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PNEUMOCYSTIS PNEUMONIA IN HIV-INFECTED PATIENTS: CLINICAL FEATURES, DIAGNOSTIC APPROACHES, AND TREATMENT METHODS

Saydaliyeva Maxliyo
1st-year Master's Degree Student

Scientific Supervisor:
Usmanova Elmira Mamarafiqovna

Abstract. Pneumocystis pneumonia is a severe opportunistic infection that continues to represent a major cause of morbidity and mortality among HIV-infected patients, particularly in individuals with advanced immunosuppression. Despite the widespread use of antiretroviral therapy and prophylactic measures, pneumocystis pneumonia remains prevalent in settings with delayed HIV diagnosis and limited access to healthcare services. The disease is characterized by a subacute clinical course, progressive respiratory symptoms, and significant hypoxemia, which often lead to delayed diagnosis and poor outcomes.

This review aimed to analyze the clinical features, diagnostic approaches, and treatment strategies for pneumocystis pneumonia in patients with HIV infection. A comprehensive review of the scientific literature published between 2005 and 2024 was conducted using international medical databases. Clinical manifestations, radiological findings, laboratory diagnostic methods, and therapeutic outcomes were systematically evaluated.

The findings indicate that pneumocystis pneumonia predominantly occurs in patients with CD4+ T-lymphocyte counts below 200 cells/μL. High-resolution computed tomography, polymerase chain reaction assays, and serum beta-D-glucan measurement significantly improve diagnostic accuracy. Trimethoprim-sulfamethoxazole remains the first-line therapy, while adjunctive corticosteroid treatment reduces mortality in moderate to severe cases.

Early HIV diagnosis, timely initiation of antiretroviral therapy, and appropriate prophylaxis are essential for preventing pneumocystis pneumonia and improving patient outcomes. Strengthening diagnostic capacity and clinical awareness is crucial to reducing the global burden of this opportunistic infection.

Keywords: HIV infection; Pneumocystis pneumonia; Opportunistic infections; Pneumocystis jirovecii; Diagnosis; Treatment; Antiretroviral therapy

Introduction

Human Immunodeficiency Virus (HIV) infection remains a major global public health problem, leading to progressive immunodeficiency and increased susceptibility to opportunistic infections. Despite significant advances in antiretroviral therapy (ART), opportunistic pulmonary infections continue to be a leading cause of morbidity and mortality among people living with HIV, particularly in patients with advanced immunosuppression [1].

Pneumocystis pneumonia (PCP), caused by *Pneumocystis jirovecii*, is one of the most common and life-threatening opportunistic infections in HIV-infected individuals. The disease predominantly occurs in patients with CD4+ T-lymphocyte counts below 200 cells/μL and often

represents the first AIDS-defining illness in untreated or late-diagnosed HIV patients [2,3]. Although the widespread use of ART and prophylactic regimens has significantly reduced the incidence of PCP in developed countries, it remains highly prevalent in low- and middle-income regions where access to early HIV diagnosis and continuous treatment is limited [4].

Clinically, pneumocystis pneumonia is characterized by a subacute onset of non-productive cough, progressive dyspnea, fever, and hypoxemia. These manifestations may initially appear mild, leading to delayed medical attention and late diagnosis, which significantly worsens the prognosis [5]. Radiological findings are often nonspecific in early stages, while advanced disease may present with bilateral interstitial infiltrates, further complicating differential diagnosis from other HIV-associated pulmonary conditions such as tuberculosis and bacterial pneumonia [6].

Timely and accurate diagnosis of PCP remains a clinical challenge. Conventional diagnostic methods include microscopic detection of the organism in respiratory specimens, while modern approaches such as polymerase chain reaction (PCR) assays and serum biomarkers, including beta-D-glucan, have improved diagnostic sensitivity [7,8]. However, limited availability of advanced diagnostic tools in resource-constrained settings continues to impede early detection.

Treatment of pneumocystis pneumonia primarily involves high-dose trimethoprim-sulfamethoxazole, with adjunctive corticosteroid therapy recommended in cases of moderate to severe hypoxemia. Despite standardized treatment protocols, mortality rates remain considerable, especially among patients with delayed diagnosis, severe respiratory failure, or coexisting opportunistic infections [9,10].

