Antibiotics before and after surgery
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1. Antibiotics before surgery: when and why
2. Perioperative antibiotics
3. Antibiotics after surgery: when and what
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You get a call to admit a patient:

• 56 y old male, PMH of DM
• He has a history of right great toe amputation for osteomyelitis last year
• He now has an open sore at the base of the second toe, without any drainage or erythema
• Empiric antibiotic therapy was started a week ago, no improvement in appearance of the wound
• No systemic symptoms
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You get a call to admit a patient:

• 56 y old male, PMH of DM
• He has a history of right great toe amputation for osteomyelitis last year
• He now has an open sore at the base of the second toe, with drainage of cloudy fluid and erythema surrounding the wound
• Empiric antibiotic therapy was started a week ago, no improvement in appearance of the wound
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You get a call to admit a patient:

• 56 y old male, PMH of DM
• He has a history of right great toe amputation for osteomyelitis last year
• He now has an open sore at the base of the second toe, with drainage of cloudy fluid and erythema surrounding the wound
• Empiric antibiotic therapy was started a week ago, no improvement in appearance of the wound
• He now has fever to 104 and redness progressing up his right leg
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You get a call to admit a patient:
• 75 y old lady, PMH of HTN, COPD
• She developed redness, swelling of her left knee, with acute onset of symptoms over a few hours
• No fever
• No labs available
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You get a call to admit a patient:

• 75 y old lady, PMH of HTN, COPD
• She developed redness, swelling of her left knee, with acute onset of symptoms over a few hours
• Knee taped in the office, 25000 WBC, 90% neutrophils, no crystals seen
• No fever or chills
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You get a call to admit a patient:

• 75 y old lady, PMH of HTN, COPD
• She developed redness, swelling of her left knee, with acute onset of symptoms over a few hours
• Knee taped in the office, 25000 WBC, 90% neutrophils, no crystals seen
• She has chills, with a fever up to 102
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- Who needs admission?
- Who needs IV antibiotics?
“Gray zone”: how likely is an infection, and what are the risk of missing an infection

Do not start empiric antibiotics unless you have a high enough “degree of suspicion”, but...

What about admission criteria?
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• DO NOT START ANTIBIOTICS JUST TO FULFILL ADMISSION CRITERIA!

• In patients who will need surgery (often orthopedic surgery), start antibiotics only if there is enough evidence of active infection.

• Even if the presentation is not severe, “treatment failure” with oral antibiotics may warrant IV antibiotics.

• In case of doubt, send the patient to the ED.
A 78 y old patient with diabetes, heart failure, is found obtunded at home by his wife

In the ED, he is found to have a necrotic 5\textsuperscript{th} toe of his left foot, with erythema going up his leg

He is hypotensive, with a lactate of 4

He receives a fluid bolus and is started on antibiotics, and is transferred to the ICU
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- He remains hypotensive, and levophed is started
- The toe is necrotic, foul smelling, but the on-call orthopedic surgeon tells you that there is no need for amputation: “The toe is necrotic, so no infection goes into the blood stream anyway.”
A 58 year old patient presents to the ED with fever, chills, worsening abdominal pain for a week.

A CT shows perforated diverticulitis, with abscess formation (5 cm), not amenable to percutaneous drainage.

Patient remains hypotensive in spite of IV fluid, antibiotics and levophed.

The on-call general surgeon recommends conservative management: “He is too unstable for surgery, and if I intervene now, he will likely end up with a permanent colostomy.”
A 73 y old lady underwent a right total hip arthroplasty 2 weeks ago
She developed redness at the incision site after one week
She saw her surgeon, who started cephalexin
She is brought to the ED by her family, because of weakness and confusion
The surgical incision has evidence of wound dehiscence, with frank purulence, and when you probe the wound with a Qtip, you can go about 7-8 cm deep
Her blood pressure stabilizes with antibiotics and IV fluids
The orthopedic surgeon wants to “cool off the patient” a few days with antibiotics
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• Who needs surgery?
ANTIBIOTIC THERAPY IN CASE OF ACTIVE INFECTION IS NOT GOING TO WORK IF YOU DO NOT HAVE SOURCE CONTROL!

Situations like these are uncomfortable, but this is when you need to insist the surgeon sees the patient.

