Medications in the Solid Organ Transplant Recipient

Monica Morgan, PharmD
Transplant Pharmacist
UT Southwestern Medical Center
Solid Organ Transplant Program

Objectives

• To describe the typical medications used for immunosuppression in solid organ transplant
• To describe typical medications used for infection prophylaxis in solid organ transplant
• To understand the conversion of transplant specific oral medication to intravenous (IV) administration
• To address administration barriers for patients NPO
• To understand which medications may not be held prior to surgery
• To review antimicrobial prophylactic strategies for general surgery
Immunosuppressants

- Calcineurin inhibitors (CNI)
  - Tacrolimus
  - Cyclosporine
- DNA synthesis inhibitors (anti-metabolites)
  - Mycophenolate
  - Azathioprine
- Corticosteroids
- mTOR inhibitors
  - Sirolimus
  - Everolimus
Tacrolimus (Prograf®)

- Available as:
  - 0.5, 1, 5 mg capsules
  - 0.5 mg/ml oral suspension
  - 5 mg/ml injection

- Mechanism of action:
  - Binds to FKBP12
  - Inhibits T cell activation and proliferation

Tacrolimus

- Used for induction and maintenance
- Larger dose should be administered in the morning
- Dose is adjusted based on trough levels
  - Trough should be drawn 1-2 hours prior to dose
  - Target 5-15 ng/ml depending on organ and time since transplant
Tacrolimus

• Administration
  – IV – continuous infusion
  – Oral
    • Given every 12 hours
    • May be given with or without food but be consistent
    • May be administered sublingually
    • Do not open capsules to administer via feeding tube
      – Must use suspension
  • Adverse Effects
    – Alopecia
    – Tremors
    – Hypomagnesemia
    – Hyperkalemia
    – Hypertension
    – Hyperglycemia
    – Headaches
    – Seizures
    – Nephrotoxicity

• Many drug interactions
• Drugs that decrease tacrolimus levels
  – Rifampin, carbamazepine, phenytoin, phenobarbital
• Drugs that increase tacrolimus levels
  – Azole antifungals, verapamil/diltiazem, macrolide antibiotics
  – Grapefruit juice
Tacrolimus XL (Astagraf XL®)

• Extended release tacrolimus
• Dosed ONCE DAILY in the morning
• May convert patients 1:1, but monitor trough levels closely
• Administer on empty stomach at least one hour before or two hours after meal

Cyclosporine

• Gengraf®
  – 25 and 100 mg capsules
• Sandimmune®
  – 50mg/ml, 5ml injection
  – 25, 100 mg capsules
  – 100mg/ml oral solution
• Neoral®
  – 25 and 100 mg capsules
  – 100 mg/ml oral solution
• Not interchangeable!
Cyclosporine

• Mechanism of action
  – Binds to cyclophyllin
  – Blocks T cell activation and proliferation

• Used for induction and/or maintenance

• Dose is adjusted according to serum drug levels
  – Trough should be drawn 1-2 hours before dose is due
  – Target trough 100-450 ng/ml
  – Dependent on organ and time since transplant

Cyclosporine

• Administration
  – IV – continuous infusion
  – Oral
    • Given every 12 hours
    • Capsules cannot be opened and must be stored in foil packet
    • Must use solution for administration via feeding tube
    • Solution must be diluted in ¼ cup orange/apple juice or chocolate milk
    • May be given with or without food, but be consistent

• Adverse Effects
  – Hirsutism
  – Hyperglycemia
  – Hyperlipidemia
  – Headache
  – Hypertension
  – Hypomagnesemia
  – Hyperkalemia
  – Gingival hyperplasia
  – Nephrotoxicity
  – Tremors
  – Seizures
Cyclosporine

• How to administer Neoral® solution
  – Remove plastic cap from bottle
  – Insert supplied tube with white cap into bottle
    • Assists with using syringe to correctly withdraw dose from vial
  – Withdraw dose and mix dose with ¼ cup orange or apple juice – lightly swirl
    • ONLY MIX IN GLASS
    • Neoral® will adhere to plastic!
  – Have patient drink mixture

Neoral® solution

• Patient may wash mixing glass
  – Ensure glass is dry prior to using
• Dosing syringe may NOT be washed
  – May wipe down with clean towel/cloth
  – Return syringe to protective case after use
Cyclosporine

