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**Preface: Aging Has Unique Effects on the Risks, Presentation, Diagnosis, Treatment, and Prognosis of Infectious Diseases**  
Robin L.P. Jump and David H. Canaday  

**Influence of Aging and Environment on Presentation of Infection in Older Adults**  
Nadim G. El Chakhtoura, Robert A. Bonomo, and Robin L.P. Jump  
In older adults, pathophysiologic, clinical, and environmental factors all affect the presentation of infections. We explore how age-related changes influence the manifestation and evaluation of infections in this population. Specific topics include immunosenescence, age-related organ-specific physiologic changes, and frailty. We also describe clinical factors influencing infection risk and presentation in older adults, including temperature regulation, cognitive decline, and malnutrition. Finally, we discuss the influence of the setting in which older adults reside on the clinical evaluation of infection. Understanding the influence of all these changes may facilitate the prevention, early recognition, and treatment of infections in older adults.

**Antimicrobial Pharmacokinetics and Pharmacodynamics in Older Adults**  
John M. Benson  
Antimicrobial use in older adults requires working knowledge of the pharmacokinetics and pharmacodynamics of these drugs, and the alterations known to occur with these models as patients age. A summary of pharmacokinetic principles relevant to antimicrobials and an overview of published medical literature describing pharmacokinetic changes known to correlate with age are presented. Pharmacodynamic models that apply to antibacterial agents are reviewed, as are likely effects of aging on these models. The understanding of how older adults respond in terms of efficacy and toxicity is increasing but limited. Further research into the effects of aging on the actions of antimicrobials in the elderly is needed.

**Antibiotic Stewardship in Nursing Facilities**  
Miranda McElligott, Grace Welham, Aurora Pop-Vicas, Lyndsay Taylor, and Christopher J. Crnich  
Misuse and overuse of antibiotic therapy is a frequent cause of resident harm in nursing facilities. As a result, newly released policy and regulatory initiatives will require antibiotic stewardship programs (ASPs) in nursing facilities. Although implementing ASPs can be challenging, improving the quality of antibiotic prescribing is achievable in this setting. The authors review the determinants of antibiotic prescribing in nursing facilities, strategies to improve antibiotic prescribing in this setting, current status of ASPs in nursing facilities, and steps that facilities can take to enhance existing ASP structure and process.
Antimicrobial Use at the End of Life

Adam Baghban and Manisha Juthani-Mehta

At least one-third of patients at the end of life (EOL) receive interventions that are without benefit, and a similar proportion of patients die in the intensive care unit. Here, the authors discuss the role of antimicrobials in patients at the EOL, including the patient populations and scenarios in which antimicrobials may or may not have benefit. They also review adverse outcomes associated with antimicrobial use at the EOL, including societal harms. Finally, an algorithm to aid management of suspected infections at the EOL is proposed.

Breaking the Chain of Infection in Older Adults: A Review of Risk Factors and Strategies for Preventing Device-Related Infections

Gregory Schrank and Westyn Branch-Elliman

Device-related infections (DRIs) are a significant cause of morbidity and mortality among older adults. Indwelling devices (urinary catheters, percutaneous feeding tubes, and central venous catheters) are frequently used in this vulnerable population. Indwelling devices provide a portal of entry for pathogenic organisms to invade a susceptible host and cause infection and are an important target for infection prevention and antimicrobial stewardship efforts. Within the “Chain of Infection” that leads to DRIs in older adults, multiple opportunities exist to implement interventions that “break the links” and reduce colonization with multidrug-resistant organisms, reduce infections, and improve antimicrobial use.

Urinary Tract Infection and Asymptomatic Bacteriuria in Older Adults

Nicolas W. Cortes-Penfield, Barbara W. Trautner, and Robin L.P. Jump

Urinary tract infections (UTIs) are a significant cause of morbidity among older adults. However, antibiotic prescriptions for clinically suspected UTIs are often inappropriate. Health care providers frequently struggle to differentiate UTI from asymptomatic bacteriuria, particularly in patients presenting with nonspecific symptoms. Patients with baseline cognitive impairments that limit history-taking can be particularly challenging. This article reviews the epidemiology and pathogenesis of UTI in older adults. It discusses an approach to diagnosis and treatment focused on recognizing patients who would likely benefit from antibiotic treatment and on identifying patients for whom empiric antibiotic therapy should not be given.

Bacterial Pneumonia in Older Adults

Oryan Henig and Keith S. Kaye

The incidence of pneumonia increases with age, and is particularly high in patients who reside in long-term care facilities (LTCFs). Mortality rates for pneumonia in older adults are high and have not decreased in the past decade. Atypical symptoms and exacerbation of underlying illnesses should trigger clinical suspicion of pneumonia. Risk factors for multidrug-resistant organisms are more common in older adults, particularly among LTCF residents, and should be considered when making
empiric treatment decisions. Monitoring of clinical stability and underlying comorbid conditions, potential drug–drug interactions, and drug-related adverse events are important factors in managing elderly patients with pneumonia.

**Septic Arthritis and Prosthetic Joint Infections in Older Adults**

Rajeshwari Nair, Marin L. Schweizer, and Namrata Singh

Older adults are at increased risk for septic arthritis and prosthetic joint infections (PJIs), owing at least in part to comorbid conditions and frailty. An increasing number of older adults undergo total joint arthroplasty to improve their quality of life. Infections in older adults differ from younger populations by the causative organisms, a great proportion of which are staphylococcal infections. Targeting important modifiable and nonmodifiable risk factors may prevent or reduce the burden of joint infections in older adults. This article summarizes the epidemiology, pathogenesis, clinical manifestations, diagnosis, management, and prevention of septic arthritis and PJIs in older adults.

