The Role of Surgeons in Antibiotic Stewardship

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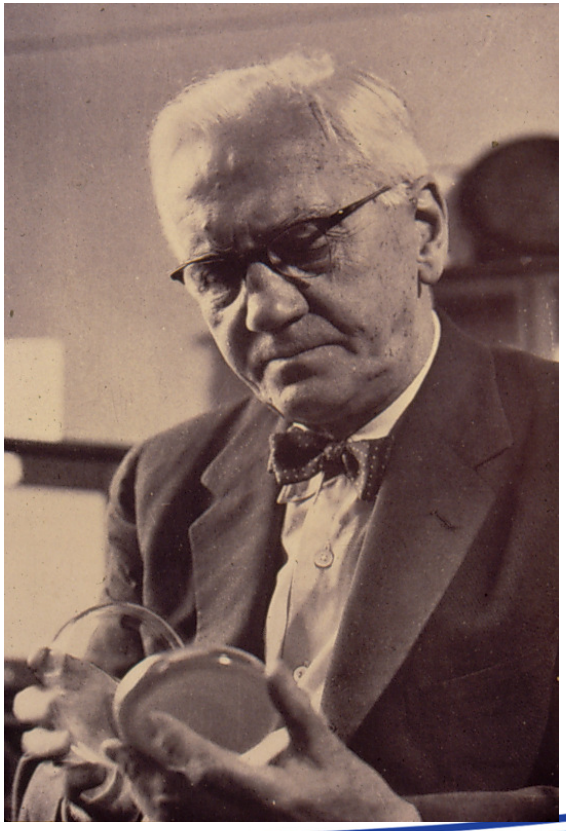
Discovery of Penicillin

- Alexander Fleming discovered Penicillin in 1929.
- The introduction of antibiotics into clinical practice(early 1940s) raised great hopes in the treatment of bacterial infection.
- In surgery, the prospects of using antibiotics for prevention was immediately recognized as a possibility.



Discovery of Sulfanilamide

- Discovered Prontosil in 1931.
- Published results in 1935
- Treated patients with streptococcal and staphylococcal infections
- Received the Nobel Prize in 1939.

Gerhard Domagk (1895-1964)


Newsweek
March 28, 1994
$2.95
ANTIBIOTICS
THE END OF MIRACLE DRUGS?
WARNING
NO LONGER EFFECTIVE AGAINST KILLER BUGS

Antimicrobial Resistance: Arrival of the Post-Antibiotic Era

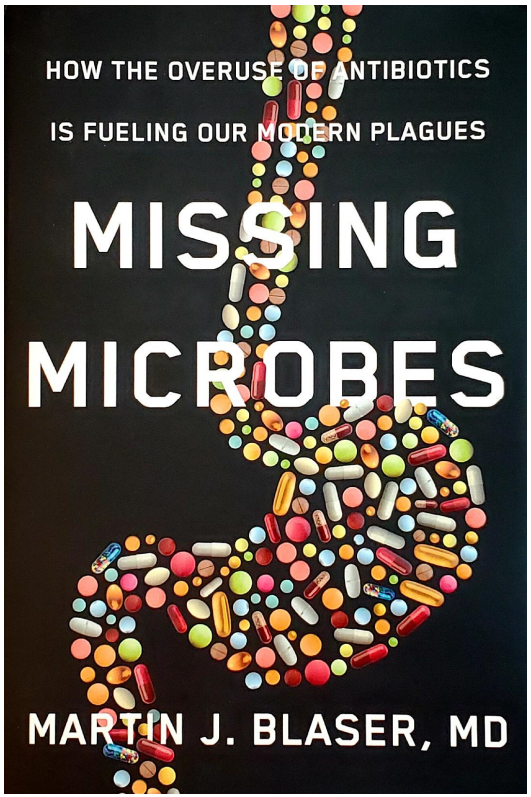
Why has resistance emerged?

- Promiscuous use of antibiotics(e.g., preventive antibiotics)
- Failure to de-escalate combination therapy of empirical choices.
- Inappropriate antibiotic therapy
- Patient expectations and demands for antibiotic therapy
- Prolonged administration when infection does exist
- Poultry industry

RESULT: **Pan-Resistance of Pathogens to all available antibiotics**

Four Horsemen of the Microbial Apocalypse

Other Potential Consequences of Antibiotics



- Asthma
- Allergies
- Obesity
- Type-2 Diabetes
- Reflux Esophagitis
- C. difficile Infection
- Oncogenesis

Antibiotic Stewardship Programs

Antibiotic Stewardship in Surgery

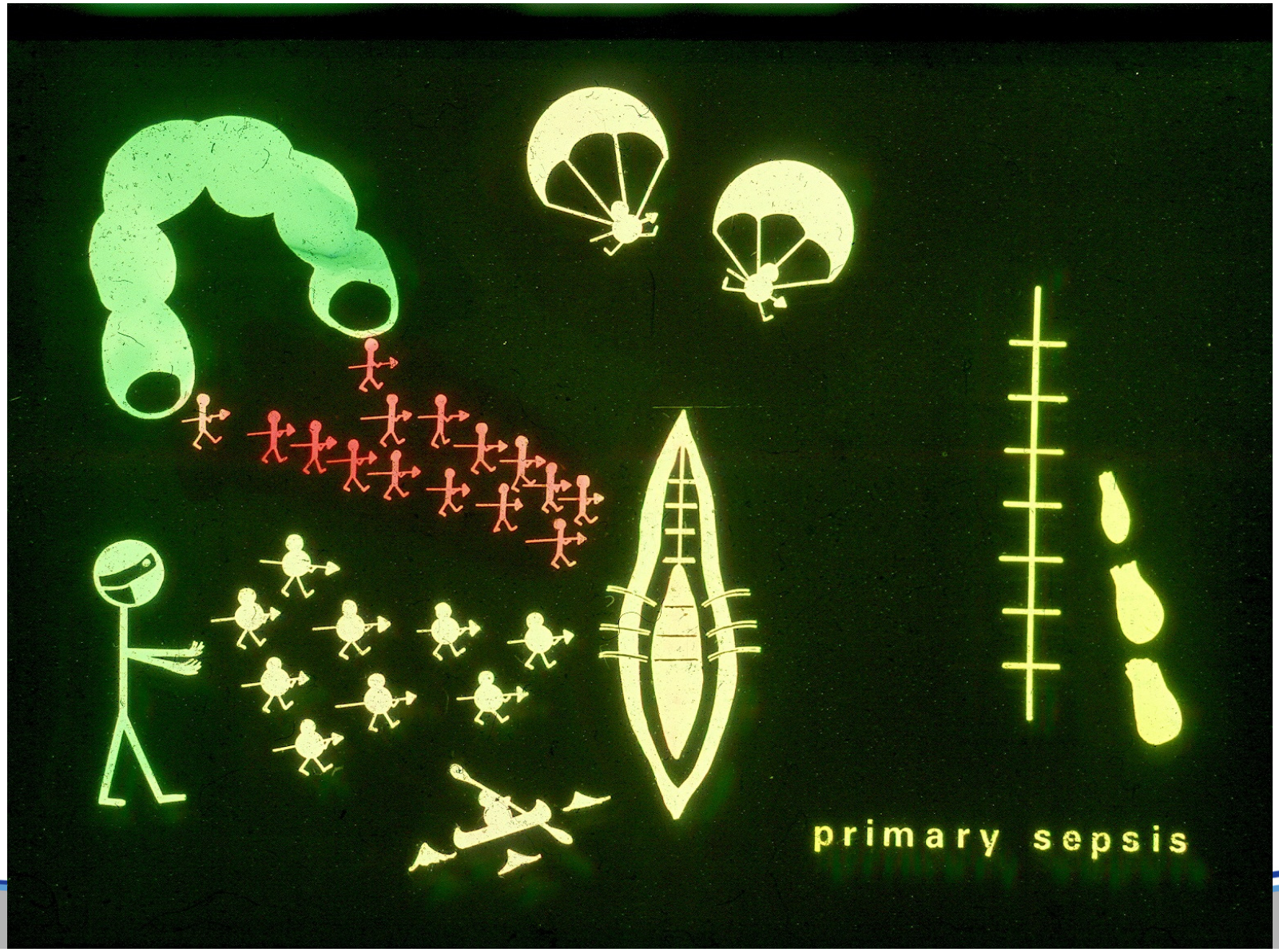
Goals

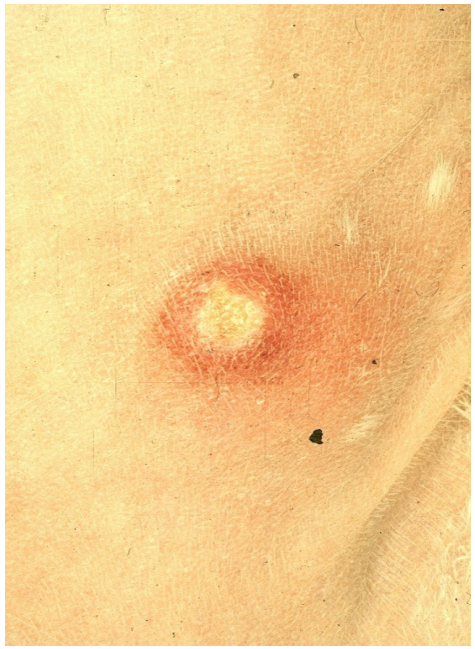
- Avoid Unnecessary Antibiotic Use
- Reduce Resistance Pressure
- Reduce Unnecessary Costs
- Reduce Antibiotic-Associated Morbidity