• Many drug interactions
• Drugs that decrease cyclosporine levels
  – Rifampin, carbamazepine, phenytoin, phenobarbital
• Drugs that increase cyclosporine levels
  – Azole antifungals, verapamil/diltiazem, macrolide antibiotics
  – Grapefruit juice

Sirolimus (Rapamune®)

• Mechanism of action
  – Binds to FKBP12 and inhibits regulatory kinase mTOR
  – Inhibits T cell activation and proliferation
• Used for maintenance of immunosuppression
• Loading dose: 6 mg, maintenance dose: 2 mg
• Trough levels drawn 1-2 hours before dose
  – Goal 5-10 ng/ml
Sirolimus

• Administration
  – Once daily
  – Give 4 hours after cyclosporine
  – May be administered with or without food
  – Liquid: mix 2 oz of OJ/H2O with dose for 1 min and drink; refill with 4 oz of OJ/H2O and drink
  – Store liquid in refrigerator
    – stable for 30 days

• Adverse effects
  – Thrombocytopenia, anemia
  – Hyperlipidemia
  – Diarrhea, constipation
  – Headache
  – Hypertension
  – Edema

Anti-metabolites

• Azathioprine (Imuran®)
  – 50 mg tablets
  – 100 mg injection
    • Injection on backorder and currently not available

• Mycophenolate
  – Mycophenolate mofetil (Cellcept®)
    • 250 mg capsules and 500 mg caplets
    • 200 mg/ml oral solution
    • 500 mg injection
  – Mycophenolate sodium (Myfortic®)
    • 180 and 360 mg tablets
    • Delayed release
Azathioprine

• Mechanism of action
  – Antagonizes purine metabolism and inhibits the synthesis of DNA, RNA and proteins
• Used for maintenance of immunosuppression

Azathioprine

• Administration
  – IV – infusion over 30-60 min
  – Oral
    • Tablets may be crushed if administering via feeding tube
    • Dosed once or twice daily depending on organ
    • Dose is weight based

• Adverse Effects
  – Anemia, leukopenia, thrombocytopenia
  – Hepatotoxicity
  – Alopecia
  – GI: nausea, vomiting, diarrhea
Azathioprine

• Drug interactions
  – Allopurinol – contraindicated
    • Allopurinol inhibits metabolism of azathioprine
  – If allopurinol and azathioprine must given together, the dose of azathioprine must be reduced by 25-35%

Mycophenolate

• Mechanism of action
  – Inhibits *de novo* guanosine nucleotide synthesis
  – Prevents T and B cell proliferation
• Used for maintenance of immunosuppression
Mycophenolate

• Administration
  – Cellcept®
    • Twice daily
    • Capsule may not be opened – must use suspension for feeding tubes
    • Best given on empty stomach, but may be given with food if intolerable
    • IV infusion over at least 2 hours
  – Myfortic®
    • Twice daily
    • Tablet may not be chewed or crushed
    • Delayed release formulation
    • Best given on empty stomach but may be given with food if intolerable

Mycophenolate

• Adverse effects
  – Leukopenia, anemia, thrombocytopenia
  – GI: nausea, vomiting, diarrhea

• Monitoring
  – Trough levels should be drawn within 1-2 hours before dose is due
  – Mycophenolic acid (MPA): 2-4 mcg/ml
Mycophenolate

• Drug interactions
  – Acyclovir \( \rightarrow \) increases serum concentrations of both medications
  – Antacids/proton pump inhibitors \( \rightarrow \) must separate dose by at least 2 hours
    • Decrease mycophenolate serum concentrations

Corticosteroids

• Prednisone
• Methylprednisolone
Corticosteroids

• Mechanism of action
  – Inhibit activation and proliferation of T cells
  – Regulate gene expression
• Used for induction, maintenance and rejection

Corticosteroids

• Administration
  – Methylprednisolone
    • May be given IVP if ≤ 125 mg
    • Use IVPB over 30-60 min if > 125 mg
  – Prednisone
    • May be crushed
    • May be given once daily up to four times daily
    • Administer with food to avoid stomach upset
    • Give larger doses in the morning
INFECTION PROPHYLAXIS

Nystatin/Clotrimazole

• Prevents oral fungal infection
• Nystatin
  – Oral suspension
  – Swish and swallow or swish and spit
• Mycelex®
  – Orally disintegrating lozenge
Sulfamethoxazole/Trimethoprim (Bactrim®)