When you are called to accept patients like these from another facility, make sure the surgeons are on board.
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- Decolonization
- Antibiotic prophylaxis
Recognized decolonization strategies to prevent health care-associated infections.

**Nasal Decolonization:**
- Mupirocin
- Povidone-iodine

**Oral Care/Selective Oropharyngeal Decontamination:**
- Chlorhexidine gluconate
- Polymyxin
- Tobramycin
- Amphotericin
- Cefotaxime

**Selective Digestive Decontamination:**
- Polymyxin
- Tobramycin
- Amphotericin

**Skin Decolonization:**
- Chlorhexidine gluconate
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• Nasal decolonization controversies:
  1. Screening or empiric use of Mupirocin for high-risk populations?
  2. Screening for MRSA, MSSA, both?
  3. PCR vs culture?
  4. For all procedures or select ones?
  5. Nasal ointment only (Mupirocin) or add chlorhexidin shower/bath?
  6. Is nasal decolonization sustainable (cost, emergence of resistance)?
• LIMITED HIGH QUALITY DATA TO ANSWER THESE QUESTIONS!

• References:


1. Universal use of Mupirocin is discouraged
2. Data available for both MRSA and MSSA, ideally screen for both organisms
4. Best data is for orthopedic and cardiothoracic surgery procedures. Probably applicable to neurosurgery as well.
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1. Best data is for S. aureus (MRSA and MSSA) screening before orthopedic and thoracic surgery procedures.

Edward J. Septimus, and Marin L. Schweizer
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5. Best data for combined approach (nasal ointment and shower/bath)
6. Limited cost-effectiveness studies, without clear answers, but probably cost-effective in high prevalence MRSA before select interventions. Furthermore, emergence of Mupirocin emergence could become a problem.

In summary, it is best to develop a local algorithm based on local resources and infection risk.
Furthermore, same-day preparation with nasal (concentrated iodine paste), oral and body prepping (chlorhexidine) may prove as effective.
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“Common principles: Ideally, an antimicrobial agent for surgical prophylaxis should (1) prevent SSI, (2) prevent SSI-related morbidity and mortality, (3) reduce the duration and cost of health care (when the costs associated with the management of SSI are considered, the cost-effectiveness of prophylaxis becomes evident), 51, 52 (4) produce no adverse effects, and (5) have no adverse consequences for the microbial flora of the patient or the hospital.

To achieve these goals, an antimicrobial agent should be (1) active against the pathogens most likely to contaminate the surgical site, (2) given in an appropriate dosage and at a time that ensures adequate serum and tissue concentrations during the period of potential contamination, (3) safe, and (4) administered for the shortest effective period to minimize adverse effects, the development of resistance, and costs.”