Objectives

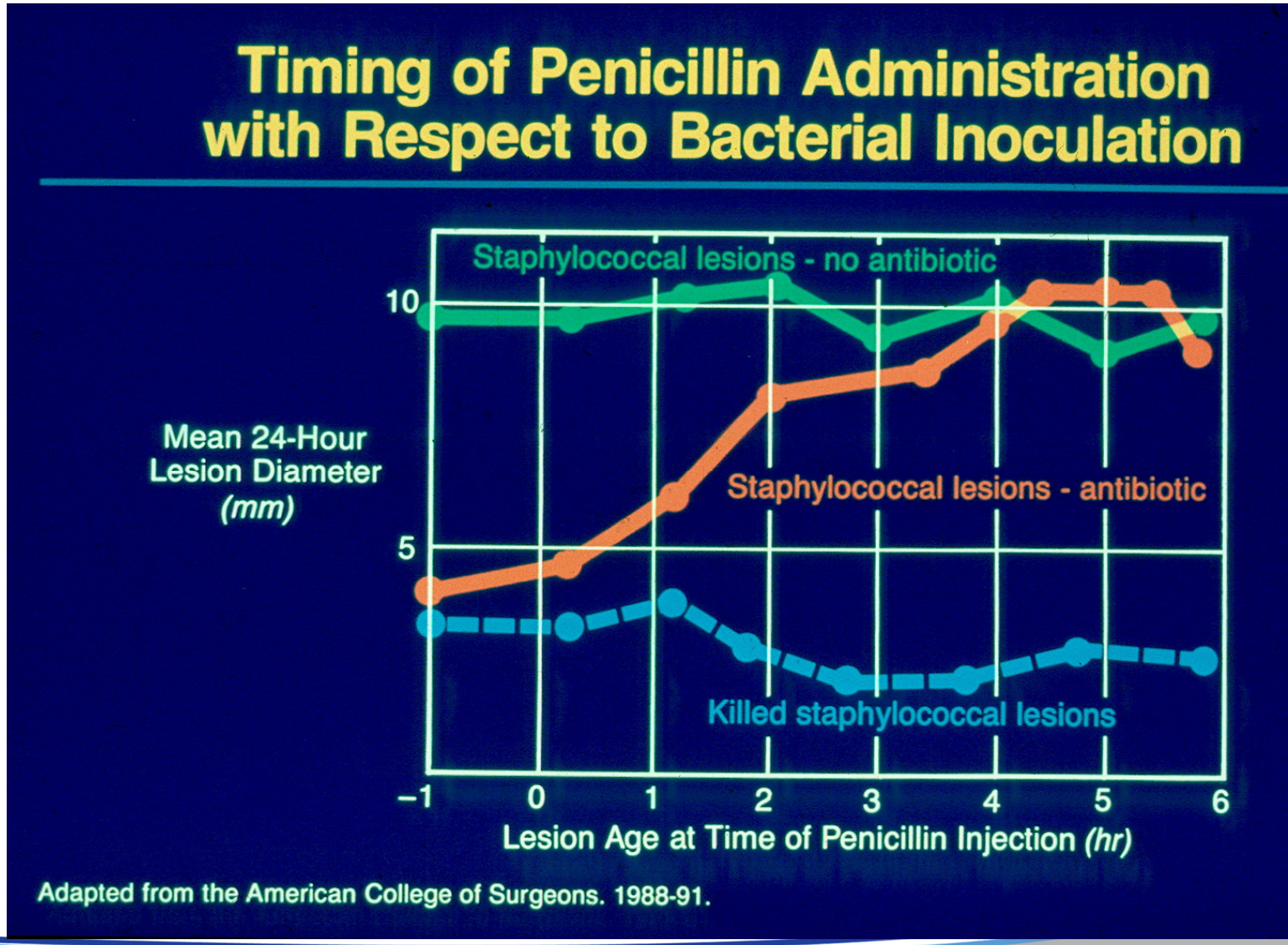
- Appropriate Preventive Antibiotic Use
- Effective Source Control of the Infection
- Avoid delays in initiation
- Avoid Excessive duration
- Better use of non-antibiotic infection management strategies

Appropriate Antibiotic Use to Prevent Surgical Site Infection


primary sepsis



Miles et al: Brit J Exp Pathol 1957



Prevention of Surgical Site Infection

Use of Preventive Antibiotics (cephaloridine): GI Surgery

Patients	101	98
Colon Pts	54	50
Infections	6	29
Colon Inf	7%	30%*

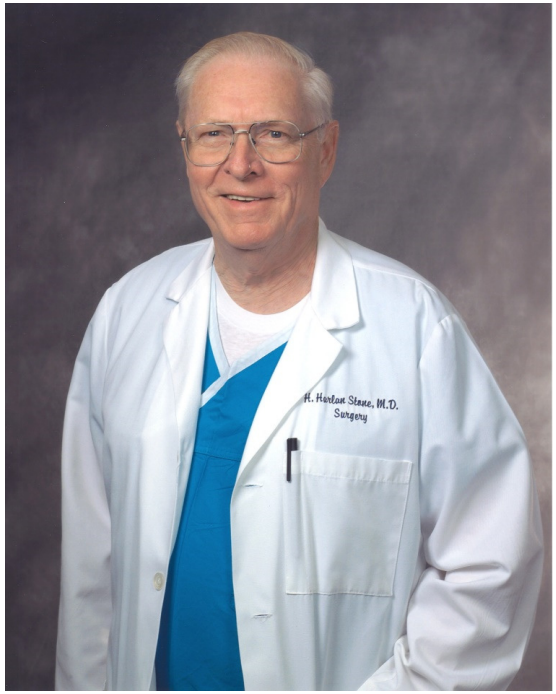
(P < .05)*

(Polk and Lopez-Mayor, *Surgery* 1969; 66:97

Preventive Systemic Antibiotics:
Importance of Timing(Cefazolin)

	8-12Hrs Preop	1Hr Preop	1-4Hrs Postop	None
Gastric	5%	4%	17%	22%
Biliary	3%	0%	9%	11%
Colon	6%	6%	15%	16%
Total	4%	3%	14%	15%

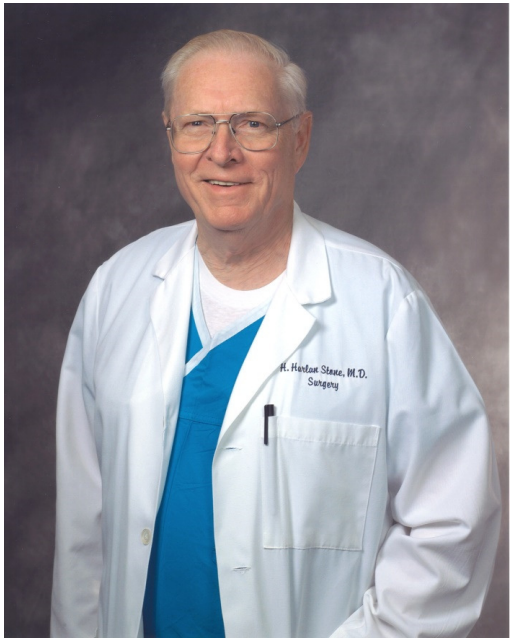
(Stone, Ann Surg 1976; 184:443)



Preventive Systemic Antibiotics
Postoperative Administration(Cefamandole)

	Preop Drug + 5 Days of Drug	Preop Drug + 5 Days of Placebo
Gastric	0%	0%
Biliary	0%	6%
Colon	11%	9%
Total	5%	6%

(Stone, Ann Surg 1979; 189:691)



Prevention of SSIs

Surgical Infection Prevention Project

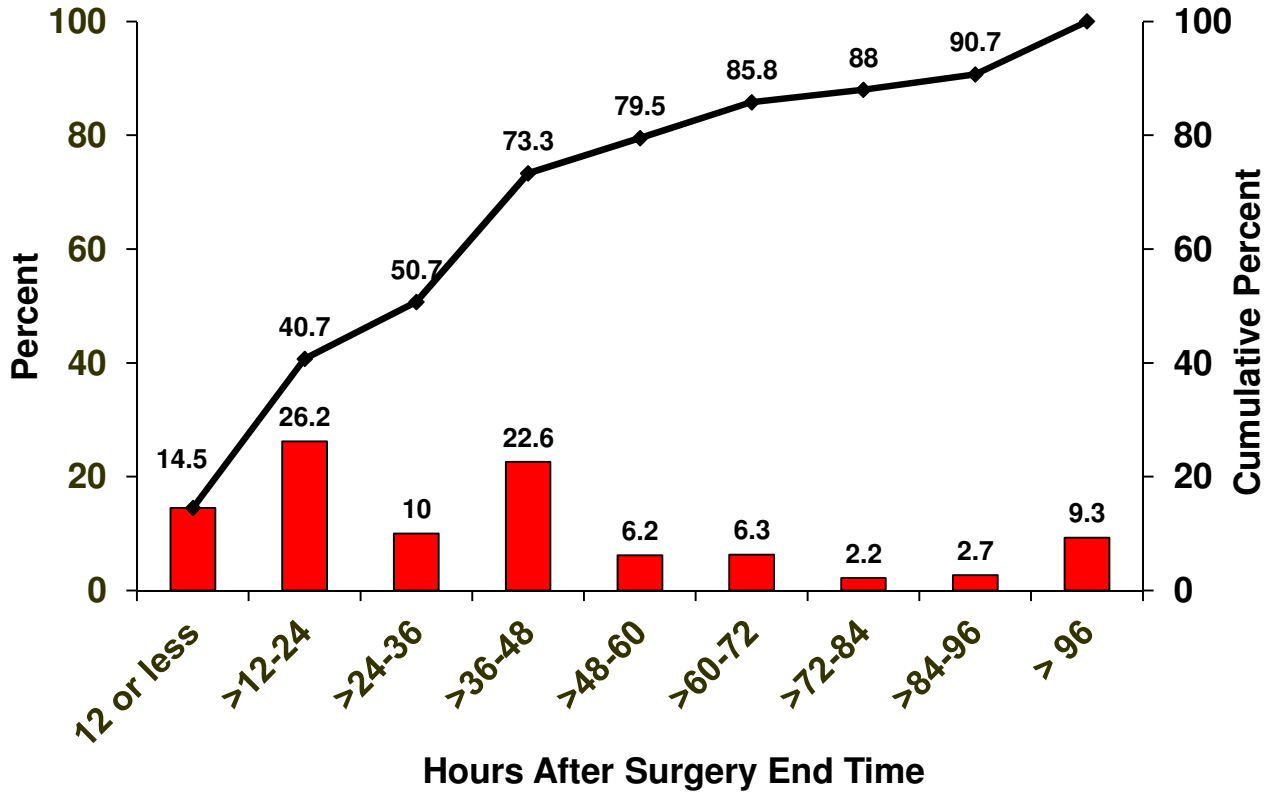
- Administration of antibiotic within 60 min of skin incision.
- Antibiotic consistent with recommended choices.
- Antibiotic should not be continued beyond 24 hours after completion of the procedure.

Bratzler et al Arch Surg 2005, 140:174-82.

Surgical Infection Prevention
Performance Stratified by Surgery

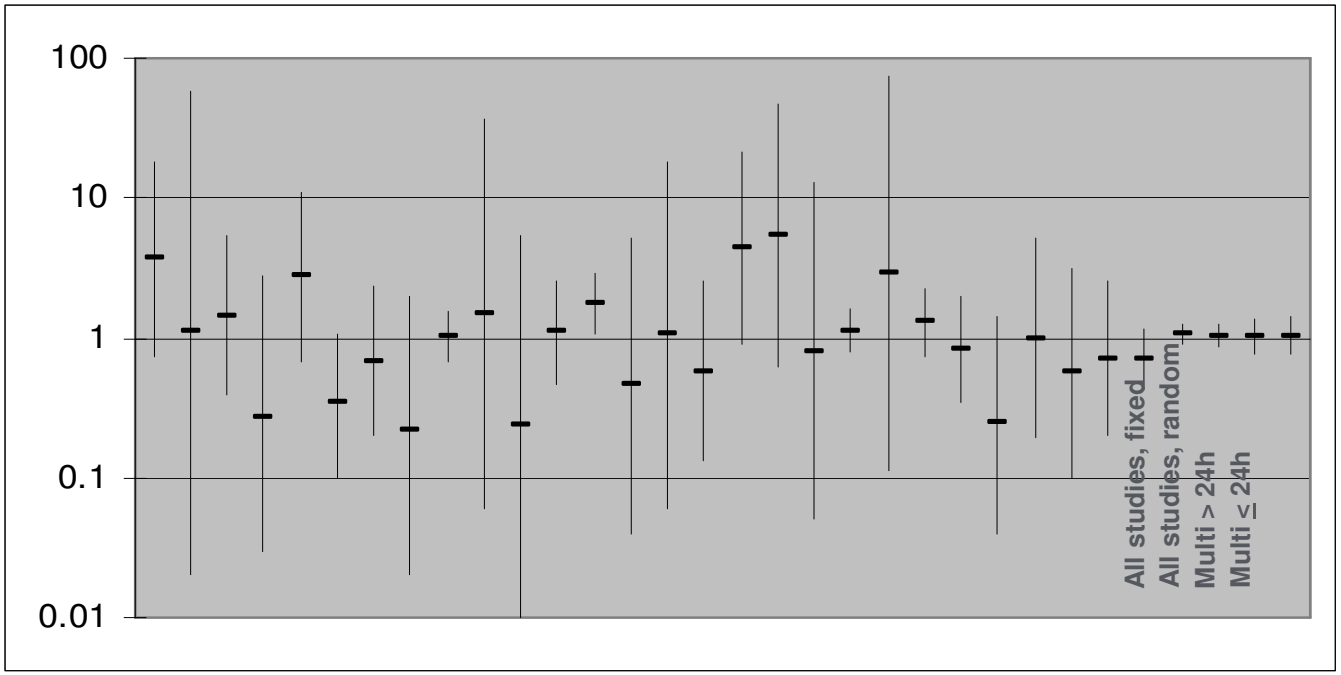
Surgery (N)	Antibiotic within 1 hour %	Correct Antibiotic %	Antibiotic Stopped within 24 hours %
Cardiac (7,861)	45.3	95.8	34.3
Vascular (3,207)	40.0	91.9	44.8
Hip/knee (15,030)	52.0	97.4	36.3
Colon (5,279)	40.6	75.9	41.0
Hysterectomy (2,756)	52.4	90.8	79.1
All Surgeries (34,133)	47.6	92.9	40.7