- Broad spectrum antibiotic
- Prevents *Pneumocystis (carinii) jiroveci* pneumonia
- SS (400/80) once daily or DS (800/160) three times weekly
- Tablet may be crushed for tube administration
  - Also manufactured as suspension

Valganciclovir (Valcyte®)

- Antiviral
- Prevents cytomegalovirus (CMV) infection
- Taken once or twice daily
  - 450 mg tablet
    - May not be crushed or chewed
  - 50 mg/ml suspension
    - Use suspension for tube administration
PREOPERATIVE CONSIDERATIONS

The Denervated Heart

• Donor heart is denervated during transplant
• Resting heart rate higher and less heart rate variability
• Lack of parasympathetic activity greater
• Eventually parasympathetic and sympathetic activity return but not completely
Box 1. Effect of various medications on the transplanted heart

**Drugs with minimal pharmacologic efficacy**
- Anticholinergics
- Atropine
- Glycopyrrrolate
- Scopolamine
- Anticholinesterases
- Neostigmine*
- Edrophonium
- Pyridostigmine

**Paralytics (usually affect heart rate)**
- Pancuronium
- Gallamine
- Physostigmine

**Drugs that retain pharmacologic efficacy**
- Isoproteranol
- Dobutamine
- Ephedrine
- Dopamine
- Glucagon
- Digoxin (inotropic effects only)
- Epinephrine (somewhat reduced)
- Norepinephrine (somewhat reduced)
- B-blockers
- Phosphodiesterase inhibitors

* May cause bradycardia

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**Infections**

<table>
<thead>
<tr>
<th>Donor-Derived Infection</th>
<th>Recipient-Derived Infection</th>
<th>Nosocomial, technical (donor or recipient)</th>
<th>Activation of latent infection (prodromal, emotional, opportunistic)</th>
<th>Community-acquired</th>
</tr>
</thead>
</table>

**Transplantation**

**Dynamic assessment of risk of infection**

**Common Infections in Solid-Organ Transplant Recipients**

**1-4 Months**
- With PCP and antiviral (CMV, HBV), prophylaxis
- Polyparasitic B1 infection, nephropathy (C. difficile colitis)
- HCV infection
- Adenoviral infection, influenza
- Cytomegalovirus infection
- Mycobacterium tuberculosis infection
- Anatomistic complications

**Without prophylaxis**
- Pneumocystis
- Infection with herpesviruses (HSV, VZV, CMV, EBV)
- HBV infection
- Infection with variola, vaccinia, varicella zoster virus, f. varicella

**5-6 Months**
- Community-acquired pneumonia, urinary tract infection
- Infection with varicella, atypical mycobacteria, macrolides
- Infection with nocardia, rhodococcus species
- Late viral infections: CMV infection (colitis and retinitis)
- Hepatitis B (HBV), HBV
- HSV encephalitis
- Community-acquired (SARS, West Nile virus infection)
- JC polycythemia virchow-Robin, Skin cancer, lymphoma (PTLD)

**Figure 4. Changing Timeline of Infection after Organ Transplantation.**

Infections occur in a generally predictable pattern after solid-organ transplantation. The development of infection is delayed by prophylaxis and accelerated by intensified immunosuppression, drug toxic effects that may cause leukopenia, or immunomodulatory viral infections such as infection with cytomegalovirus (CMV), hepatoitis C virus (HCV), or Epstein-Barr virus (EBV). At the time of transplantation, a patient’s short-term and long-term risk of infection can be stratified according to donor and recipient screening, the technical outcome of surgery, and the intensity of immunosuppression required to prevent graft rejection. Subsequently, an ongoing assessment of the risk of infection is used to adjust both prophylaxis and immunosuppressive therapy. MSIA denotes methicillin-resistant Staphylococcus aureus, VRE vancomycin-resistant Enterococcus faecalis, HSV herpes simplex virus, LCMV lymphocytic choriomeningitis virus, HIV human immunodeficiency virus, CMV cytomegalovirus, HBV hepatitis B virus, VZV varicella-zoster virus, SARS severe acute respiratory syndrome, PML progressive multifocal leukoencephalopathy, and PTLD post-transplantation lymphoproliferative disorder. Modified from Fishman and Ruben and Rubin et al. 45
To Hold or Not to Hold Prior to Surgery...