### Table 2. Recommendations for Surgical Antimicrobial Prophylaxis

<table>
<thead>
<tr>
<th>Type of Procedure</th>
<th>Recommended Agents</th>
<th>Alternative Agents in Pts With β-Lactam Allergy</th>
<th>Strength of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiac</strong></td>
<td></td>
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<tr>
<td>Coronary artery bypass</td>
<td>Cefazolin, cefuroxime</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Cardiac device insertion procedures (e.g., pacemaker implantation)</td>
<td>Cefazolin, cefuroxime</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Ventricular assist devices</td>
<td>Cefazolin, cefuroxime</td>
<td>Clindamycin, vancomycin</td>
<td>C</td>
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<tr>
<td><strong>Thoracic</strong></td>
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</tr>
<tr>
<td>Noncardiac procedures, including lobectomy, pneumonectomy, lung resection, and thoracotomy</td>
<td>Cefazolin, ampicillin-sulbactam</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Video-assisted thoracoscopic surgery</td>
<td>Cefazolin, ampicillin-sulbactam</td>
<td>Clindamycin, vancomycin</td>
<td>C</td>
</tr>
<tr>
<td><strong>Gastrointestinal</strong></td>
<td></td>
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<tr>
<td>Procedures involving entry into lumen of gastrointestinal tract (bariatric, pancreaticoduodenectomy)</td>
<td>Cefazolin</td>
<td>Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone</td>
<td>A</td>
</tr>
<tr>
<td>Procedures without entry into gastrointestinal tract (antireflux, highly selective vagotomy) for high-risk patients</td>
<td>Cefazolin</td>
<td>Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone</td>
<td>A</td>
</tr>
<tr>
<td><strong>Biliary tract</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open procedure</td>
<td>Cefazolin, cefoxitin, cefotetan, ceftriaxone, ampicillin-sulbactam</td>
<td>Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone</td>
<td>A</td>
</tr>
<tr>
<td>Laparoscopic procedure</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Elective, low-risk</td>
<td>None</td>
<td>None</td>
<td>A</td>
</tr>
<tr>
<td>Elective, high-risk</td>
<td>Cefazolin, cefoxitin, cefotetan, ceftriaxone, ampicillin-sulbactam</td>
<td>Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone</td>
<td>A</td>
</tr>
<tr>
<td>Appendectomy for uncomplicated appendicitis</td>
<td>Cefoxitin, cefotetan, cefazolin + metronidazole</td>
<td>Clindamycin + aminoglycoside or aztreonam or fluoroquinolone</td>
<td>A</td>
</tr>
<tr>
<td>Small intestine</td>
<td></td>
<td></td>
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<tr>
<td>Nonobstructed</td>
<td>Cefazolin</td>
<td>Clindamycin + aminoglycoside or aztreonam or fluoroquinolone</td>
<td>C</td>
</tr>
<tr>
<td>Type of Procedure</td>
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<tr>
<td>Obstructed</td>
<td>Cefazolin + metronidazole, cefoxitin, cefotetan</td>
<td>Metronidazole + aminoglycoside or fluoroquinolone</td>
<td>C</td>
</tr>
<tr>
<td>Hemis repair (hemiplasty and hemionrhaphy)</td>
<td>Cefazolin</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Colorectal</td>
<td>Cefazolin + metronidazole, cefoxitin, cefotetan, ampicillin–sulbactam, ceftriaxone + metronidazole, ertapenem</td>
<td>Clindamycin, vancomycin or gentamicin or amikacin or netilmicin or tobramycin or ciprofloxacin or levofloxacin or moxifloxacin</td>
<td>A</td>
</tr>
<tr>
<td>Head and neck</td>
<td>None</td>
<td>None</td>
<td>B</td>
</tr>
<tr>
<td>Clean with placement of prosthesis (excludes tympanostomy tubes)</td>
<td>Cefazolin, cefuroxime</td>
<td>Clindamycin</td>
<td>C</td>
</tr>
<tr>
<td>Clean-contaminated cancer surgery</td>
<td>Cefazolin + metronidazole, cefoxitin, cefotetan, ampicillin–sulbactam</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Other clean-contaminated procedures with the exception of tonsillectomy and functional endoscopic sinus procedures</td>
<td>Cefazolin + metronidazole, ampicillin–sulbactam</td>
<td>Clindamycin</td>
<td>B</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>Cefazolin</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Elective craniotomy and cerebrospinal fluid-shunting procedures</td>
<td>Cefazolin</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Implantation of intrathecal pumps</td>
<td>Cefazolin</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Cesarean delivery</td>
<td>Cefazolin</td>
<td>Cefazolin + aminoglycoside</td>
<td>A</td>
</tr>
<tr>
<td>Hysterectomy (vaginal or abdominal)</td>
<td>Cefazolin, cefotetan, cefoxitin, ampicillin–sulbactam</td>
<td>Clindamycin or vancomycin or aminoglycoside or aztreonam or fluoroquinolone</td>
<td>A</td>
</tr>
<tr>
<td>Ophthalmic</td>
<td>Topical neomycin–polymyxin B–gramicidin or fourth-generation topical fluoroquinolones (gatifloxacin or moxifloxacin) given as 1 drop every 5–15 min for 5 doses</td>
<td>None</td>
<td>B</td>
</tr>
<tr>
<td>Orthopedic</td>
<td>None</td>
<td>None</td>
<td>C</td>
</tr>
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<td>---------------------------------------------------------------------------------</td>
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<tr>
<td>Hip fracture repair</td>
<td>Cefazolin</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Implantation of internal fixation devices (e.g., nails, screws, plates, wires)</td>
<td>Cefazolin</td>
<td>Clindamycin, vancomycin</td>
<td>C</td>
</tr>
<tr>
<td>Total joint replacement</td>
<td>Cefazolin</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Urologic</td>
<td></td>
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<tr>
<td>Lower tract instrumentation with risk factors for infection (includes transrectal prostate biopsy)</td>
<td>Fluoroquinolone, trimethoprim-sulfamethoxazole, cefazolin</td>
<td>Aminoglycoside or without clindamycin</td>
<td>A</td>
</tr>
<tr>
<td>Clean without entry into urinary tract</td>
<td>Cefazolin (the addition of a single dose of an aminoglycoside may be recommended for placement of prosthetic material [e.g., penile prosthesis])</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Involving implanted prosthesis</td>
<td>Cefazolin ± amoxicillin, cefazolin ± aztreonam, ampicillin–sulbactam</td>
<td>Clindamycin ± aminoglycoside or aztreonam, vancomycin ± aminoglycoside or aztreonam</td>
<td>A</td>
</tr>
<tr>
<td>Clean with entry into urinary tract</td>
<td>Cefazolin (the addition of a single dose of an aminoglycoside may be recommended for placement of prosthetic material [e.g., penile prosthesis])</td>
<td>Fluoroquinolone, aminoglycoside with or without clindamycin</td>
<td>A</td>
</tr>
<tr>
<td>Clean-contaminated</td>
<td>Cefazolin + metronidazole, cefoxitin</td>
<td>Fluoroquinolone, aminoglycoside + metronidazole or clindamycin</td>
<td>A</td>
</tr>
<tr>
<td>Vascular</td>
<td></td>
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<tr>
<td>Heart, lung, heart–lung transplantation</td>
<td>Cefazolin</td>
<td>Clindamycin, vancomycin</td>
<td>A (based on cardiac procedures)</td>
</tr>
<tr>
<td>Heart transplantation</td>
<td></td>
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</tr>
<tr>
<td>Lung and heart–lung transplantation</td>
<td>Cefazolin</td>
<td>Clindamycin, vancomycin</td>
<td>A (based on cardiac procedures)</td>
</tr>
<tr>
<td>Liver transplantation</td>
<td>Piperacillin–tazobactam, cefotaxime + ampicillin</td>
<td>Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone</td>
<td>B</td>
</tr>
<tr>
<td>Pancreas and pancreas–kidney transplantation</td>
<td>Cefazolin (for patients at high risk of fungal infection [e.g., those with enteric drainage of the pancreas])</td>
<td>Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone</td>
<td>A</td>
</tr>
</tbody>
</table>