National SURGICAL INFECTION PREVENTION Medicare Quality Improvement Project


100
80
60
40
20
0
Percent
100
80
60
40
20
0
Cumulative Percent
14.5
26.2
10
22.6
6.2
6.3
2.2
2.7
9.3
40.7
50.7
73.3
79.5
85.8
88
90.7
12 or less
>12-24
>24-36
>36-48
>48-60
>60-72
>72-84
>84-96
> 96
Hours After Surgery End Time

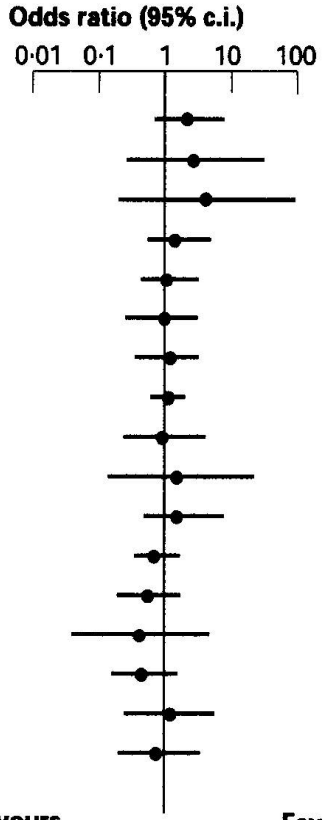
18

Single vs Multiple Dose Surgical Prophylaxis: Systematic Review



McDonald. Aust NZ J Surg 1998;68:388

Reference	Year	Antibiotic	Proportion with surgical wound infection
Carr *et al.*[68]	1984	Metronidazole(1) *versus* (2-4)	7 of 22 *versus* 11 of 68
Aberg and Thore[69]	1991	Cefuroxime + metronidazole(1) *versus* (3)	2 of 19 *versus* 1 of 29
Corman *et al.*[27]	1993	Cefoxitin(1) *versus* (4)	2 of 31 *versus* 0 of 27
Kow *et al.*[70]	1995	Cefoxitin(1) *versus* (3)	10 of 73 *versus* 8 of 81
Jensen *et al.*[25]	1990	Ampicillin + metronidazole(1) *versus* (3)	14 of 100 *versus* 12 of 104
Juul *et al.*[71]	1987	Ampicillin + metronidazole(1) *versus* (4)	9 of 149 *versus* 8 of 145
Hall *et al.*[31]	1989	Latamoxef(1) *versus* (8)	12 of 119 *versus* 10 of 126
Bates *et al.*[72]	1992	Co-amoxiclav(1) *versus* (3)	23 of 113 *versus* 17 of 111
Grundmann *et al.*[73]	1987	Mezlocillin + metronidazole(1) *versus* (3)	4 of 77 *versus* 4 of 77
Mendel *et al.*[74]	1987	Mezlocillin + metronidazole(1) *versus* (9)	2 of 54 *versus* 1 of 46
Bittner *et al.*[75]	1989	Mezlocillin + metronidazole(1) *versus* (7)	6 of 46 *versus* 3 of 44
Cuthbertson *et al.*[76]	1991	Ticarcillin/clavulanic acid(1) *versus* (2)	16 of 146 *versus* 17 of 132
Kow *et al.*[70]	1995	Cefotaxime + metronidazole(1) *versus* (3)	7 of 84 *versus* 9 of 81
Goransson *et al.*[77]	1984	Doxycycline(1) *versus* (4)	1 of 53 *versus* 2 of 49
Wenzel *et al.*[78]	1985	Gentamicin + metronidazole(1) *versus* (3)	6 of 30 *versus* 10 of 30
Lohr *et al.*[79]	1984	Cefotaxime(1) *versus* (3)	4 of 30 *versus* 3 of 30
Tuchmann *et al.*[80]	1988	Piperacillin + metronidazole(1) *versus* (3)	4 of 61 *versus* 5 of 63



Song and Glenny: Brit J Surg 1998; 85:1232

Fig. 5 Effect of single *versus* multiple doses of antibiotic in preventing surgical wound infection in colorectal surgery. Values in parentheses are number of doses. c.i., Confidence interval

Preventive Antibiotics
Why Postoperative administration does not work

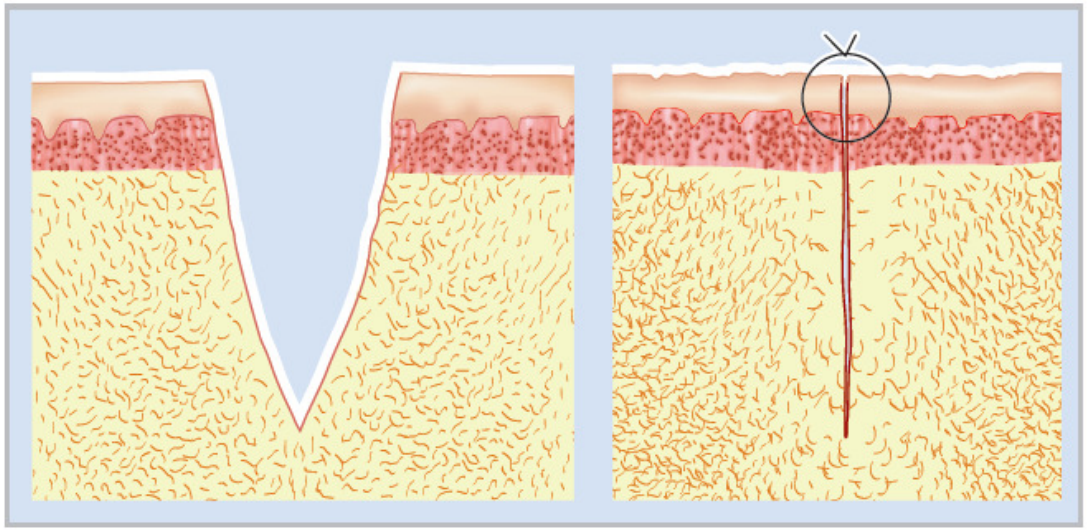


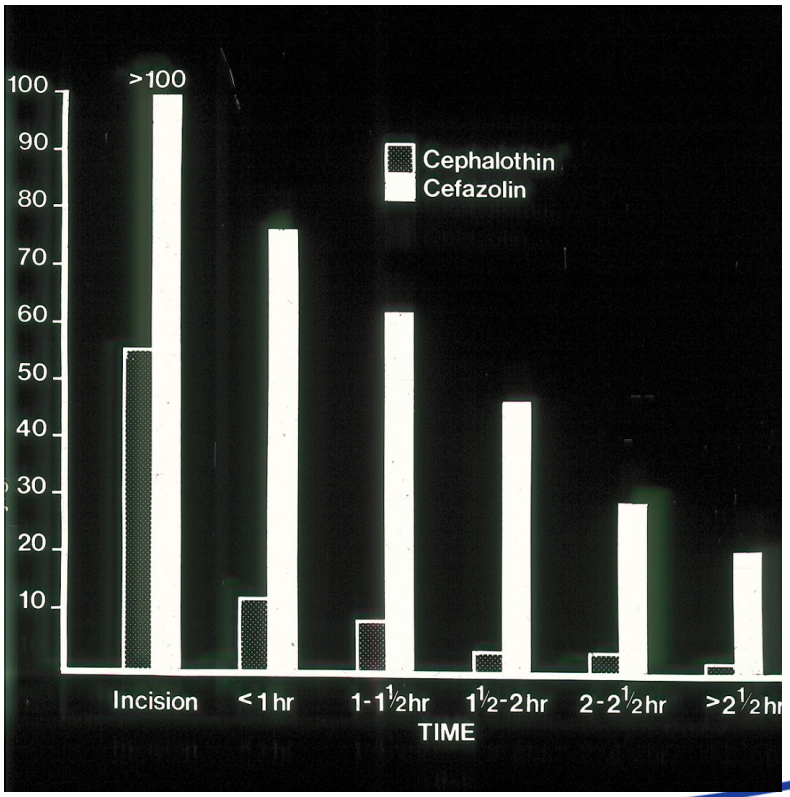
Figure 4.3 The fibrin layer on the wound interface and the presence of the fibrin matrix in the closed wound. Note the "halo" of edema about the closed wound and the potential consequences of increased tissue hydrostatic pressure and ischemia of the interface.

Systemic Preventive Antibiotics

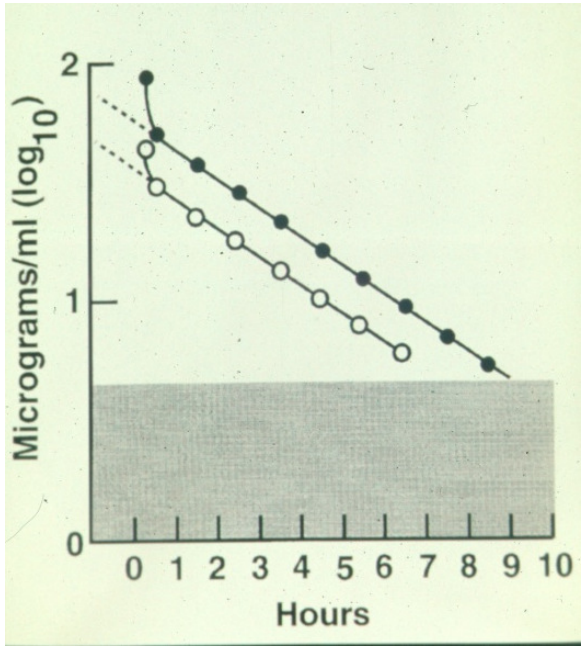
Elimination Half-life Counts!

- Cephalothin is gone from the wound in 90 min from time of administration.
- Cefazolin in therapeutic concentrations beyond 2½ hours.

