Infections in Patients With Cancer

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Disclosure

Dr. Quilitz discloses the following:
- Nonbranded presentation for Merck (12/16/13) – Invasive Fungal Infections (IFI) in Cancer Patients: Risk and Prevention Considerations
- Member of advisory board panels
  - Isavuconazole: Astellas Pharma US
  - Telavancin: Theravance Biopharma

Learning Objectives

- Review the risk factors for infections in oncology patients
- Identify prominent bacterial, fungal, and viral pathogens which cause infections in immunocompromised cancer patients
- Discuss and select appropriate antimicrobial options to prevent or treat infections in immunocompromised cancer patients
- Apply the principles of a health-care team approach for the management of infections in immunocompromised cancer patients
Which cancer patients do you predominantly follow?

A. Medical oncology: Solid tumors JL240
B. Surgical oncology: Solid tumors JL241
C. Hematology oncology: Leukemia/lymphoma/myeloma JL242
D. Stem cell transplant recipients, autologous JL243
E. Stem cell transplant recipients, allogeneic JL244

Which of the following types of infectious complications in patients with cancer would you most like to hear about?

A. Bacterial infections JL245
B. Fungal infections JL246
C. Viral infections JL247
D. Something weird: Protozoa, parasites, etc. JL248

Key Resources

**Risk Factors Associated With Primary Malignancy**

- Advanced or refractory solid tumors may increase risk of infection due to anatomic factors
- May outgrow blood supply leading to necrosis
- Endobronchial tumors → obstructive pneumonia
- Abdominal tumors →
  - Obstruct GU system → pyelonephritis
  - Obstruct biliary tract → cholangitis
- Tumors invading through colonic mucosa → local abscess formation and/or sepsis
- Infections associated with aggressive tumor resection

**Risk Factors for Infection**

- Hypogammaglobulinemia
  - Associated with CLL, MM
  - MM may have elevated IgG but low functional levels
- Asplenia/functional asplenia
  - Results from splenectomy, splenic radiation, or chronic GVHD in alloSCT recipients
- Increased susceptibility to encapsulated bacteria
  - Streptococcus pneumoniae, Hemophilus influenzae, and Neisseria meningitidis
  - Vaccination indicated if able to mount immune response

**Risk Factors: Corticosteroids and Other Lymphotoxins**

- Risk increases with dose and duration of corticosteroids + coexisting immunodeficiencies + other immunosuppressants
- Corticosteroids blunt fever and signs of infection
- Purine analogs (i.e., fludarabine): Lymphotoxic, especially to CD4+ lymphocytes
  - Fludarabine + prednisone → CD4+ depression may last for months
- Temozolomide + XRT for glioblastoma – PCP prophylaxis recommended
- Alemtuzumab (Campath) – monoclonal-Ab vs. GCSF
  - GCSF found on most normal lymphocytes
  - Severe lymphopenia CD4+ and CD8+ counts suppressed in some patients for more than 12 mo after therapy
  - Require PCP/HSV prophylaxis + 2 mo or CD4+ > 200
  - CMV surveillance + 2 mo or CD4+ > 100
An absolute neutrophil count (ANC) of < 500 cells/µL or an ANC that is expected to decrease to < 500 cells/µL during the next 48 hr

- ANC = WBC × ([%polys] + [%bands]) × 1,000
- If WBC = 2.2k, 12% polys, 2% bands:
  - ANC = 2.2 × [0.12 + 0.02] × 1,000 = 308

The single most important risk factor for infection following chemotherapy is neutropenia
- Severity — highest risk when ANC < 100 = “profound”
- 10%–20% will develop bloodstream infection
- Rapid decline of ANC
- Duration — greater risk when ANC < 500 for > 10 days
- Rate of decline and duration are a measure of bone marrow reserve
- “Functionally neutropenic”: Patients with heme malignancies associated with impaired neutrophil function
  - Reduced phagocytosis and pathogen killing
  - Increased risk of infection despite “normal” neutrophil count

Breakdown of barrier to infection in GI, sinopulmonary, GU tracts → invasion of local flora
- Increased risk of bloodstream infections by viridans streptococci such as Streptococcus mitis (stomatitis), Candida, GNR, Enterococcus
- Combination of enteritis plus neutropenia → typhilitis or neutropenic enterocolitis

GI = gastrointestinal, GNR = Gram-negative rod.
AutoSCT < AlloSCT: Most infections occur during neutropenia or first 3 mo after SCT until recovery of cellular immunity

AlloSCT
- 1st month after SCT: Neutropenia/mucositis
  - After myeloid recovery: Immunosuppressant therapy to prevent and/or treat GVHD results in increased risk of wide variety of opportunistic infections
- Chronic GVHD: Functionally asplenic