* Table 2 (continued)
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- Cefazolin (alone or in combination) is the preferred agent in almost every situation
- Vancomycin is reserved for patients with B-lactam allergy, in case of an outbreak of B-lactam resistant organisms, or known MRSA colonization. In situations “in which pathogens other than staphylococci and streptococci are likely, an additional agent with activity against those pathogens should be considered.”
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• Timing: within 60 minutes of incision (exceptions: IV quinolones and Vancomycin, which need to be started 2 hours before incision)

• Duration. “The shortest effective duration of antimicrobial administration for preventing SSI is not known; however, evidence is mounting that postoperative antimicrobial administration is not necessary for most procedures. The duration of antimicrobial prophylaxis should be less than 24 hours for most procedures. Cardiothoracic procedures for which a prophylaxis duration of up to 48 hours has been accepted without evidence to support the practice is an area that remains controversial.”
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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>A.</strong></td>
<td>Administration of Vancomycin should start within 30-60 minutes before surgical incision.</td>
</tr>
<tr>
<td><strong>B.</strong></td>
<td>Vancomycin is the drug of choice for all cardiac device insertion procedure (such as pacemaker).</td>
</tr>
<tr>
<td><strong>C.</strong></td>
<td>When Vancomycin is used for surgical prophylaxis for a total joint replacement, prophylaxis should continue for 48 hours after surgery.</td>
</tr>
<tr>
<td><strong>D.</strong></td>
<td>Vancomycin may be included in the regimen of choice when a cluster of MRSA cases (e.g., mediastinitis after cardiac procedures) or methicillin resistant coagulase-negative staphylococci SSIs have been detected at an institution.</td>
</tr>
<tr>
<td><strong>E.</strong></td>
<td>In a patient known to be colonized with MRSA undergoing a large bowel resection, prophylaxis with Vancomycin monotherapy is appropriate.</td>
</tr>
</tbody>
</table>
The Impact of a Reported Penicillin Allergy on Surgical Site Infection Risk

Kimberly G. Blumenthal,1,2,4 Erin E. Ryan,5,6 Yu Li,12 Hang Lee,47 James L. Kuhlen,8 and Erica S. Shenoy2,4,8

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(See the Editorial Commentary by Dellinger et al on pages 337–8.)

