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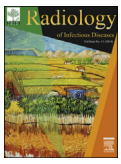

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Review

Imaging pulmonary infectious diseases in immunocompromised patients

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Abstract

Immunocompromised patients are subject to a variety of infectious pathogens involving lungs. Imaging examination of pulmonary conditions could provide valuable information for differentiation diagnosis, treatment assessment as well as prognostic prediction. Imaging manifestations of immunocompromise-related pulmonary diseases could be either pathogen-specific or -non-specific. It is particularly fundamental to recognize these imaging characteristics at suspicion of opportunistic infections in such patients. In this article, we attempt to present a review to refresh and update our knowledge of imaging features of pulmonary infectious diseases in immunocompromised patients.

Keywords: Immunocompromise; Infectious diseases; Imaging; *Pneumocystis jiroveci* pneumonia

The immunocompromised conditions can be attributed to various disorders impairing human immune systems, including human immunodeficiency virus (HIV) infection, primary immune deficiency, and immunosuppression-related medical treatment, such as high-dose corticosteroid use, chemotherapy or transplantation therapy [1]. Among them, HIV infections and consequent AIDS are the most notorious. Since first recognized in 1981, HIV infection has became a global healthcare challenge, being responsible for the death of over 25 million patients. Currently around 33.3 million people are suffering from HIV infection and its associated complications [2]. Clinical complications in immunocompromised patients vary from severe opportunistic infections to unusual malignancies affecting major organs. Fig. 1 outlines the major classes of immunocompromised conditions and associated infections.

Most of imaging modalities available today have certain roles in the evaluation of the pulmonary complications occurring in immunocompromised patients. For example, ultrasound can be used for quantitation of pleural effusion and guiding thoracentesis, if necessary. There have been interests in the roles of MRI in evaluating immunocompromised patients – many are young and there is concern about frequent imaging using ionizing radiation. Still, chest radiograph and CT or high-resolution CT (HRCT) remain the most useful tools. Particularly, cross sectional images from CT or sometimes HRCT, enables better precise characterization of the extent, activity and pattern of pulmonary lesions, guides tissue biopsy whenever necessary, and monitors treatment response. A normal CT may allow exclusion of certain infections, for example pneumocystis, but certain pathogen-related pulmonary infection could be negative in imaging at the initial developing phase of the disease, for example fungal infections. Thus, imaging examination should always be interpreted in the context of the patient's clinical presentation. Table 1 lists the common imaging patterns seen in HRCT examination and frequently underlying infections. In this

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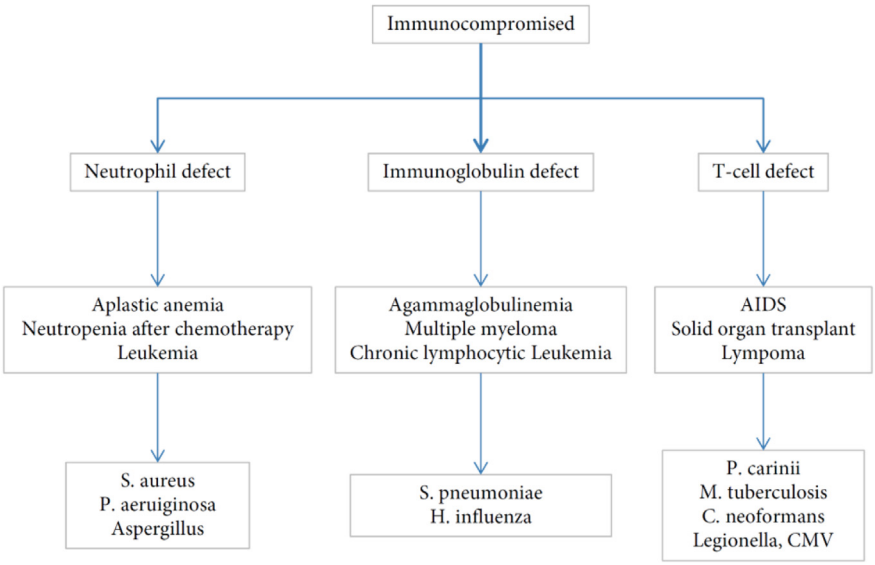

Fig. 1. Major classes of immunocompromised conditions, related clinical entities and infections most commonly associated with each class (Baughman RP [3]).

article, we attempt to present an overview of imaging characteristics of pulmonary infectious diseases in this particular patient population.

1. Bacterial pneumonia

Mycobacterial infection, including both tuberculosis (TB) and non-tuberculous mycobacterial infection, is an important cause of morbidity and mortality in immunocompromised patients, particularly in AIDS patients. According to a report from the World Health Organization in 2009, among the 9.27 million cases of TB, approximately 14.8% occurred in HIV-positive patients with about half of million deaths from HIV-infected TB patients. Fatality rate among HIV-infected TB cases remains 13–14% against less than 4% in HIV negative TB cases [4]. The most common HRCT findings in active TB are centrilobular or linear structures, tree-in-bud appearance and macro-nodules. Consolidation, lymphadenopathy, pleural effusion, ground glass opacity and cavitation also can be observed [5]. In smear-negative AIDS patients with pulmonary TB, specific CT findings have predictive values for accurate diagnosis. These findings include miliary nodules, necrotic lymph nodes, lobular consolidation and tree-in-bud [6]. Of note, unusual radiographic manifestations of TB are more common in immunocompromised patients than in immunocompetent populations.

Table 1
Common HRCT imaging patterns with frequent immunocompromise-related infections.

Imaging patterns		Associated infections
Ground-glass opacity		• Pneumocystis • Cytomegalovirus
Nodules	<1 cm diameter	• Viral pneumonia
	>1 cm diameter	• Invasive aspergillosis • Septic embolism
	"Halo sign"	• Invasive aspergillosis • Candidiasis • Cytomegalovirus pneumonia
	Cavitated nodules	• Septic embolism • Invasive aspergillosis
Tree-in-bud pattern		• Infectious bronchiolitis
Consolidation	Lobar	• Pneumococcus • Klebsiella
	Rounded	• Pneumococcus • Legionella
	Bronchopneumonia	• Gram-negative bacteria • Staphylococcus

The most common non-tuberculous mycobacteria involving lungs is mycobacterium avium complex (MAC). According to a study by the Centers of Disease Control of United States from 1991 through 1992, MAC dominated M. tuberculosis as the leading mycobacterium isolated from immunocompromised patients, particularly since pneumocystis prophylaxis was widely given [7]. It has been reported that MAC infection developed in 33.4% of HIV-infected patients, with predisposition of developing disseminated diseases, involving extrapulmonary organs, such as kidney and liver [8]. However, incidence of MAC infection is quite low in non-HIV immunocompromised patients. Localized pulmonary disease is rare, only seen in less than 5% of patients. Radiographic findings dramatically vary, ranging from normal to mediastinal lymphadenopathy, lobar infiltrates, diffuse or patchy nodular or alveolar infiltrates, without specific imaging patterns associated with MAC infection [9]. Clinically, low CD4 counts less than 50 cells/mm^3 could be indicative of this disease when non-specific pulmonary involvement exists.

According to the Pulmonary Complications of HIV Infection Study, increased incidence of community-acquired bacterial pneumonia (CAP) was associated with HIV infection with 5.5 episodes of pneumonia per hundred person years in HIV-infected patients in comparison with 0.9 episodes in the non-HIV group [10]. However, with the development of antiretroviral treatment, the incidence of CAP in