Risk Factors: High-Dose Chemotherapy With SCT

Cancer patients have blunted inflammatory responses
- Common signs and symptoms of infections may be minimized or absent
- The most important sign of infection in a neutropenic patient is FEVER
  - Single oral temperature of > 38.3°C (101°F) or oral temperatures of 38°C to 38.2°C (100.4° to 100.9°F) persisting for 1 hr or longer

Infectious Timeline After AlloBMT

Neutropenic Fever
Consequences of Neutropenic Fever

- Incidence of neutropenic fever
  - 10%–50% of patients with solid tumors
  - > 80% of patients with hematologic malignancies
- Infections documented in 20%–30% NF episodes
  - Bacteremia: 10%–20% of patients with NF, esp. prolonged/profound
- Neutropenic fever is a medical emergency
  - Urgent empiric antibiotic therapy within 2 hr of presentation to prevent progression to sepsis
- Antimicrobial prophylaxis may reduce infections in high-risk patients at risk of fostering resistance

Pathogens in Neutropenic Fever

- Figure 2: Changing pathogens in neutropenia.

Bacterial Infections

Table 1. Common Bacterial Pathogens in Neutropenic Patients

<table>
<thead>
<tr>
<th>Common gram-positive pathogens</th>
<th>Coagulase-negative staphylococci</th>
<th>Staphylococcus aureus, including methicillin-resistant strains</th>
<th>Enterococcus species, including vancomycin-resistant strains</th>
<th>Viridans group streptococci</th>
<th>Streptococcus pneumoniae</th>
<th>Streptococcus pyogenes</th>
</tr>
</thead>
</table>

References:

Bacterial Infections

Common gram-negative pathogens

- Escherichia coli
- Klebsiella species
- Enterobacter species
- Pseudomonas aeruginosa
- Citrobacter species
- Acinetobacter species
- Stenotrophomonas maltophilia

Low- vs. High-Risk Neutropenic Fever

- Low risk: < 7 days neutropenia with minimal comorbid conditions, MASCC < 21: Candidates for oral/outpatient Rx
- High risk: > 7 days, ANC < 100, and/or significant medical comorbid conditions, MASCC > 21: Admit for IV Rx

Initial Antibacterial Therapy for Neutropenic Fever

- Low risk
  - Amoxicillin-clavulanate + ciprofloxacin

- High risk
  - Monotherapy with anti-pseudomonal β-lactam is recommendation by IDSA guidelines (1A)
    - Cefepime
    - Piperacillin-tazobactam
    - Carbapenem: doripenem, imipenem, or meropenem
      - Not ertapenem due to lack of anti-PsA activity
When to Add Vancomycin (or Other Agents vs. Gram+ Bacteria)

- VRE-colonized patients should initially receive empiric daptomycin ≥ 8 mg/kg/day or linezolid 600 mg po/IV bid.
- Reassess need for continued Gram+ agents after 48 to 72 hr.
- Hemodynamically unstable.
- Positive cultures for Gram-negative bacteria (especially bacteremia).
- Consider in patients with recent history of multi-drug-resistant GNR infection.
- Reevaluate need for expanded Gram-negative coverage in 48 to 72 hr based on culture and susceptibility data.

When to Add Aminoglycosides or Fluoroquinolones

- Hemodynamically unstable.
- Positive cultures for Gram-negative bacteria (especially bacteremia).
- Consider in patients with recent history of multi-drug-resistant GNR infection.
- Reevaluate need for expanded Gram-negative coverage in 48 to 72 hr based on culture and susceptibility data.

Addition of Anaerobic Coverage

- Neutropenic enterocolitis, a.k.a. typhilitis
  - Severe RLQ abdominal pain.
  - Add metronidazole to anti-pseudomonal β-lactam such as ceftazidime.
  - Piperacillin-tazobactam or carbapenem monotherapy provides excellent anaerobic coverage; do not add metronidazole.
  - Suspected or documented *Clostridium difficile* colitis.
**Addition or Expansion of Antifungal Therapy**

**IDSA guidelines**
- Patients who remain hemodynamically unstable after initial doses with standard agents for neutropenic fever should have their antimicrobial regimen broadened to include coverage for resistant gram-negative, gram-positive, and anaerobic bacteria and fungi (A-III).
  - Options: Fluconazole, caspofungin/micafungin, Iposomal amphotericin B
- Empirical antifungal coverage should be considered in high-risk patients who have persistent fever after 4–7 days of a broad-spectrum antibacterial regimen and no identified fever source (A-II).
  - Options: Caspofungin/micafungin, Iposomal amphotericin B