Background. A reported penicillin allergy may compromise receipt of recommended antibiotic prophylaxis intended to prevent surgical site infections (SSIs). Most patients with a reported penicillin allergy are not allergic. We determined the impact of a reported penicillin allergy on the development of SSIs.

Methods. In this retrospective cohort study of Massachusetts General Hospital hip arthroplasty, knee arthroplasty, hysterectomy, colon surgery, and coronary artery bypass grafting patients from 2010 to 2014, we compared patients with and without a reported penicillin allergy. The primary outcome was an SSI, as defined by the Centers for Disease Control and Prevention’s National Healthcare Safety Network. The secondary outcome was perioperative antibiotic use.

Results. Of 8385 patients who underwent 9004 procedures, 922 (11%) reported a penicillin allergy, and 241 (2.7%) had an SSI. In multivariable logistic regression, patients reporting a penicillin allergy had increased odds (adjusted odds ratio, 1.51; 95% confidence interval, 1.02–2.22) of SSI. Penicillin allergy reporters were administered less cefazolin (12% vs 92%; P < .001) and more clindamycin (49% vs 3%; P < .001), vancomycin (35% vs 3%; P < .001), and gentamicin (24% vs 3%; P < .001) compared with those without a reported penicillin allergy. The increased SSI risk was entirely mediated by the patients’ receipt of an alternative perioperative antibiotic; between 112 and 124 patients with reported penicillin allergy would need allergy evaluation to prevent 1 SSI.

Conclusions. Patients with a reported penicillin allergy had a 50% increased odds of SSI, attributable to the receipt of second-line perioperative antibiotics. Clarification of penicillin allergies as part of routine preoperative care may decrease SSI risk.

Keywords. prophylaxis; antibiotic; healthcare-associated infections; surgical site infections; allergy.
“As a consequence, our standard surgical prophylaxis order forms encourage the administration of cefazolin for patients listed as “allergic to penicillin” unless there is a history of anaphylaxis or Stephens-Johnson syndrome.”
PREOPERATIVE ANTIBIOTICS ARE TYPICALLY THE RESPONSIBILITY OF THE SURGEON AND THE ANESTHESIOLOGIST, BUT HOSPITALIST HAVE A ROLE AS WELL!
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• Post-operative fever: who needs antibiotics?
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- Post-operative fever: 5 Ws
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• Wind: pneumonia, sinusitis
• Wound: surgical incision, decubitus ulcers, lines
• Walk: DVT, PE
• Water: UTI, prostatitis, epididymitis
• Wonder drugs (drug fever): antibiotics, malignant hyperthermia, neuroleptic malignant syndrome
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In addition:

- Inflammation (gout, pseudogout, pancreatitis)
- tissue necrosis (MI, necrotizing pancreatitis)
- blood (hemothorax, retroperitoneal hematoma, any blood in the CSF)
- transfusion reactions
- Rarities such as thyroid storm, adrenal insufficiency, fat embolism

can all cause fever in the absence of infection
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“Well, I'll do everything humanly possible. Unfortunately, we barbers aren't gods. You know, medicine is not an exact science, but we are learning all the time. Why, just fifty years ago, they thought a disease like your daughter's was caused by demonic possession or witchcraft. But nowadays we know that Isabelle is suffering from an imbalance of bodily humors, perhaps caused by a toad or a small dwarf living in her stomach.”

Theodoric of York, medieval barber
Atelectasis as a cause of postoperative fever: where is the clinical evidence? Mavros MN¹, Velmahos GC², Falagas ME³.

Abstract

BACKGROUND:
Atelectasis is considered to be the most common cause of early postoperative fever (EPF) but the existing evidence is contradictory. We sought to determine if atelectasis is associated with EPF by analyzing the relevant published evidence.