(Fry, Arch Surg 1990; 125:1490)



Preventive Antibiotics in Trauma
Effect of dosing



- Mean age: 37 years
- Dose of Amikacin: 7.5 - 10 mg/kg
- All had normal creatinine
- $T_{1/2}$ Estimated = 3.3 hrs
- $T_{1/2}$ Measured = 1.9 hrs
- V_d Estimated = 14. 3 L
- V_d Measured = 20. 9 L

	≤ 10mg/kg	≥ 10 mg/kg	P=
All patients	21/87 (24%)	5/63 (8%)	<0.01
No Colon	12/57 (21%)	1/48 (2%)	<0.005
+ Colon	9/30 (30%)	4/15 (27%)	N.S.
High Blood Loss (>6L)	16/43 (37%)	3/27 (11%)	<0.02
ISS > 20	11/32 (34%)	1/18 (6%)	<0.025
ISS < 20	10/55 (18%)	4/45 (9%)	N.S.

Ericsson et al: J Trauma 1989; 29:1356

Preventive Antibiotics in Surgery Coverage of MRSA?

- Randomized trial in cardiovascular procedures.
- An environment with high rates of MRSA infection
- Randomization of vancomycin vs. cefazolin
- Overall SSI rates were the same.
- Cefazolin-associated infections had high frequency of MRSA
- Vancomycin-associated infections had high frequency of MSSA

Finkelstein et al: JTCVS, 2002;123:326

TABLE 2. Outcomes of 885 patients receiving vancomycin or cefazolin prophylaxis for cardiovascular operations

	Vancomycin (n = 452)	Cefazolin (n = 433)
Superficial incisional SSI (No.)		
All	25 (5.5%)	20 (4.6%)
Donor site	7 (1.5%)	10 (2.3%)
Chest	18 (4%)	10 (2.3%)
Deep incisional SSI (No.)		
All	12 (2.6%)	7 (1.6%)
Donor site	2 (0.4%)	2 (0.4%)
Chest	10 (2.2%)	5 (1.2%)
Organ-space SSI (No.)		
All	6 (1.3%)	12 (2.7%)
Mediastinitis	5 (1.1%)	7 (1.6%)
Osteomyelitis	0	3 (0.7%)
Endocarditis	1 (0.2%)	2 (0.4%)
Pericarditis	0	0
Any SSI (No.)	43 (9.5%)	39 (9.0%)
Duration of postoperative hospitalization (d, mean ± SD)	8.7 ± 8	9.3 ± 11
Deaths (No.)	13 (2.9%)	14 (3.2%)

No differences were significant at $P \leq .05$.

Preventive Antibiotic Stewardship Summary

- No Antibiotics administered after wound closure
- Use longer half-life antibiotics and re-dose at two half-life intervals for longer operation.
- Administer the drugs within ≤ 60 minutes before incision.
- Increase the administration dose for emergency/trauma cases
- Monitor home antibiotic following Outpatient/Ambulatory Surgery

Antibiotic Choice

- SCJP choices are appropriate for uncomplicated patients.
- Beware of the Patient with adverse colonization!
  - 90-day prior hospitalization
  - 90-day prior antibiotic therapy
  - Hemodialysis Patient
  - Nursing Home Patients
  - History of Prior Surgical Site Infections
  - Known MRSA carrier

The Best Antibiotic Stewardship in Surgery in avoiding preventable Infections!

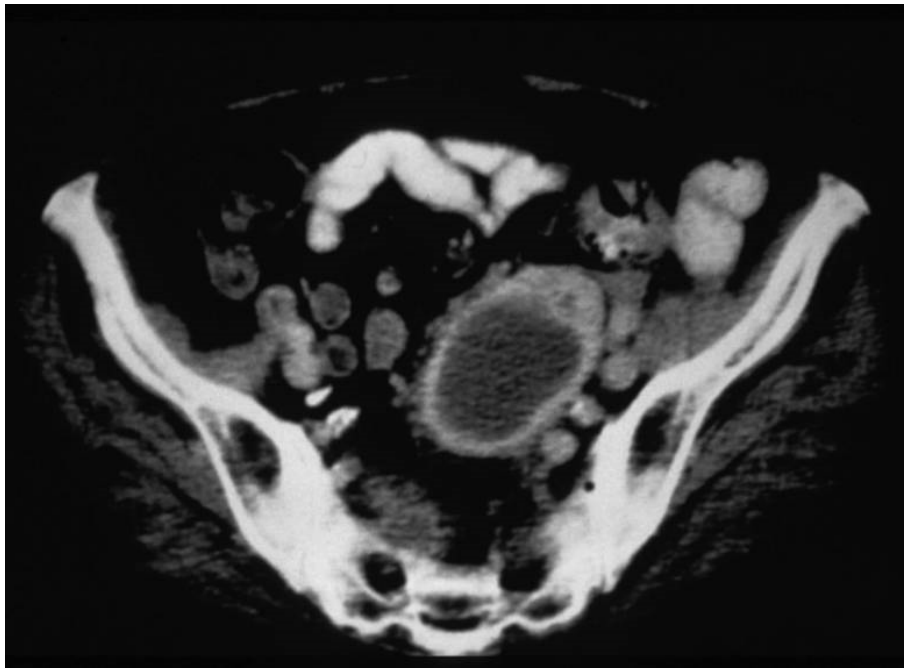
Effective Source Control of Infection

Inadequate Source Control

Fix the hole; Debride dead tissue; Drain the Pus!

Gross Contamination/Pus

- Very large bacterial inoculum (> 10^7 bacteria/ml)
- Inoculum Effect neutralizes anticipated antimicrobial activity
- Environment is anaerobic, acidic, protein-rich.
- Fibrin-entrapped bacteria not affected by systemic drugs
- Polymicrobial and Synergistic



Inadequate Source Control

- Tellor (Mazuski), Surg Infect 2015
  - N= 108 patients
  - All with positive blood cultures from an intraabdominal infection
  - Median APACHE II = 20
  - 72% Mechanically ventilated
  - Overall Mortality = 28%

- Significant Clinical Outcome Predictors

TABLE 9. MULTIVARIATE LOGISTIC REGRESSION ANALYSIS

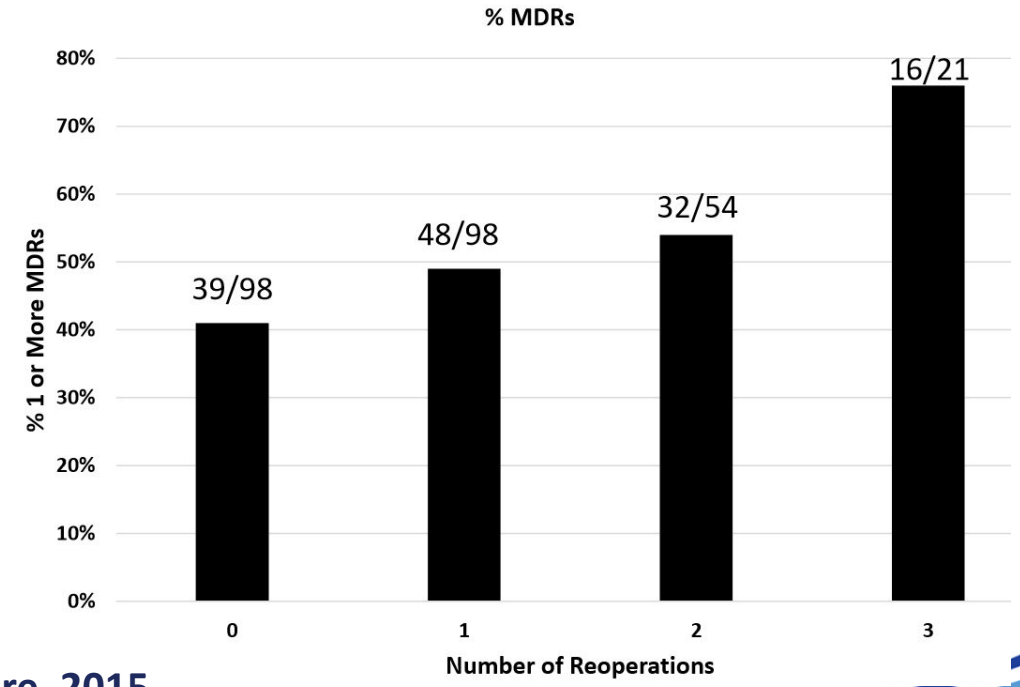
Variable	*AOR, 95% CI*	p
Inadequate source control	7.46, 2.08–26.32	0.002
Inappropriate antibiotics	3.86, 1.28–11.64	0.016
APACHE II score (1 point increments)	0.93, 0.87– 1.01	0.084

Hosmer-Lemeshow p = 0.943, AUROC = 0.776.
AOR = adjusted odds ratio; CI = confidence interval; APACHE = Acute Physiology and Chronic Health Evaluation.

Inadequate Source Control Promotes Multidrug Resistant (MDR) Pathogens

- 220 ICU Patients: Initial operation for IAI
- Reoperated and non-reoperated patients had similar Pathogens at initial cultures.
- Initial antibiotic profiles were similar between no reoperation and reoperation groups.

Conclusion: Failed source control promotes resistant pathogens.

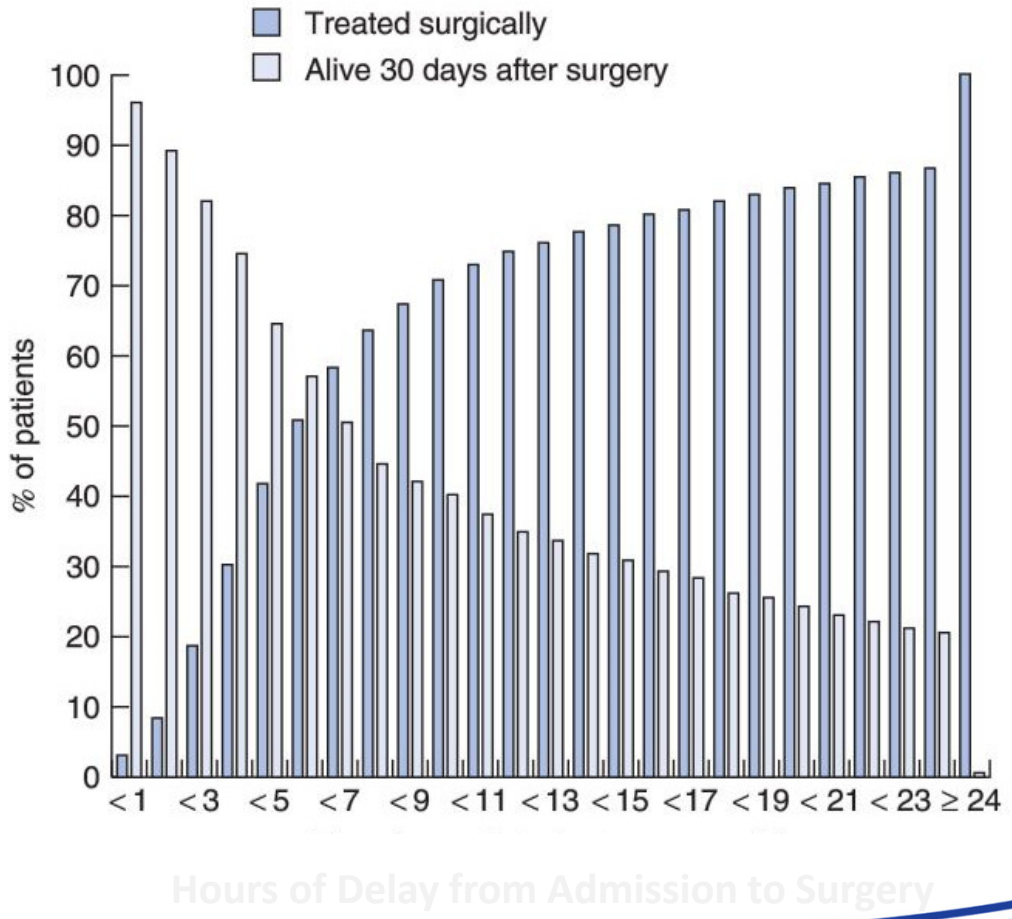


Montravers P, et al: Critical Care, 2015

Delay in Surgical Intervention

Buck DL: Brit J Surg, 2013.
Perforated Ulcers.