**Deescalation in Neutropenics**

**IDSA guidelines**
- Positive culture: Modifications to the initial antibiotic regimen should be guided by clinical and microbiologic data (A-II)
  - Can be appropriately narrowed to specifically treat the defined infection once afebrile
  - NCCN does not recommend deescalation from anti-pseudomonal until ANC > 500
- Negative culture: Traditional approach is to continue broad-spectrum antibiotics until the patient is afebrile for ≥ 2 days and ANC > 500

**ECIL guidelines**
- Positive culture
  - Deescalate to a narrower-spectrum therapy based on susceptibility profile (AII)
- Negative culture
  - If patient was hemodynamically unstable at presentation, no change until neutrophil recovery
  - Empiric antibiotics can be discontinued after ≥ 72 hr in patients who were hemodynamically stable AND afebrile ≥ 48 hr irrespective of ANC or expected duration of neutropenia (BIII)
    - Or resume fluoroquinolone prophylaxis (CII)

NCCN = National Comprehensive Cancer Network

ECIL = European Conference on Infections in Leukemia
**Antibacterial Prophylaxis**

Consider fluoroquinolone prophylaxis (ciprofloxacin or levofloxacin) in patients receiving myelosuppressive chemo if:

- NCCN guidelines
  - Intermediate risk (7–10 days of neutropenia) such as autologous SCT, lymphoma, MM, CLL, purine analog therapy
  - High risk (> 10 days of neutropenia) such as alloSCT, acute leukemia
- IDSA guidelines
  - ANC < 100 for > 7 days
  - Levofloxacin preferred for patients at risk for invasive viridans streptococcal infection (i.e., severe mucositis)

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**Fungal Pathogens**

- **Yeast**
  - Candida
  - Cryptococcus
  - Torulopsis
  - Emerging pathogens
    - Rhodotorula
    - Malassezia
    - Saccharomyces
- **Dimorphic fungi**
  - Blastomyces dermatitidis
  - Coccioides immitis
  - Histoplasma capsulatum
  - Sporothrix
- **Molds**
  - Aspergillus
  - Fusarium
  - Zygomyces
    - Absidia
    - Coccidioides
    - Mucor
    - Rhizopus
- **More molds**
  - Scopulariopsis
  - Dimatiaeous molds
    - Alternaria
    - Bipolaris
    - Curvularia
    - Exophiala

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**Risk Factors for Invasive Fungal Infections**

- **Risk of invasive fungal infection**
  - Duration of neutropenia
    - > 14 days
    - 7–14 days
    - < 7 days

- **High-risk of IFI**
  - Allogeneic HT (HB-HLA-matched)
  - AML/MDS consolidation or relapse
- **Medium-risk of IFI**
  - Allogeneic HT (HLA-mismatched)
  - Other diseases different from Ac or MG
- **Low-risk of IFI**
  - Autologous HT
  - Other diseases different from AI or MG
Disseminated Candida Infections

- Fungemia, predominantly candidemia, accounts for 19% of positive BSIs in severely septic ICU patients
- Negative blood culture in 20%–30% of disseminated candidiasis cases
- Risk factors
  - Neutropenia, hematologic cancer, DM, immunodeficiency, high-dose steroids, immunosuppressants, antineoplastics, CVCs, hemodialysis, TPN, multiple antibiotics, extensive GI tract surgery

Organ Involvement of Disseminated Candidiasis

- Abdomen: abscess, peritonitis
- Bone: hematogenous spread to spine, sternum, femur
- Cardiac: central venous catheter, fungal endocarditis, superinfection of bacterial endocarditis
- CNS: s/p neurosurgery, IVDA, alcoholics, premature infants
- Joint: s/p trauma, underlying joint disease, prosthesis, monoarthritis
- Lung: hematogenous spread, bilateral nodular PN
- UTI: DM, hydronephrosis, catheter, stone

Sites of Disseminated Candidiasis
Antifungal Spectrum: Candida

<table>
<thead>
<tr>
<th>ANTIFUNGAL</th>
<th>FLUC</th>
<th>ITRA</th>
<th>VOPI</th>
<th>POSA</th>
<th>ECHINO</th>
<th>AMPHO</th>
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<tbody>
<tr>
<td>C. albicans</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>C. glabrata</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>C. tropicalis</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>C. parapsilosis</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>(higher MIC)</td>
<td>+++</td>
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<tr>
<td>C. krusei</td>
<td>+</td>
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</tbody>
</table>

Ubiquitous mold: Soil, water, plants

Species: fumigatus, flavus, niger, terreus

Infections

- Superficial
- Allergic pulmonary
- Aspergilloma (fungus ball)
- Invasive (disseminated) infection

Aspergillosis

Echinocandin-resistant Candida glabrata infections, including one case of fungemia occurring in low dose micafungin, have been reported.

