_2 *during* procedure
- Difficult to develop process to continue high FiO_2 *after* procedure

Skin Prep

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

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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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.

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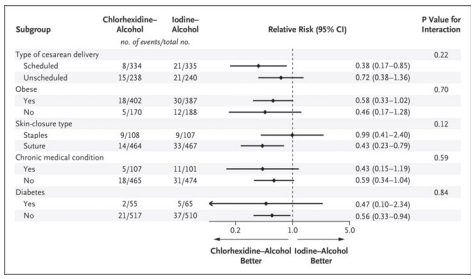
CHG v. PI

RCT of 1,147 women



Tuuli et al. NEJM 2016;374:647

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.

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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

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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	

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

Supplementary Strategies – To Do or Not?

- Wound lavage
- "Colorectal bundle"
  - Glove change for closure?
- Screening and decolonization for *S. aureus*
- Use of vancomycin
- Antimicrobial sutures
- Negative pressure wound therapy

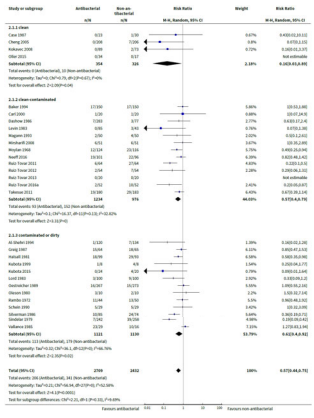
Wound Lavage

- 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.



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

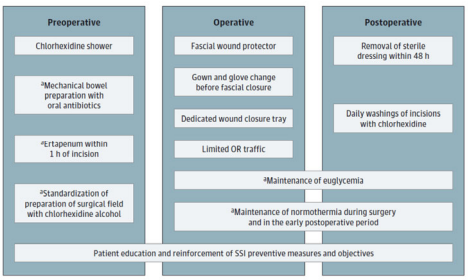
De Jonge et al. Surg Infect 2017;18:508. Thom H et al. Surg Infect 2021;22:144.

Colorectal Bundle – The Duke Experience

- 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

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	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 concensus
- Frankly, not a bad idea

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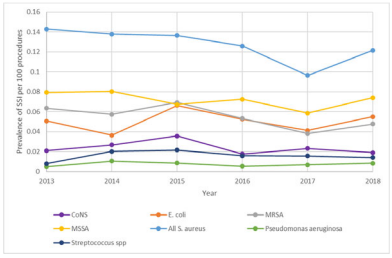
S. aureus Screening/Decolonization

- 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!



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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

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S. aureus Decolonization

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

Included screening and decolonization

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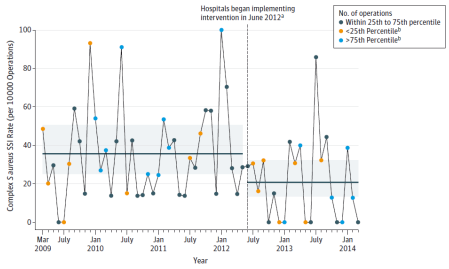

Schweizer et al. JAMA 2015;313:2162.

Screening/Decolonization Considerations

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

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.

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.

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.

Take Home Points

- SSI is the most common and 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 at least use the basic strategies

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Questions?

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