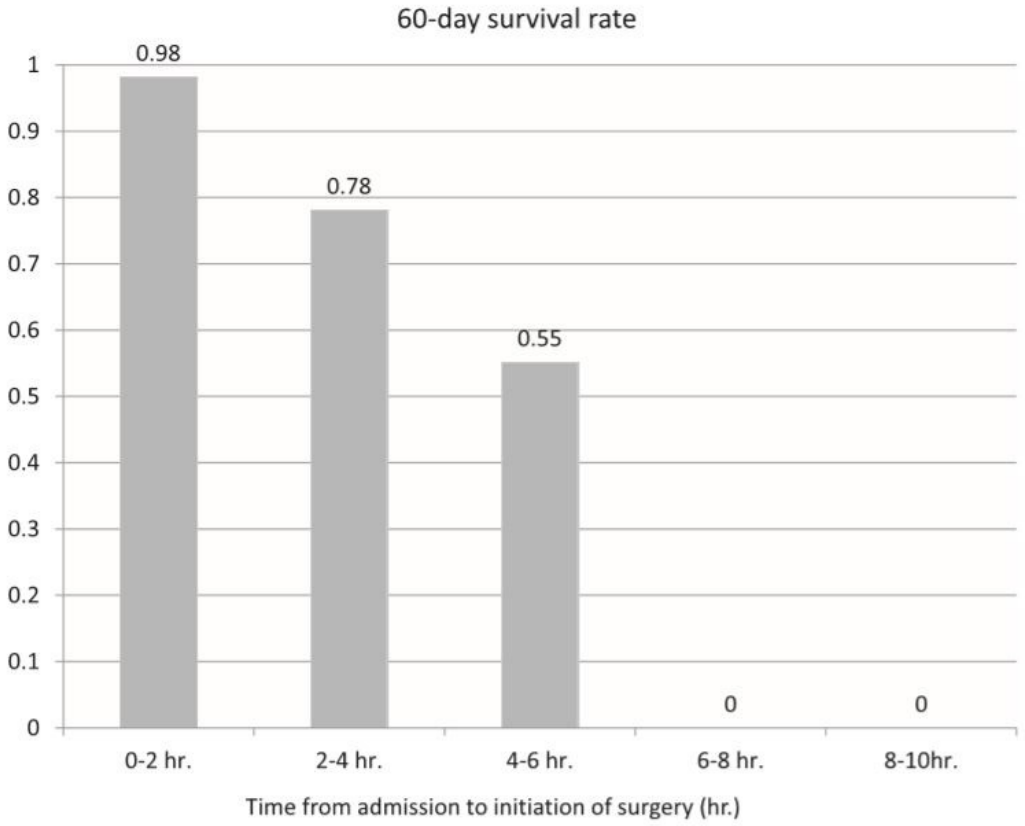
- **Danish Clinical Registry of Emergency Surgery (N=2,668)**
- **30-day mortality measured by number of hours from admission to OR.**
- **Mean age = 70 years**
- **ASA ≥ 3 in 45.6%**
- **Alcohol Abuse = 18.9%**
- **Tobacco Abuse = 61.3%**
- **30 Day Morality = 26.5%**
- **Death rate increase 2% per hour of delay.**



Delay in Source Control: IAI
Azuhata T, et al: Crit Care 2014

Table 1 Primary diseases of all patients

	Patients, number (%)	Deaths, number (%)
Colon/rectal diverticulitis	35 (22.7)	6 (17.6)
Mechanical small bowel obstruction	27 (17.5)	3 (8.8)
Mesenteric ischemia and necrotic bowel	21 (13.6)	9 (26.5)
Idiopathic lower digestive tract perforation	16 (10.4)	5 (14.7)
Colon/rectal cancer	15 (9.7)	0 (0.0)
Gastric/duodenal peptic ulcer	9 (5,8)	1 (2.9)
Non-occlusive mesenteric ischemia	9 (5.8)	4 (11,8)
Gastric canes	5 (3.2)	1 (2.9)
Inflammatory bowel disease	5 (3.2)	1 (2.9)
Sigmoid volvulus	3 (1.9)	0 (0.0)
Strangulated inguinal/femur hernia	3 (1.9)	0 (0.0)
Toxic mega-colon	2 (1.3)	2 (5.9)
Other	4 (2.6)	2 (5.9)
Total	154	34



Prompt Initiation of Antibiotics for Established Infection

Delay in Initiation of Antibiotic Therapy

Barie et al:Surg Infect, 2005

Patient Population:

- 334 ICU Surgical Patients
- 40% Pneumonia
- 30% IAI
- 10% Soft Tissue
- 30.8% Deaths

TABLE 5. BINARY LOGISTIC REGRESSION ANALYSIS (DEPENDENT VARIABLE, MORTALITY)

		95.0% C.I.		
Parameter	*Odds ratio*	*Lower*	*Upper*	*p value*
Age, years	1.028	1.001	1.055	0.04
APACHE III	1.025	1.01	1.04	0.001
Peak temperature	1.108	0.62	1.978	0.729
ICU day peak temperature	1.088	0.979	1.208	0.116
Days of antibiotics	1.135	0.997	1.292	0.056
Time to Abx administration	1.021	1.003	1.038	0.02
Time to Abx comfirmation	0.996	0.99	1.003	0.266
Male gender	0.482	0.228	1.019	0.056
Appropriateness Abx 1	1.623	0.776	3.391	0.198
Appropriateness Abx 2	0.923	0.824	1.033	0.162

Abx, antibiotic.
Model χ^2 8.038 (good discrimination), Hosmer-Lemeshow goodness of fit p = 0.441 (good calibration).

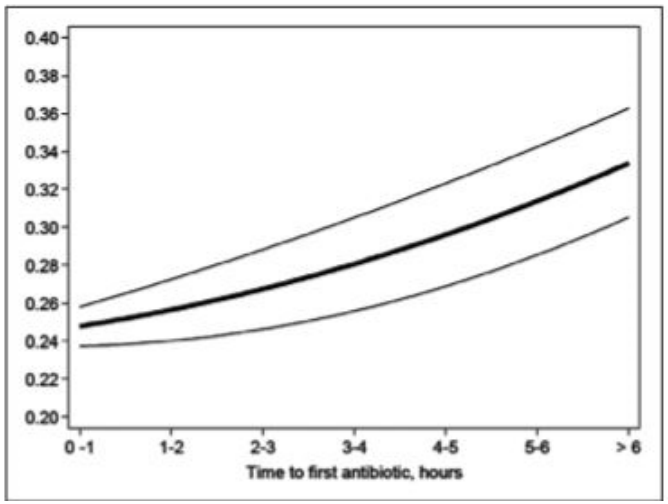
Delay in Initiation of Antibiotics

Surviving Sepsis Campaign Database: Ferrer et al, Crit Care Med, 2015

Patient Characteristic, *n* (%)	Antibiotic Timing (Hr)							
	0.0–1.0	1.0–2.0	2.0–3.0	3.0–4.0	4.0–5.0	5.0–6.0	> 6.0	*p*[a]
Site of infection								
Pneumonia	2,388 (50.5)	2,308 (50.2)	1,398 (46.3)	729 (42.0)	430 (41.5)	252 (39.4)	982 (43.9)	< 0.001
Urinary tract infection	1,076 (22.8)	1,332 (29.0)	950 (31.5)	518 (29.9)	273 (26.3)	164 (25.6)	444 (19.9)	< 0.001
Abdominal	914 (19.3)	738 (16.1)	545 (18.1)	387 (22.3)	225 (21.7)	146 (22.8)	550 (24.6)	< 0.001
Meningitis	101 (2.1)	57 (1.2)	39 (1.3)	23 (1.3)	16 (1.5)	5 (0.8)	36 (1.6)	0.002
Skin	294 (6.2)	294 (6.4)	212 (7.0)	119 (6.9)	66 (6.4)	35 (5.5)	113 (5.1)	0.040
Bone	46 (1.0)	57 (1.2)	48 (1.6)	28 (1.6)	7 (0.7)	9 (1.4)	37 (1.7)	0.075
Wound	206 (4.4)	242 (5.3)	124 (4.1)	78 (4.5)	50 (4.8)	20 (3.1)	95 (4.3)	0.080
Catheter	169 (3.6)	157 (3.4)	106 (3.5)	75 (4.3)	37 (3.6)	29 (4.5)	88 (3.9)	0.596
Endocarditis	46 (1.0)	42 (0.9)	33 (1.1)	15 (0.9)	14 (1.4)	11 (1.7)	26 (1.2)	0.548
Device	54 (1.1)	51 (1.1)	43 (1.4)	24 (1.4)	16 (1.5)	9 (1.4)	22 (1.0)	0.704
Other infection	260 (9.7)	528 (11.5)	399 (13.2)	216 (12.5)	145 (14.0)	95 (14.8)	337 (15.7)	< 0.001

Delay in Initiation of Antibiotics

Surviving Sepsis Campaign Database: Ferrer et al, Crit Care Med, 2015



Time to Antibiotics (Hr)	OR[a]	95% CI	p	Probability of Mortality (%)[b]	95% CI
0–1[c]	1.00			24.6	23.2–26.0
1–2	1.07	0.97–1.18	0.165	25.9	24.5–27.2
2–3	1.14	1.02–1.26	0.021	27.0	25.3–28.7
3–4	1.19	1.04–1.35	0.009	27.9	25.6–30.1
4–5	1.24	1.06–1.45	0.006	28.8	25.9–31.7
5–6	1.47	1.22–1.76	<0.001	32.3	28.5–36.2
>6	1.52	1.36–1.70	<0.001	33.1	30.9–35.3

De-escalate Antibiotic Therapy with Culture Results

De-escalation of Antibiotic Therapy: Post-operative Intraabdominal Infection(IAI)

- 13-year study of 311 consecutive ICU patients with post-operative IAI
- Antibiotics were a clinical choice
- De-escalation was also a clinical decision
- De-escalation was evaluated on Median day 3 of treatment.
- No evaluation of adequacy of Source Control