Incidence of Invasive Pulmonary Aspergillosis in Prolonged Neutropenia Without Prophylaxis

- Cultures
  - Blood, CNS, BM rarely +
  - Respiratory cx may reflect colonization
- Examination of invaded tissues
  - Even with bx/BAL, only positive in 40% of cases
- Galactomannan assay
  - Cell wall polysaccharide
  - Opportunity for early diagnosis
  - False-positive with concurrent piperacillin-tazobactam
  - Decreased sensitivity in patients on antimold agents
  - Initially approved for serum assay only
  - Combination of serum and BAL galactomannan assay may improve reliability
- CT thorax w/o contrast

Diagnosis of Invasive Aspergillosis

Aspergillus on the CT Scan

- "Halo sign." Ground-glass attenuation surrounding nodule due to alveolar hemorrhage
  - Early sign of aspergillosis, progressively less frequent with time
- "Air crescent sign" indicates necrotic area, later sign, not seen during neutropenia
Antifungal Spectrum: Aspergillus

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<tr>
<th>ANTIFUNGAL</th>
<th>FLUC</th>
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<tr>
<td>Aspergillus fumigatus</td>
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<td>Aspergillus flavus</td>
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<td>+++</td>
<td>+++</td>
<td>++</td>
<td>(Higher MIC)</td>
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<tr>
<td>Aspergillus terreus</td>
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Disseminated Aspergillus fumigatus infections have been reported in alloSCT recipients despite voriconazole or caspofungin prophylaxis
- Treatment of choice: Amphotericin B (lipid formulations)

Voriconazole vs. Amphotericin B for Primary Therapy of Invasive Aspergillosis

- 277 patients with IA randomized to:
  - Voriconazole 6 mg/kg IV q12h ×2 then 4 mg/kg IV q12h for at least 7 days, transitioned to 200 mg po bid when stable
  - Amphotericin B deoxycholate 1–1.5 mg/kg IV q24h
- Voriconazole median duration: 77 days
- Amphotericin B median duration: 10 days – 80% switched to OLA (other licensed antifungal therapy)
- Success at 12 wk: 52.8% (V) vs. 31.6% (A)
  - 95% CI of difference = 10.4 – 32.9%
- Survival at 12 wk: 70.8% (V) vs. 57.9% (A)
  - Survival rate was statistically significantly higher for voriconazole
  - Hazard ratio: 0.59, 95% CI = 0.4–0.88
- Voriconazole is first-line treatment of choice for invasive aspergillosis
### Antifungal Spectrum: Emerging Molds

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<td>Fusarium sp</td>
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<td>Mucormycosis</td>
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<td>Rhizopus</td>
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<td>S. apiospermum</td>
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<td>-</td>
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<td>++</td>
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<tr>
<td>Dematiaceous molds</td>
<td>-</td>
<td>-</td>
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Adapted from Sanford Guide, 2014

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### Pneumocystis jiroveci Pneumonia

- Fungal infection that produces diffuse ground-glass pneumonia in lymphopenic patients
- Major cause of morbidity and mortality in immunocompromised patients w/o prophylaxis
- TMP/SMX SS or DS 1 tab po daily; or DS 1 tab Mon/Wed/Fri
- Treatment of choice: TMP/SMX 15–20 mg/kg/d in 3–4 doses for 14–21 days +/- prednisone if $pO_2 < 70$ mm Hg

TMP/SMX = trimethoprim/sulfamethoxazole; SS = single strength; DS = double strength

Images from the photo collection of Dr. John N. Greene
- Herpes simplex (HSV)
- Varicella zoster (VZV)
- Cytomegalovirus (CMV)
- Human herpesvirus-6 (HHV-6)
- Epstein-Barr virus (EBV)
- Adenovirus
- BK virus
- JC virus

HSV-1, HSV-2
- α-herpes virus which establishes latency in nerve root ganglia
- HSV-1: predominantly oro-labial infections
- HSV-2: predominantly genital infections
- More severe and frequent mucocutaneous HSV infections in neutropenia/SCT/SOT
  - Oral or esophageal: HSV can aggravate chemotherapy-induced mucositis
- Visceral or disseminated disease
  - Disseminated cutaneous, esophagitis, hepatitis, pneumonitis, encephalitis
Primary varicella = "chicken pox"
- Fever and rash (vesicular, pruritic) usually for 7–10 days in immunocompetent patients
- Rare, life-threatening visceral invasion leading to hepatitis, pancreatitis, pneumonitis, encephalitis
- Followed by lifelong latency
  - Cranial nerve and dorsal root ganglia
- Herpes zoster = "shingles" years to decades later
  - Vesicular lesions usually limited to single dermatome
  - Postherpetic neuralgia
Cytomegalovirus (CMV)