METHODS:
We performed a systematic search in PubMed and Scopus databases to identify studies examining the association between atelectasis and EPF.
Atelectasis as a cause of postoperative fever: where is the clinical evidence? Mavros MN¹, Velmahos GC², Falagas ME³.

RESULTS:
A total of eight studies, including 998 cardiac, abdominal, and maxillofacial surgery patients, were eligible for analysis. Only two studies specifically examined our question, and six additional articles reported sufficient data to be included. Only one study reported a significant association between postoperative atelectasis and fever, whereas the remaining studies indicated no such association. The performance of EPF as a diagnostic test for atelectasis was also assessed, and EPF performed poorly (pooled diagnostic OR, 1.40; 95% CI, 0.92-2.12). The significant heterogeneity among the studies precluded a formal metaanalysis.
CONCLUSION:
The available evidence regarding the association of atelectasis and fever is scarce. We found no clinical evidence supporting the concept that atelectasis is associated with EPF. More so, there is no clear evidence that atelectasis causes fever at all. Large studies are needed to precisely evaluate the contribution of atelectasis in EPF.
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Kane JM³, Friedman M, Mitchell JB, Wang D, Huang Z, Backer CL.

Abstract

BACKGROUND:
Postoperative fever is common after cardiac surgery. In the absence of documented infection, atelectasis is often suggested as a cause of postoperative fever. However, this link is not well supported by pathophysiologic mechanisms. The purpose of this study was to investigate whether an association exists between atelectasis and postoperative fever in pediatric patients undergoing cardiac surgery.

METHODS:
A retrospective review was performed on consecutive pediatric patients who underwent cardiac surgery on cardiopulmonary bypass at a single cardiac surgery center from January 1, 2009, to December 31, 2009. Postoperative chest radiographs were evaluated and each lung was scored independently for atelectasis. Clinical parameters including the highest daily recorded temperature were noted and compared to atelectasis data.
Abstract

RESULTS:
A total of 203 patients were enrolled; 139 patients (68.5%) had fever at least once during the first 3 postoperative days. The incidence of atelectasis on each day was 41%, 57%, and 71%, respectively. There was no association between fever and atelectasis on any postoperative day (P = .21). Microbiological cultures were performed on 81 patients, and infection was found in 7 patients (3.5%). The frequency of either fever or atelectasis was similar between cyanotic and acyanotic patients.

CONCLUSIONS:
Postoperative fever and atelectasis are both common after pediatric cardiac surgery. In our study, there was no significant association between postoperative fever and atelectasis. In children undergoing cardiac surgery with cardiopulmonary bypass, fever in the postoperative period should not be attributed to atelectasis.
"Essentially, all models are wrong, but some are useful."


In my cynical worldview, the usefulness of the “atelectasis as cause of post-operative fever” theory is that it avoids unnecessary testing and empiric antibiotics in many patients.
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Abstract

**OBJECTIVE:**

To identify the timing and relative frequency of common postoperative complications in a contemporary, diverse surgical population and develop a mnemonic for teaching and clinical decision support.

**PATIENTS AND METHODS:**

We enrolled a cohort of general and vascular surgical patients undergoing elective, inpatient surgery in the American College of Surgeons National Surgical Quality Improvement Program database between 2005 and 2011. Index complications were noted by postoperative day (POD). Timing and incidence were compared within each day.
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Objectives:

1. Investigating the “Rule of W,” a mnemonic for teaching on postoperative complications.

2. To evaluate the incidence and outcomes of postoperative complications among 614,525 patients.

RESULTS:

Among 614,525 patients, 51,173 (9.88%) experienced the following index complications over 30 days: pneumonia (n = 5947), urinary tract infection (n = 9459), superficial surgical site infection (sSSI) (n = 20,460), deep/organ space surgical site infection (dSSI) infection (n = 11,847), venous thromboembolism (n = 4478), kidney injury (n = 2620), and myocardial infarction (n = 1813). Median time to complication differed significantly for index complications (p < 0.0001). On POD 0, the most common complication was myocardial infarction (incidence 4.26/10,000 patient days; 95% CI: 3.75-4.76). On POD 1 and 2, pneumonia was the most common complication, with peak incidence on POD 2 (20.36; 95% CI: 19.22-21.54). On POD 3, pneumonia (16.3%; 95% CI: 15.27-17.33) and urinary tract infection (15.5; 95% CI: 14.49-16.51) were significantly more common than other complications. On POD 4, the most common complication was sSSI (16.24; 95% CI: 15.20-17.28). From POD 5 to POD 30, sSSI and dSSI were the 2 most common complications. Risk of venous thromboembolism declined only slightly through POD 30.