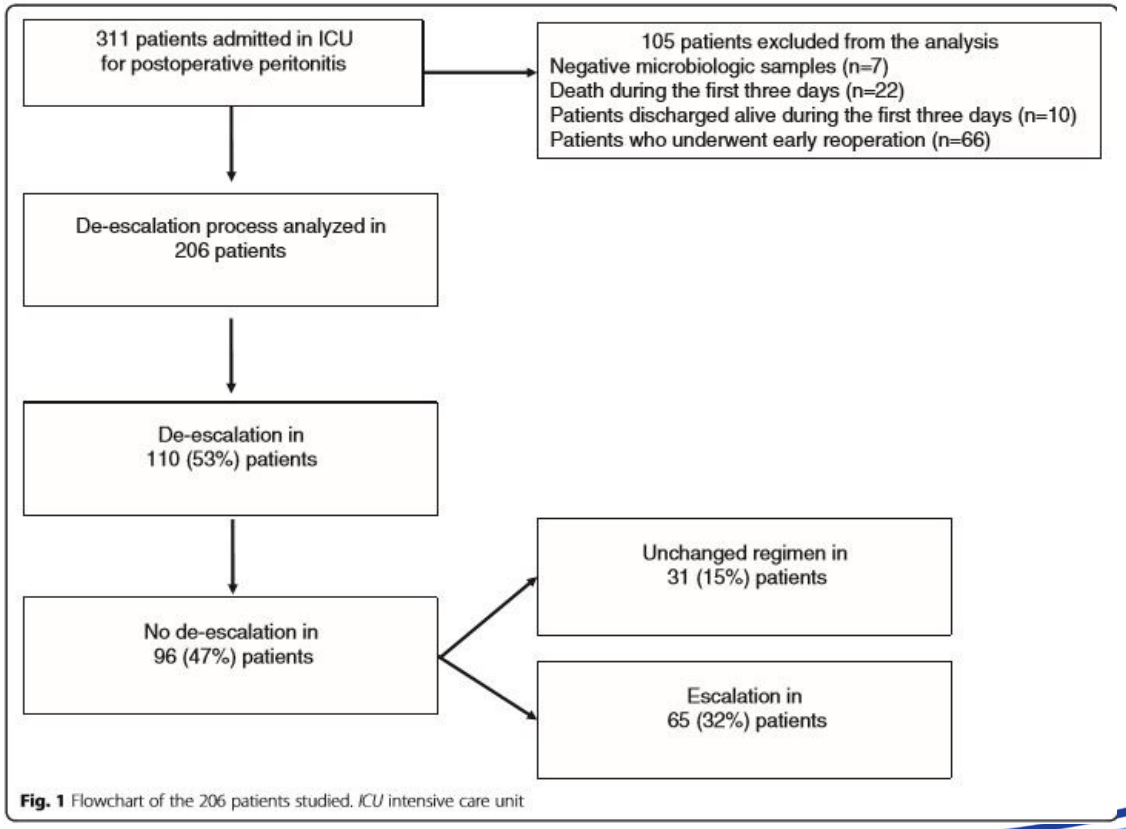


Fig. 1 Flowchart of the 206 patients studied. *ICU* intensive care unit

Montravers et al: Critical Care, 2016.

De-escalation of Antibiotic Therapy: Post-operative Intraabdominal Infection(IAI)

Determinants of De-escalation:

- Adequate Empirical Choice
- Use of Vancomycin
- Use of Carbapenem
- Use of Aminoglycoside

Risk Factors for No De-escalation:

- Multidrug Resistant Bacteria
- Non-fermenting Gram Negatives
- Enterococcus???

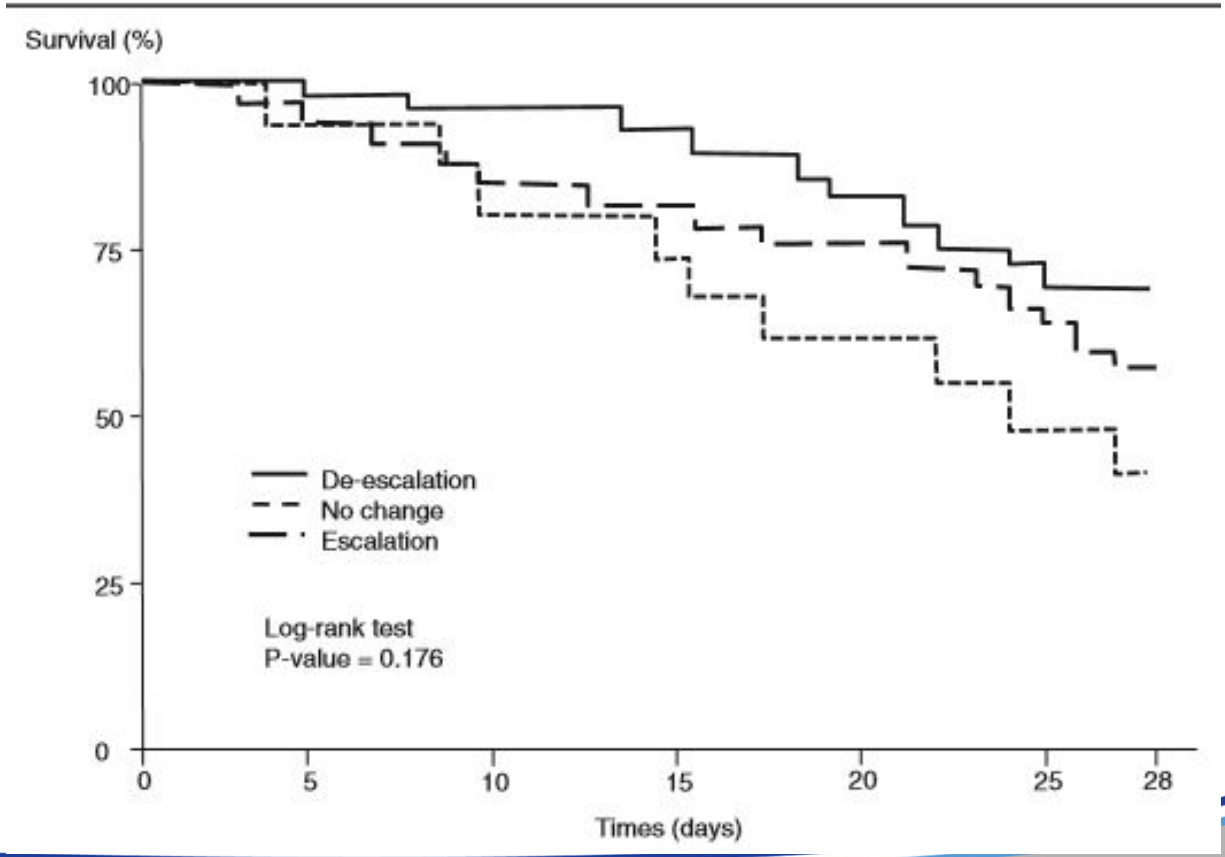
Risk Factors for 28-day Deaths:

- Positive fungal Culture
- Elevated SOFA score
- Age > 69 years

De-escalation did not adversely affect 28-day outcomes

Escalation was of **NO SURVIVAL BENEFIT**

Montravers et al: Critical Care, 2016.



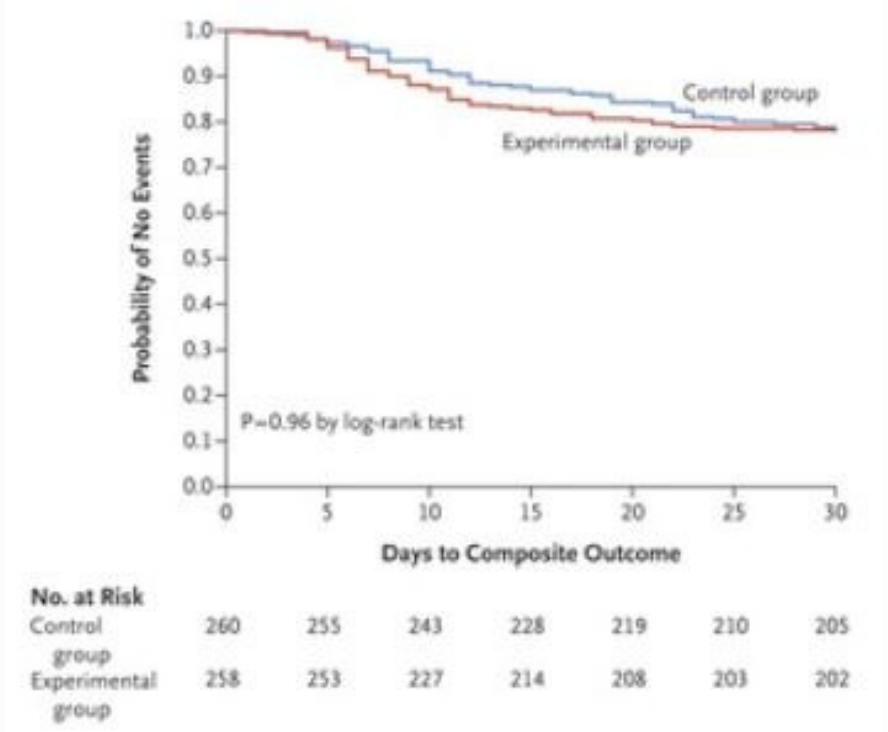
Avoid Excessive Duration of Antibiotic Therapy

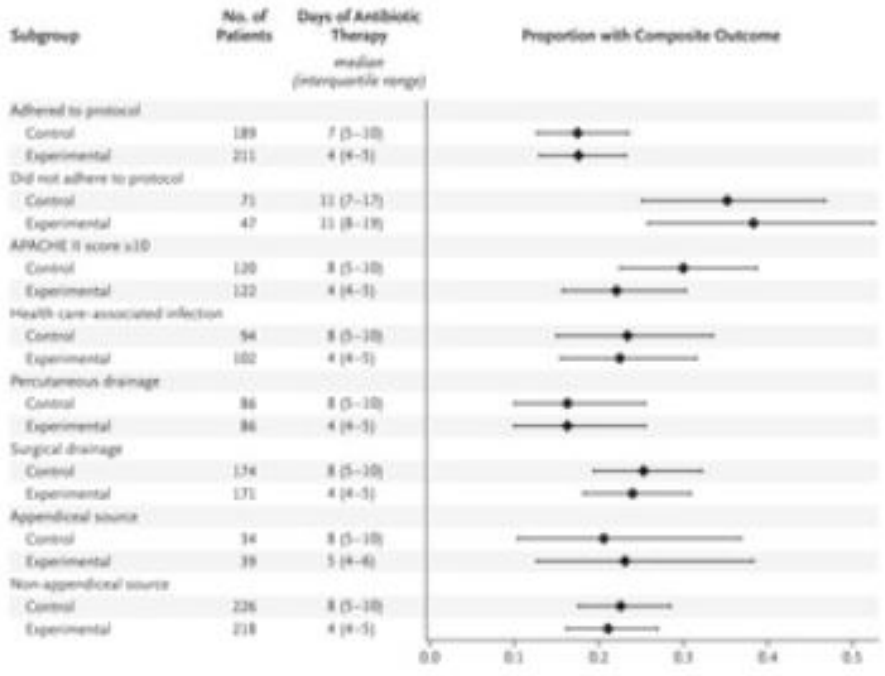
Excessive Duration of Antibiotic Therapy

Variable	Control Group (N=260)	Experimental Group (N=257)	P Value
Primary outcome: surgical-site infection, recurrent intraabdominal infection, or death — no. (%)	58 (22.3)	56 (21.8)	0.92
Surgical-site infection	23 (8.8)	17 (6.6)	0.43
Recurrent intraabdominal infection	36 (13.8)	40 (15.6)	0.67
Death	2 (0.8)	3 (1.2)	0.99
Time to event — no. of days after index source-control procedure			
Diagnosis of surgical-site infection	15.1±0.6	8.8±0.4	<0.001
Diagnosis of recurrent intraabdominal infection	15.1±0.5	10.8±0.4	<0.001
Death	19.0±1.0	18.5±0.5	0.66