- CMV infection = Viral replication (not latent)
  - Monitor via CMV DNA by PCR or pp65 antigenemia
  - Fever, malaise, leukopenia, thrombocytopenia
  - Pneumonitis, hepatitis, retinitis, GI disease, encephalitis
- Major cause of morbidity and/or mortality in SOT and alloSCT recipients
  - Highest risk in SOT: CMV D+/R-
    - Lung, small intestine, pancreas higher risk than liver or kidney
    - Highest risk AlloSCT: CMV R+ (reactivation)
- CMV-negative or leukocyte-depleted blood products for CMV recipients (alloSCT), CMV D-/R- (SOT)
CMV Pneumonitis

Image from the photo collection of Dr. John N. Greene

CMV First-Line Treatment Options

- Ganciclovir 5 mg/kg IV q12h
  - DLT: Myelosuppression (esp. neutropenia)
  - Adjust dose for renal insufficiency
  - CMV resistance rare in previously untreated patients
  - Alternative: Valganciclovir 900 mg po bid-food
  - ~ 90% bioavailability
- Foscarnet 60 mg/kg IV q8h or 90 mg/kg IV q12h
  - SE: Nephrotoxicity, electrolyte wasting (K, Mg, Ca, Phos), genital ulcerations
  - NB 1-2 L/day recommended to reduce nephrotoxicity
  - Adjust dose for renal insufficiency
  - No oral dosage formulation
  - Primarily used in pts with baseline neutropenia or GCV resistant
- Consider addition of IVIG or CMV-IVIG for alloBMT recipients with CMV pneumonia

CMV Disease Prevention


Table 1: Prophylaxis versus preemptive therapy

<table>
<thead>
<tr>
<th>Prophylaxis</th>
<th>Prevent</th>
<th>Identify</th>
<th>Prevent</th>
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<tr>
<td>Drug</td>
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Table 2: Currently available drugs for cmv prophylaxis

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dosage</th>
<th>Comments on use and major toxicity</th>
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</thead>
<tbody>
<tr>
<td>Neuraminidase 3% 0.2 mL daily</td>
<td>Ease of administration, tolerability</td>
<td></td>
</tr>
<tr>
<td>Oral Neuraminidase 1 g 3 times daily</td>
<td>Low oral bioavailability, high pill burden, ineffectiveness, high pill burden, neurologic effects</td>
<td></td>
</tr>
<tr>
<td>Neuraminidase 3% 0.2 mL daily</td>
<td>Tolerability, ineffectiveness, high pill burden, neurologic effects</td>
<td></td>
</tr>
<tr>
<td>Valaciclovir 2 g 12 times daily</td>
<td>Tolerability, ineffectiveness, high pill burden, neurologic effects</td>
<td></td>
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</tbody>
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  - Aliyah Bakuzih, MD
  - Jamie Morano, MD
  - Ana Velez, MD
- Infectious Diseases/Antimicrobial Stewardship Clinical Pharmacists
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  - Yanina Pasikhova, PharmD, BCPS-AQ ID, AAHIVP
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  - Chiara Quintana, RN
- Microbiology
  - Ramon Sandin, MD, MS, FCAP, ABP-MM
  - Dawn Rojas, BS, MT (ASCP)
- Infection Prevention
  - Kay Sims, RN, BSN, OIC
  - Stacy Martin, RN, BSN, CIC
  - Stephanie Caraway, Infection Prevention Specialist
Depending on their underlying disease and oncologic treatments, oncology patients may be susceptible to a wide variety of infections (bacterial, fungal, viral, and parasitic), some of which we have briefly reviewed today.

Given the complexity of these patients' immunosuppressive therapies in combination with prophylactic and therapeutic antimicrobial therapies, the clinical pharmacist plays a vital role in the care of these patients as part of an interdisciplinary care team.

Conclusions

What ID issues in cancer patients would you most like to learn more about in future presentations?

A. Antibacterial resistance/antimicrobial stewardship JL249
B. Antifungal agent clinical pearls JL250
C. Pneumocystis jiroveci prevention/treatment JL251
D. Viral hepatitis JL252
E. Stem cell transplant infectious complications JL253
F. After this lecture, I never want to hear about ID again! JL254

Questions?