CONCLUSION:

We propose a mnemonic for postoperative complication timing and frequency, independent of fever, as follows: Waves (myocardial infarction), Wind (pneumonia), Water (urinary tract), Wound (sSSI and dSSI), and Walking (venous thromboembolism) in the order of likelihood.
Figure: Daily Incidence of Index Postoperative Complications

Post-operative fever in orthopaedic surgery: How effective is the ‘fever workup?’ Blair at al. Journal of Orthopaedic Surgery 25(3) 1–9, 2017

Abstract

Background: Defining the appropriate threshold at which to initiate a fever workup is imperative to promote patient safety, appropriate resource utilization, and antibiotic stewardship. Our group performed a systematic review of the available literature on perioperative fever (POF) workups in orthopaedic patients to evaluate the frequency, timing and utility of blood cultures (BC) and other investigations in the POF workup, to determine the clinical relevance of any infections and to evaluate their cost effectiveness.

Methods: Studies were identified by searching MEDLINE, EMBASE, Pubmed, Cochrane and Google Scholar for articles through September 2016. Forty-nine articles were retrieved and 22 articles met the pre-determined inclusion criteria. Proportions of positive studies were noted and averaged using random effects analysis.
Post-operative fever in orthopaedic surgery: How effective is the ‘fever workup?’ Blair at al. Journal of Orthopaedic Surgery 25(3) 1–9, 2017

Results: Post-operative pyrexia ranged in prevalence between 8.1% and 87.3%. The studies routinely performed during a fever workup had wide ranges of diagnostic yield, including chest X-rays from 0% to 40%, urinalyses from 8.2% to 38.7%, urine cultures from 0% to 22.4% and BC from 0% to 13.3%. Only two patients with positive BC developed clinical sepsis. Cost per fever evaluation ranged from $350 to $950.

Conclusion: The findings of this review suggest that early post-operative fever is an expected event following orthopaedic surgery. Based on the available literature, any kind of workup in the absence of localizing symptoms in the third post-operative day or before is unwarranted and is an inappropriate use of hospital resources.
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Post-operative antibiotics:

• Post-procedure: 2 doses of antibiotics at most in case of prophylaxis (exception: open fracture)

• Yes in case of active infection, or suspected post-operative infection (not fever alone)
<table>
<thead>
<tr>
<th>Gram Positive Organisms</th>
<th>Ampicillin</th>
<th>Vancomycin</th>
<th>Quinupristin</th>
<th>Linezolid</th>
<th>Carabomycin</th>
<th>Doxycycline</th>
<th>Meropenem</th>
<th>Pencillin</th>
<th>Ceftriaxone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterococcus species (n=163)</td>
<td>94%</td>
<td>95%</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>Enterococcus faecalis (n=58)</td>
<td>100%</td>
<td>95%</td>
<td>9%</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>Staphylococcus aureus (n=295)</td>
<td>100%</td>
<td>90%</td>
<td>53%</td>
<td>35%</td>
<td>93%</td>
<td>50%</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Staphylococcus aureus - MRSA (n=75)</td>
<td>100%</td>
<td>90%</td>
<td>77%</td>
<td>37%</td>
<td>34%</td>
<td>-</td>
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</tr>
<tr>
<td>Staphylococcus aureus - MSSA (n=216)</td>
<td>100%</td>
<td>90%</td>
<td>100%</td>
<td>83%</td>
<td>53%</td>
<td>37%</td>
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<tr>
<td>Staphylococcus coagulase negative - ALL (n=48)</td>
<td>-</td>
<td>100%</td>
<td>47%</td>
<td>66%</td>
<td>62%</td>
<td>65%</td>
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<tr>
<td>Streptococcus pneumoniae</td>
<td>-</td>
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</tbody>
</table>