**Sepsis in Older Adults**

Theresa A. Rowe and June M. McKoy

Sepsis disproportionally affects older adults, with more than 60% of sepsis diagnoses attributed to adults aged 65 years and older. Identifying, diagnosing, and treating sepsis in older individuals remain a challenge for clinicians, and few studies focus specifically on older adults with multiple medical comorbidities. Principles guiding management of sepsis for older adults are generally the same as in younger adults; however, unique considerations particularly pertinent to the care of older adults include antimicrobial selection and dosing, delirium management, and goals of care discussions. Other factors, such as medical comorbidities, cognitive impairment, and functional status, impact outcomes more than age alone.

**Clostridium difficile in Older Adults**

Curtis J. Donskey

Recent increases in the incidence of *Clostridium difficile* infection (CDI) have been observed in all age groups, but the elderly have been disproportionately affected and long-term care facilities (LTCFs) have borne a significant proportion of the increasing burden. Recurrences are common in older adults and may have significant adverse effects on quality of life. Ensuring appropriate diagnostic testing and management is challenging for older adults in the community and in LTCFs. This article focuses on current concepts related to the epidemiology, diagnosis, and management of CDI in older adults.

**Influenza in Older Adults**

H. Keipp Talbot

Annually, influenza viruses cause significant disease in older adults, varying with the virulence of the circulating strain, prior exposure to circulating strain, and influenza vaccine effectiveness. Older adults often present...
atypically (eg, without fever) and with complications of influenza infection, such as chronic obstructive pulmonary disease and congestive heart failure exacerbations. Prevention methods include antiviral medications and vaccines. Current influenza vaccines have moderate effectiveness for the prevention of hospitalization, but newer more immunogenic vaccines designed for adults 65 and older have been licensed.

Respiratory Syncytial Virus and Other Noninfluenza Respiratory Viruses in Older Adults

Fumihiro Kodama, David A. Nace, and Robin L.P. Jump

Respiratory viral infections may cause serious complications for older adults, including residents of long-term care facilities (LTCFs). Although influenza is the most common cause of viral respiratory infections among older adults, several other respiratory viruses also cause significant morbidity and mortality, most notably respiratory syncytial virus. Other noninfluenza respiratory viral pathogens include human metapneumovirus, parainfluenza virus, rhinovirus, coronavirus, and adenovirus. All of these may cause outbreaks among LTCF residents. Recently developed rapid diagnostic molecular tests may clarify the epidemiology of these viruses and have potential, through early identification, to limit the severity of outbreaks among older adults living in LTCFs.

Human Immunodeficiency Virus and Aging in the Era of Effective Antiretroviral Therapy

Puja Van Epps and Robert C. Kalayjian

Persons living with human immunodeficiency virus (HIV) infection (PLWH) have accentuated risks for age-associated comorbidities. Compared with the general population, PLWH have a twofold higher risk of cardiovascular disease, a threefold increased risk of fracture, and a risk of kidney disease that is comparable to that in diabetes. Some comorbidities may present at younger ages than among the general population, suggesting the possibility of accelerated aging with HIV infection.

Herpes Zoster in the Older Adult

Amrita R. John and David H. Canaday

Herpes zoster (HZ) is the result of reactivation of latent varicella zoster virus and occurs most frequently in older adults. Classically, HZ presents as a unilateral, self-limited, dermatomal rash. Postherpetic neuralgia (PHN) is a common sequela, presenting as severe pain that persists after the rash has resolved. In the elderly, PHN can be debilitating and requires a prompt diagnosis, treatment with antivirals, and adequate pain control. A longer-term pain management strategy is required if PHN occurs. A modestly effective vaccine exists and is recommended for older individuals.

Hepatitis C Virus Infection in the Older Patient

Michael Reid, Jennifer C. Price, and Phyllis C. Tien

Hepatitis C virus (HCV) is the most common blood-borne infection in the United States and is of concern in older adults. HCV infection is associated
with not only hepatic but also extrahepatic comorbidities common to the aging patient, including diabetes, kidney and cardiovascular diseases, and neurocognitive impairment. The effect of direct-acting antiviral agents to treat HCV on these outcomes is limited. This article summarizes the literature regarding the epidemiology and natural history of HCV infection; the impact of age on clinical outcomes in HCV-infected persons; and current knowledge regarding safety and efficacy of HCV treatment regimens in the older patient.

Norovirus Infection in Older Adults: Epidemiology, Risk Factors, and Opportunities for Prevention and Control 839

Cristina V. Cardemil, Umesh D. Parashar, and Aron J. Hall

Norovirus is the leading cause of acute gastroenteritis. In older adults, it is responsible for an estimated 3.7 million illnesses, 320,000 outpatient visits, 69,000 emergency department visits, 39,000 hospitalizations, and 960 deaths annually in the United States. Older adults are particularly at risk for severe outcomes, including prolonged symptoms and death. Long-term care facilities and hospitals are the most common settings for norovirus outbreaks in developed countries. Diagnostic platforms are expanding. Several norovirus vaccines in clinical trials have the potential to reap benefits. This article summarizes current knowledge on norovirus infection in older adults.