**May NOT be withheld**
- CNI
- Antimetabolite
- Corticosteroids
- Beta blockers
- Long acting insulin – give ½ dose

**May be withheld**
- ACEI/ARB
- Diuretics
- Oral antidiabetic agents
- Rapid acting insulin

**For antiplatelet and anticoagulant medications, must verify with surgeon when medication should be discontinued**

IV TO PO
Calcineurin inhibitors

• Cyclosporine
  – PO dose is 3x IV dose
  – Determine daily dose from IV rate and divide by 2 since cyclosporine is administered twice daily
    • IV is continuous infusion
• Tacrolimus
  – PO dose is 3-4x IV dose
  – Must multiply hourly rate (mcg/hr) x 24 or calculate daily dose (mg/kg/day)
    • IV is continuous infusion
  – Divide by 2 since tacrolimus is administered twice daily

Antimetabolites

• Azathioprine
  – 1:1 PO: IV
    • Injection on backorder
• Mycophenolate
  – Cellcept® is 1:1, PO: IV
  – Myfortic® must be converted to Cellcept® if IV is needed
    • 1080 mg Myfortic® = 1500 mg Cellcept®
    • 720 mg Myfortic® = 1000 mg Cellcept®
    • 360 mg Myfortic® = 500 mg Cellcept®
Corticosteroids

• 4 mg methylprednisolone = 5 mg prednisone
<table>
<thead>
<tr>
<th>Operation</th>
<th>Recommended antibiotic prophylaxis</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiothoracic surgery</td>
<td>Cefazolin, cefuroxime, or cefamandole; if patient has a β-lactam allergy: vancomycin or clindamycin</td>
<td>Most of the guidelines agree that prophylaxis for cardiac surgery should be administered for &gt; 24 hours after surgery. The ASHP suggests continuation of prophylaxis for cardiothoracic surgery up to 72 h; however, its authors suggest that prophylaxis for &lt; 24 h may be appropriate. Cefamandole is not available in the U.S.</td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>Cefazolin or cefuroxime; if patient has a β-lactam allergy: Vancomycin with or without gentamycin, or clindamycin</td>
<td></td>
</tr>
<tr>
<td>Colon surgery</td>
<td>Oral: neomycin plus erythromycin base, or neomycin plus metronidazole; parenteral: cefoxitin or cefotetan, or cefazolin plus metronidazole</td>
<td>Currently, none of the guidelines address antimicrobial prophylaxis for those patients with β-lactam allergy. Cefmetazole is not available in the U.S. Although a recent study indicates that the combination of oral prophylaxis with parenteral antibiotics may result in lower wound infection rates, this is not specified in any of the published guidelines.</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Operation</th>
<th>Recommended antibiotic prophylaxis</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip or knee arthroplasty</td>
<td>Cefazolin or cefuroxime; if the patient has a β-lactam allergy: vancomycin or clindamycin</td>
<td>Although not addressed in any of the published guidelines, the workgroup recommends that prophylactic antimicrobial be completely infused before inflation of the tourniquet. Cefuroxime is recommended as a choice for patients undergoing total hip arthroplasty.</td>
</tr>
<tr>
<td>Vaginal or abdominal hysterectomy</td>
<td>Cefazolin, cefotetan, cefoxitin, or cefuroxime</td>
<td>Metronidazole monotherapy is recommended in the ACOG Practice Bulletin as an alternative to cephalosporin prophylaxis for patients undergoing hysterectomy. Trovafloxin, although still available in the U.S., is recommended only for serious infections.</td>
</tr>
</tbody>
</table>

**Abbreviations:** ACOG, American College of Obstetricians and Gynecologists; ASHP, American Society of Health-System Pharmacists.