Sawyer RG: NEJM, 2015

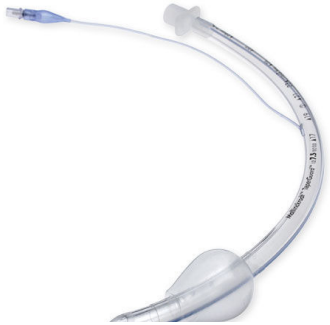
Excessive Duration of Antibiotic Therapy

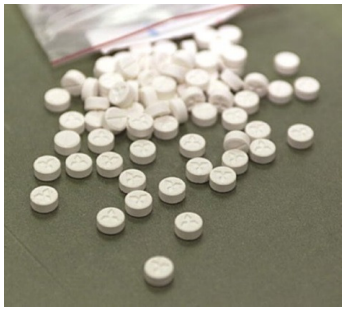


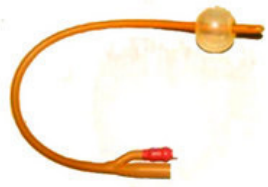


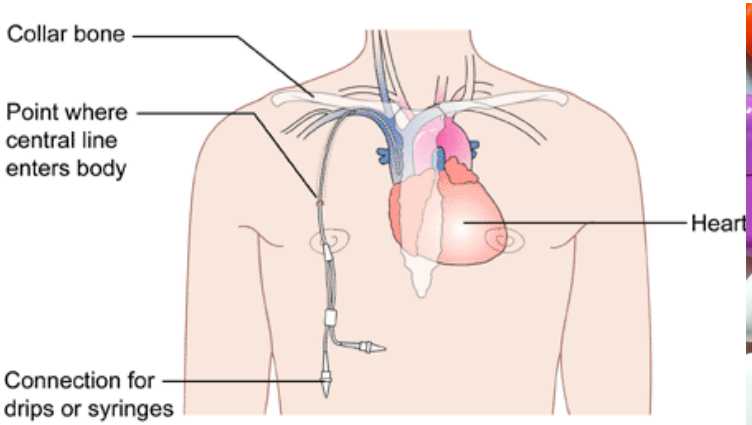
Sawyer RG, et al: NEJM, 2015

Potential Weapons of Mass Destruction









Alternatives to Antibiotics in Surgery: The Post Antibiotic Era

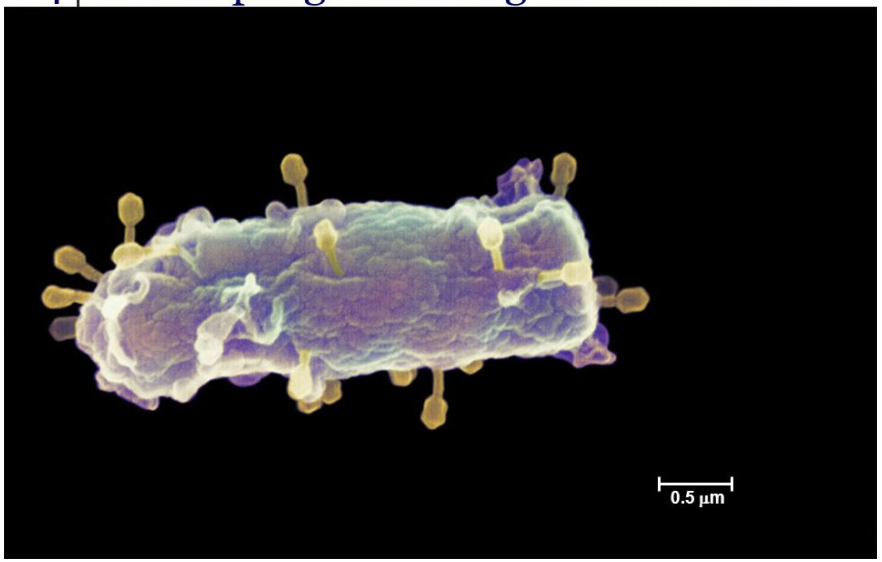
Surgical Infection in the Post-Antibiotic Era

- Bacteriophage Treatment
- Antimicrobial Peptides
- Passive Immune Enhancement
- Immunization of the Host
- Ionic Modulation of Microbial Virulence
- Manipulation of the Host Microbiome
- Revisiting Topical Antiseptics/Irrigation

Bacteriophage

- Viruses that infect Bacteria
- Commonly identified in feces
- Estimated to be > 10^{30} phage types
- Virus injects phage DNA into the bacterial cell
- Two Effects upon Infected Bacterial Cell
  - Lysis due to viral replication, or
  - Lysogenic effects: phage DNA is incorporated into the bacterial cell genome

T4 bacteriophage infecting an *E. coli* cell



Bacteriophage Therapy

Advantages

- **Phage have bacterial specificity**; will not affect or promote resistance in the normal microflora.
- Phage do not attach human cells
- We ingest and are exposed to phage constantly with no identified effects.
- Phage multiply at the site of an active infection and are then eliminated when susceptible pathogens are gone.
- New phage are constantly evolving.
- Phage components (lysins) can be developed as targeted antibiotic treatments

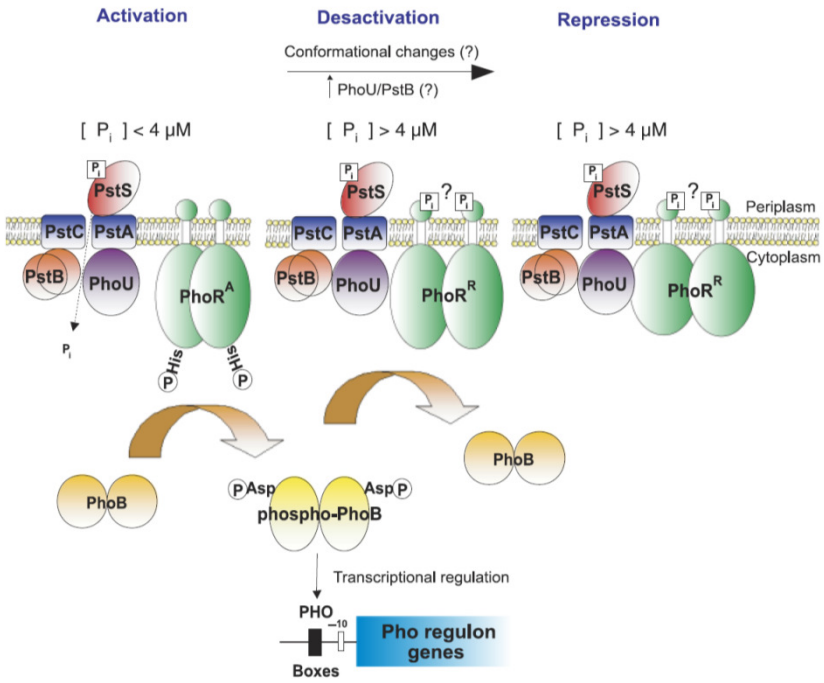
Disadvantages

- No clinical trials have proven human efficacy
- High degree of specificity is problematic when the pathogen is unknown.
- Resistance can develop to specific phage strains.
- Phage are large particles compared to antibiotics; pharmacokinetics?
- Antibodies to phage may pose an issue with sustained or repeated therapy.
- Can lysogenic phage transduce resistance genes from lysed bacteria to sensitive organisms?

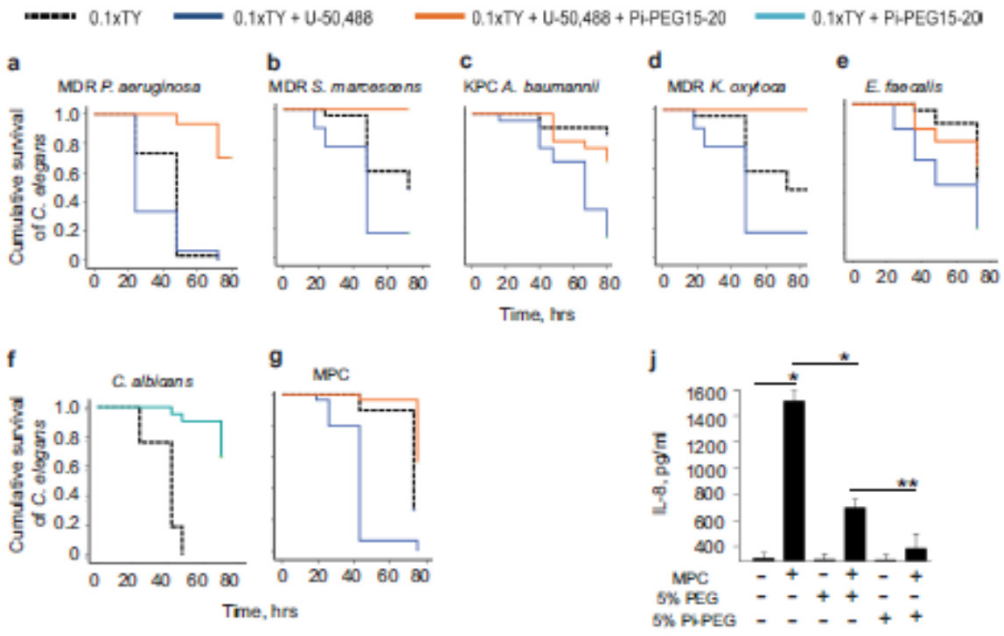
Ionic Modulation of Bacterial Virulence

Managing the Pathobiome

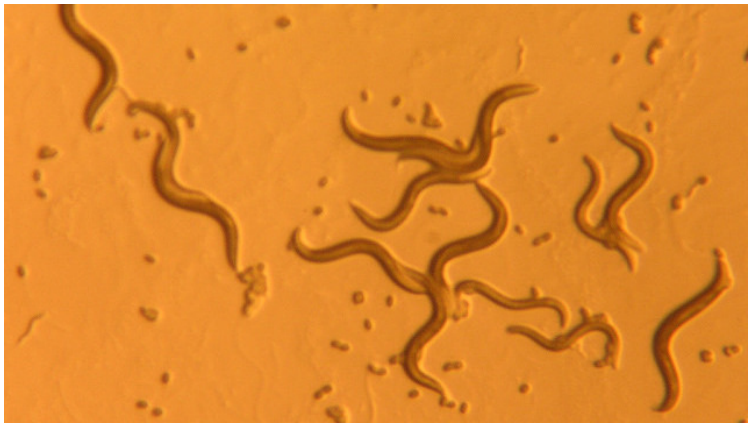
- Probiotics: Restore normal bacteria (e.g., gut anaerobes) from exogenous sources
- Selective Gut Decontamination: Oral antibiotics to eliminate all potential pathogens
- Phosphate Replacement:
  - Phosphate is depleted in the stress response
  - Low phosphate is a quorum signal for microbes
  - Low phosphate increases the virulent microbial phenotype



Ionic Modulation of Bacterial Virulence



C. Elegans (nematode)



Zaborin A, et al: Antimicrob Agents Chemother, 2014.