**Pseudomonas and/or Multi-Drug Resistant Organisms Suspected**

<table>
<thead>
<tr>
<th>Gram Negative Organisms</th>
<th>Cefazolin</th>
<th>Ampicillin</th>
<th>Ceftazidime</th>
<th>Ampicillin Sulbactam (Hanyo)</th>
<th>Levofloxacin</th>
<th>Trimethoprim / Sulfamethoxazole (Bactrim)</th>
<th>Pencillin</th>
<th>Imipenem</th>
<th>Cephalin</th>
<th>Meropenem</th>
<th>Gentamicin</th>
<th>Tobramycin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escherichia coli (n=531)</td>
<td>90%</td>
<td>61%</td>
<td>97%</td>
<td>62%</td>
<td>86%</td>
<td>80%</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Klebsiella species (n=153)</td>
<td>90%</td>
<td>97%</td>
<td>81%</td>
<td>97%</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Proteus species (n=55)</td>
<td>93%</td>
<td>79%</td>
<td>38%</td>
<td>89%</td>
<td>88%</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Serratia species (n=160)</td>
<td>-</td>
<td>-</td>
<td>100%</td>
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<tr>
<td>Neumococcus influenza (n=33)</td>
<td>33% (11/33)</td>
<td>33% (11/33)</td>
<td>33% (11/33)</td>
<td>33% (11/33)</td>
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<td>33% (11/33)</td>
</tr>
<tr>
<td>Entobacter species (n=60, close = 40)</td>
<td>-</td>
<td>-</td>
<td>79%</td>
<td>100%</td>
<td>-</td>
<td>77%</td>
<td>38%</td>
<td>38%</td>
<td>38%</td>
<td>38%</td>
<td>38%</td>
<td>38%</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa (n=55)</td>
<td>-</td>
<td>-</td>
<td>30%</td>
<td>37%</td>
<td>100%</td>
<td>36%</td>
<td>50%</td>
<td>36%</td>
<td>50%</td>
<td>36%</td>
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<td>36%</td>
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</tbody>
</table>

* Includes hospital and community isolates from all human sources. Isolates have been removed. 
† Susceptibility against betalactam, betalactamase, or beta-lactamase positive.
Empiric choices:

1) HAP: guidelines recommend, Piperacillin-Tazobactam, Levofloxacin, Vancomycin, but depending upon your local 
antiobiogram and epidemiology, monotherapy with Piperacillin-
Tazobactam may be sufficient/7 days (unless MRSA or 
Pseudomonas)

2) CAUTION: NEVER SEND A CULTURE IN A PATIENT WITH A FOLEY 
CATHETER WITHOUT CHECKING A UA FIRST! If the patient is 
symptomatic and probably has a UTI, empiric Ceftriaxone or 
Cefepime/7-10 days, depending on clinical response
Empirc choices:

3) Wound infection: Vancomycin, add GNR coverage for abdominal incisions, probably OK for others (Ceftriaxone or Cefepime)

4) Intra-abdominal infections: Ceftriaxone and Metronidazole OK in most cases, Piperacillin-Tazobactam or Cefepime and metronidazole / 4 days if adequate source control (percutaneous drainage IS NOT adequate source control)
Figure 3. Cumulative hazard estimates for the 75-day resistance rate, according to (A) fluoroquinolone resistance by fluoroquinolone exposure, (B) third-generation cephalosporin resistance by third-generation cephalosporin exposure, (C) ampicillin-sulbactam resistance by ampicillin-sulbactam exposure, and (D) imipenem resistance by imipenem exposure. Data are from the University of Utah Medical Center, 1994–1998.
• DO NOT START ANTIBIOTICS JUST TO FULFILL ADMISSION CRITERIA!
• ANTIBIOTIC THERAPY IN CASE OF ACTIVE INFECTION IS NOT GOING TO WORK IF YOU DO NOT HAVE SOURCE CONTROL!
• PREOPERATIVE ANTIBIOTICS ARE TYPICALLY THE RESPONSIBILITY OF THE SURGEON AND THE ANESTHESIOLOGIST, BUT HOSPITALIST HAVE A ROLE AS WELL!
• Post-operative antibiotics in case of active infection, or suspected post-operative infection (not fever alone)
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• Questions?