*Adapted from* Bratzler, DW, Houck, PM. Antimicrobial prophylaxis for surgery: an advisory statement from the national surgical prevention project. CID 2004;38:1706–15; with permission.
### Table 1: 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>Coronary artery bypass</td>
<td>Cefazolin, cefoxitin</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Cardiac device insertion procedures (e.g., pacemaker implantation)</td>
<td>Cefazolin, cefoxitin</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Ventricular assist devices</td>
<td>Cefazolin, cefoxitin</td>
<td>Clindamycin, vancomycin</td>
<td>C</td>
</tr>
<tr>
<td>Thoracic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noncardiac procedures, including thoracotomy, pneumonectomy, lung resection, and thoracotomy</td>
<td>Cefazolin, ampicillin–sulbactam</td>
<td>Clindamycin, vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Video-assisted thoracic surgery</td>
<td>Cefazolin, ampicillin–sulbactam</td>
<td>Clindamycin, vancomycin</td>
<td>C</td>
</tr>
<tr>
<td>Gastrointestinal (†)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedures involving entry into lumen of gastrointestinal tract (Bariatric, percutaneous endoscopy†)</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 (enterotomy, 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>Biliary tract</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open procedure</td>
<td>Cefazolin, cefotaxim, ceftriaxone, ampicillin–sulbactam</td>
<td>Clindamycin or aminoglycoside or aztreonam or fluoroquinolone†; Metronidazole + aminoglycoside or fluoroquinolone†</td>
<td>A</td>
</tr>
<tr>
<td>Laparoscopic procedure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective, low-risk</td>
<td>None</td>
<td>None</td>
<td>A</td>
</tr>
<tr>
<td>Elective, high-risk</td>
<td>Cefazolin, cefotaxim, ceftriaxone, ampicillin–sulbactam</td>
<td>Clindamycin or aminoglycoside or aztreonam or fluoroquinolone†; Metronidazole + aminoglycoside or fluoroquinolone†</td>
<td>A</td>
</tr>
<tr>
<td>Appendectomy for uncomplicated appendicitis</td>
<td>Cefazolin, cefotaxim, cefazolin + metronidazole</td>
<td>Clindamycin + amoxicillin–clavulanate or aztreonam or fluoroquinolone†; Metronidazole + aminoglycoside or fluoroquinolone†</td>
<td>A</td>
</tr>
<tr>
<td>Small intestinal resections</td>
<td>Cefazolin</td>
<td>Clindamycin or aminoglycoside or aztreonam or fluoroquinolone†</td>
<td>C</td>
</tr>
</tbody>
</table>

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### Table 1 (continued)

<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>Obstructed</td>
<td>Cefazolin + metronidazole, cefoxitin, ceftriaxone</td>
<td>Metronidazole + aminoglycoside or fluoroquinolone†</td>
<td>C</td>
</tr>
<tr>
<td>Hernia repair (hernioplasty and herniorrhaphy)</td>
<td>Cefazolin</td>
<td>Clindamycin or vancomycin</td>
<td>A</td>
</tr>
<tr>
<td>Colorectal†</td>
<td>Cefazolin + metronidazole, cefoxitin, ceftriaxone, ampicillin–sulbactam</td>
<td>Clindamycin or aminoglycoside or aztreonam or fluoroquinolone†; Metronidazole + aminoglycoside or fluoroquinolone†</td>
<td>A</td>
</tr>
<tr>
<td>Head and neck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean</td>
<td>None</td>
<td>None</td>
<td>B</td>
</tr>
<tr>
<td>Clean–contaminated cancer surgery</td>
<td>Cefazolin</td>
<td>Clindamycin†</td>
<td>B</td>
</tr>
<tr>
<td>Clean–contaminated procedure with the exception of tonsillectomy and functional endoscopic sinus procedures</td>
<td>Cefazolin + metronidazole, cefoxitin + metronidazole, ampicillin–sulbactam</td>
<td>Clindamycin†</td>
<td>A</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>Cefazolin</td>
<td>Clindamycin†</td>
<td>B</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>Cefazolin</td>
<td>Clindamycin†</td>
<td>C</td>
</tr>
<tr>
<td>Ophthalmic</td>
<td>Cefazolin, cefotaxim, ceftriaxone, ampicillin–sulbactam</td>
<td>Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone†; Metronidazole + aminoglycoside or fluoroquinolone†</td>
<td>A</td>
</tr>
<tr>
<td>Ophthalmic</td>
<td>Topical neomycin–polymyxin B–gramicidin or fourth-generation topical fluoroquinolones (paraffin or methyl–acetate) given as 1 drop every 5–10 min for 5 doses. Addition of cefazolin 100 mg by subconjunctival injection or intraocular cefazolin 1–2.5 mg or ceftriaxone 1 mg at the end of procedure is optional</td>
<td>None</td>
<td>B</td>
</tr>
<tr>
<td>Orthopedic</td>
<td>Clean operations involving hand, knee, or foot and not involving implantation of foreign materials</td>
<td>None</td>
<td>C</td>
</tr>
<tr>
<td>Spinal procedures with and without instrumentation</td>
<td>Cefazolin</td>
<td>Clindamycin or vancomycin†</td>
<td>A</td>
</tr>
</tbody>
</table>