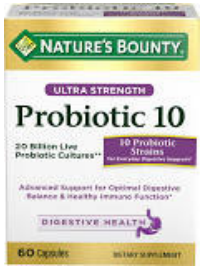
Ionic Modulation of Bacterial Virulence Mechanical Bowel Preparation

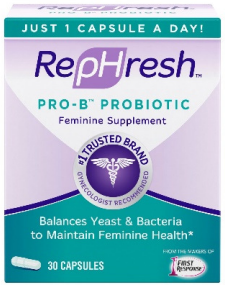
	Polyethylene Glycol	Sodium Phosphate
N=	303	367
SSIs	103 (34%)	87 (24%)

P = 0.03 (Univariate analysis)
P = 0.065 (Multi-variate analysis)

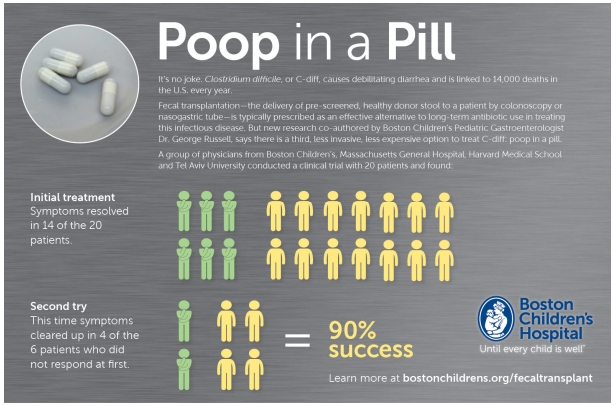
Itani KM et al: Am J Surg 2007; 193:190

Probiotics: A Commercial “Orgy”





Restoration of the Gut Microbiome: Fecal Transplants



SCIENCE 01/11/2013 08:50 am ET Huffington Post

Artificial Poop, RePOOPulate, May Lead To Synthetic Fecal Transplants

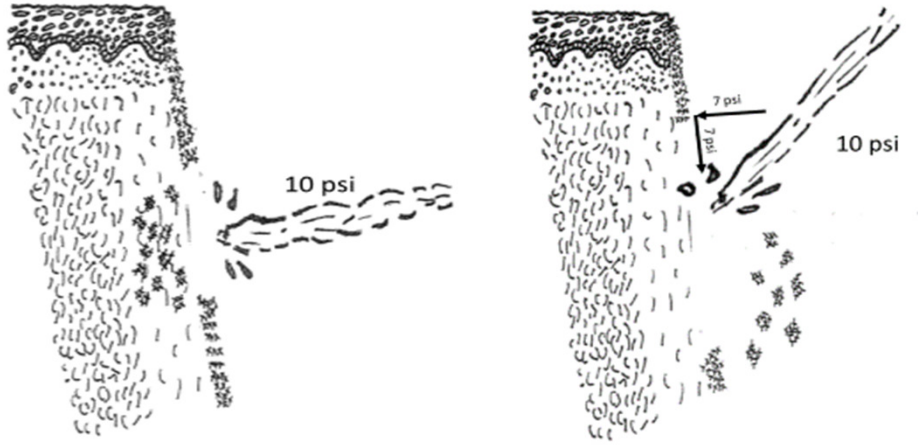
By Christie Wilcox

Pressure Lavage of the Surgical Wound

Pressure Lavage: Unanswered Questions

- **Optimum Pressure**
- **Addition of Antiseptics to Irritants**
- **Angle of Irrigation**
- **Treatment or Preventive applications**

The Angle of Irrigation?



Fry DE: Surgical Infections, 2017

Chlorhexidine: A potential open wound application?

Table 1

Log reduction of selective gram-positive and gram-negative surgical isolates following timed exposure to 0.05% chlorhexidine gluconate solution*

		Log_{10} colony-forming units† (log reduction)	
Organism	CFU‡	60 Seconds	5 Minutes
MRSA	8.7	3.4 (>5 logs)	2.6 (>6 logs)
MSSA	8.4	3.5 (>5 logs)	2.6 (>6 logs)
Staphylococcus epidermidis§	8.3	2.9 (>5 logs)	2.5 (>5 logs)
Escherichia coli	8.8	2.7 (>6 logs)	2.1 (>6 logs)
Escherichia aerogenes	8.9	3.1 (>5 logs)	2.8 (>6 logs)

CFU, Colony-forming units; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *MSSA*, methicillin-susceptible *Staphylococcus aureus*.

*0.05% Chlorhexidine gluconate (IRRISEPT; IrriMax Corp, Lawrenceville, GA).

†Postexposure: log_{10} CFU/milliliter.

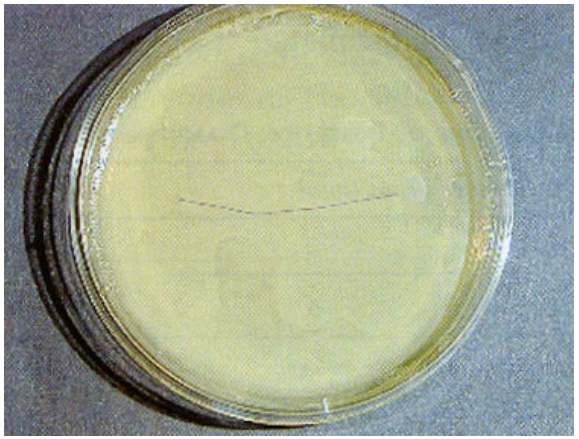
‡Baseline: initial log_{10} CFU/milliliter.

§Biofilm-producing strain from vascular graft infection.

Edmiston CE, et al: Am J Infect Control,2013

Antibacterial Suture

Control Polyglactin 910 Suture **without** Triclosan

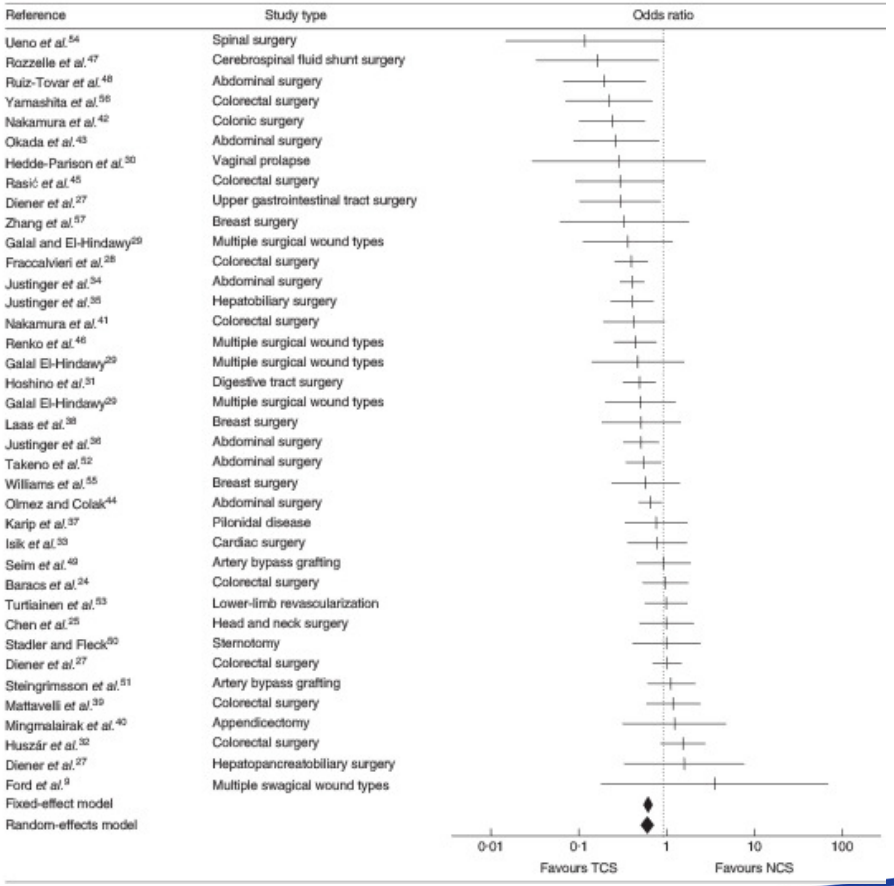


Polyglactin 910 Suture **with** Triclosan

Triclosan-coated Sutures

- 34 Clinical Trials in the Analysis
- A Heterogeneous populations of surgical cases and surgical patients
- Triclosan-coated sutures associated with a significant reduction in SSI rates (P<0.001)
- Cost savings per case = 91.25 £

Leaper et al: Br J Surg, 2017



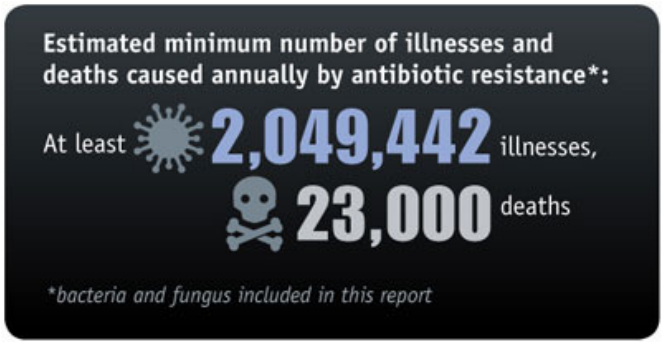
Other Proposed Methods for Reducing SSIs

- Antimicrobial Wound Barrier Devices
- Chlorhexidine + pressure irrigation devices
- Chlorhexidine/Silver plastic adhesive skin devices
- Implantable drug delivery systems
- Negative Pressure Wound Therapy
- Many Others

CDC Antibiotic Awareness Week
November 13-19, 2017

- Stop needless antibiotic administration
- Use Preventive Antibiotics for only the perioperative period
- Reduce the length of antibiotic administration with active infections; remember, failed antibiotics may mean failed source control!
- De-escalate combination empirical therapy when culture results are available.
- **Significant reductions in total antibiotic utilization can reverse resistance trends (e.g. aminoglycosides)**

Annual Burden of Antibiotic Resistance in the United States



BE ANTIBIOTICS AWARE

SMART USE, BEST CARE

U.S. ANTIBIOTIC AWARENESS WEEK

November 18–24, 2019

www.cdc.gov/antibiotic-use

1. **Antibiotics save lives.** When a patient needs antibiotics, the benefits outweigh the risks of side effects or antibiotic resistance.
2. **Antibiotics aren't always the answer.** Everyone can help improve antibiotic prescribing and use.
3. **Antibiotics do not work on viruses,** such as those that cause colds, flu, bronchitis, or runny noses, even if the mucus is thick, yellow, or green.
4. **Antibiotics are only needed for treating infections caused by bacteria,** but even some bacterial infections get better without antibiotics, including many sinus infections and some ear infections.
5. **Antibiotics will not make you feel better if you have a virus.** Respiratory viruses usually go away in a week or two without treatment. Ask your healthcare professional about the best way to feel better while your body fights off the virus.
6. **If you need antibiotics, take them exactly as prescribed.** Talk with your doctor if you have any questions about your antibiotics, or if you develop any side effects, especially diarrhea, since that could be a *Clostridioides difficile* infection (also called *C. difficile* or *C. diff*), which needs to be treated.
7. **Antibiotics are critical tools for treating life-threatening conditions** such as pneumonia and sepsis.

Antibiotic Stewardship in Surgical Care

- Select the correct drug specific to the patient for prophylaxis
- Discontinue needless post-operative antibiotic administration
  - Inpatient procedures
  - Outpatient/Ambulatory procedures
- Effective Source Control
- Reduce inappropriate/unnecessary antibiotic therapy in established infections
- Cover all likely pathogens with empirical antibiotic choices
- Engage in de-escalation when culture results are available
- Consider alternatives to Antibiotics as future data for prevention and treatment evolve.