Continued on next page
Table 2 (continued)

<table>
<thead>
<tr>
<th>Type of Procedure</th>
<th>Recommended Agents&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Alternative Agents in Pts With β-Lactam Allergy</th>
<th>Strength of Evidence&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip fracture repair</td>
<td>Cefazolin</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</td>
<td>A</td>
</tr>
<tr>
<td>Hip fracture implantation of internal fixation devices (e.g., nails, screws, plates, wires)</td>
<td>Cefazolin</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</td>
<td>B</td>
</tr>
<tr>
<td>Total joint replacement</td>
<td>Cefazolin</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</td>
<td>C</td>
</tr>
<tr>
<td>Lower tract instrumentation with risk factors for infection (including transurethral prostate biopsy)</td>
<td>Cefazolin, ciprofloxacin&lt;sup&gt;b&lt;/sup&gt;, sulfamethoxazole-tetracycline</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</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., perineal prosthesis))</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</td>
<td>A</td>
</tr>
<tr>
<td>Involving implanted prosthesis</td>
<td>Cefazolin, amikacin, ampicillin-sulbactam</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</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., perineal prosthesis))</td>
<td>Cefazolin, (the addition of a single dose of an aminoglycoside may be recommended for placement of prosthetic material (e.g., perineal prosthesis))</td>
<td>A</td>
</tr>
<tr>
<td>Clean contaminated</td>
<td>Cefazolin, metronidazole, cefotin</td>
<td>Cefazolin, (the addition of a single dose of an aminoglycoside may be recommended for placement of prosthetic material (e.g., perineal prosthesis))</td>
<td>A</td>
</tr>
<tr>
<td>Vascular&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Cefazolin</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</td>
<td>A</td>
</tr>
<tr>
<td>Heart-lung, heart-lung transplantation&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Cefazolin</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</td>
<td>A</td>
</tr>
<tr>
<td>Heart transplantation&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Cefazolin</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</td>
<td>A</td>
</tr>
<tr>
<td>Lung and heart-lung transplantation&lt;sup&gt;f&lt;/sup&gt;</td>
<td>Cefazolin</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</td>
<td>A</td>
</tr>
<tr>
<td>Liver transplantation&lt;sup&gt;g&lt;/sup&gt;</td>
<td>Piperacillin--tazobactam, ceftriaxone + ampicillin</td>
<td>Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone&lt;sup&gt;a&lt;/sup&gt;</td>
<td>B</td>
</tr>
<tr>
<td>Pancreas and pancreate-kidney transplantation&lt;sup&gt;h&lt;/sup&gt;</td>
<td>Cefazolin, fusidic acid (for patients at high risk of fungal infection (e.g., those with enteral drainage of the pancreas))</td>
<td>Clindamycin or vancomycin + aminoglycoside or aztreonam or fluoroquinolone&lt;sup&gt;a&lt;/sup&gt;</td>
<td>A</td>
</tr>
<tr>
<td>Clean with risk factors or clean-contaminated</td>
<td>Cefazolin, ampicillin--sulbactam</td>
<td>Clindamycin, clavulanic acid, vancomycin&lt;sup&gt;a&lt;/sup&gt;</td>
<td>C</td>
</tr>
</tbody>
</table>

<sup>a</sup> Alternative agents are based on local hospital formulary and may vary by institution.

<sup>b</sup> Evidence levels: A = Level I, B = Level II, C = Level III.

<sup>c</sup> Includes transplantation of vascular structures.

<sup>d</sup> Includes transplantation of heart-lung and heart-lung transplantation.

<sup>e</sup> Includes transplantation of heart.

<sup>f</sup> Includes transplantation of lung and heart-lung transplantation.

<sup>g</sup> Includes transplantation of liver.

<sup>h</sup> Includes transplantation of pancreas and pancreate-kidney transplantation.

<sup>i</sup> Includes transplantation of plastic surgery.
Conclusions

- Transplant medications are critical
- Immunosuppressed - more at risk for infection
- Infection risk varies based on time since transplant

References

- Tacrolimus package insert
- Cyclosporine package insert