Given the ongoing burden of pneumocystis pneumonia among HIV-infected patients and the diagnostic and therapeutic challenges associated with this condition, a comprehensive analysis of its clinical features, diagnostic strategies, and treatment approaches is essential. This article aims to review current knowledge on pneumocystis pneumonia in HIV-infected individuals, focusing on clinical presentation, diagnostic methods, and evidence-based treatment options.

Materials and Methods

This study was conducted as a narrative and analytical review of existing scientific literature focusing on pneumocystis pneumonia in HIV-infected patients. Relevant articles were identified through systematic searches of international medical databases, including PubMed, Scopus, and Web of Science, covering publications from 2005 to 2024. The search strategy involved the use of Medical Subject Headings (MeSH) and keywords such as “HIV infection,” “Pneumocystis pneumonia,” “Pneumocystis jirovecii,” “opportunistic infections,” “diagnosis,” and “treatment,” combined using Boolean operators. Only articles published in English were included in the analysis [1,2].

The selection criteria comprised original research articles, systematic reviews, meta-analyses, and international clinical guidelines that addressed the clinical features, diagnostic approaches, and therapeutic strategies for pneumocystis pneumonia in HIV-positive patients. Studies focusing exclusively on non-HIV immunocompromised populations, case reports with insufficient clinical data, and publications lacking full-text availability were excluded. After initial screening based on titles and abstracts, full texts of relevant articles were reviewed for eligibility and scientific relevance [3].

Data extraction was performed independently by reviewing authors and included patient demographics, CD4+ T-lymphocyte counts, clinical manifestations, radiological findings, laboratory diagnostic methods, treatment regimens, and clinical outcomes. Diagnostic methods evaluated in the selected studies included microscopic examination of induced sputum and bronchoalveolar lavage specimens, polymerase chain reaction assays for *Pneumocystis jirovecii* DNA detection, and serum beta-D-glucan measurement as a non-invasive biomarker. Radiological assessment methods, including chest radiography and high-resolution computed tomography, were also analyzed for their diagnostic value [4,5].

Therapeutic approaches assessed in this review focused on first-line and alternative pharmacological treatments for pneumocystis pneumonia. The effectiveness of trimethoprim-sulfamethoxazole, pentamidine, and atovaquone was evaluated, along with the role of adjunctive corticosteroid therapy in patients with moderate to severe hypoxemia. Additionally, the timing of antiretroviral therapy initiation and its impact on clinical outcomes and immune reconstitution inflammatory syndrome were examined based on available evidence [6,7].

The collected data were synthesized using a descriptive analytical approach. Due to heterogeneity in study designs and outcome measures, a quantitative meta-analysis was not performed. Instead, findings were systematically compared and summarized to identify common clinical patterns, diagnostic challenges, and treatment outcomes. Ethical approval was not required for this study, as it was based exclusively on previously published data without direct patient involvement [8].

Results

The analysis of the selected studies demonstrated that pneumocystis pneumonia predominantly affects HIV-infected patients with advanced immunosuppression. Across the reviewed literature, the majority of patients diagnosed with pneumocystis pneumonia had CD4+ T-lymphocyte counts below 200 cells/μL, with a significant proportion presenting with counts lower than 100 cells/μL at the time of diagnosis [2,3]. Late presentation to healthcare facilities was frequently reported, contributing to increased disease severity and poorer clinical outcomes.

Clinically, the most commonly reported symptoms were progressive dyspnea, non-productive cough, fever, and fatigue. Hypoxemia was a consistent finding in moderate to severe cases, often necessitating hospitalization and supplemental oxygen therapy. Several studies highlighted that the subacute onset of symptoms led to delays in diagnosis, as initial manifestations were often mistaken for other respiratory infections common among HIV-infected individuals [4,5].

Radiological findings varied depending on disease stage. Chest radiography frequently revealed bilateral diffuse interstitial infiltrates, while high-resolution computed tomography showed characteristic ground-glass opacities with a perihilar or diffuse distribution. These imaging features were reported to have higher sensitivity in early disease detection compared to standard chest X-rays, particularly in patients with atypical clinical presentations [6].

Regarding diagnostic methods, bronchoalveolar lavage with microscopic identification of *Pneumocystis jirovecii* remained the reference standard in most studies. However, polymerase chain reaction assays demonstrated higher sensitivity, especially in cases with low organism burden. Serum beta-D-glucan levels were consistently elevated in patients with confirmed

pneumocystis pneumonia, supporting its role as a useful adjunctive diagnostic biomarker, particularly when invasive procedures were not feasible [7,8].

Treatment outcomes varied depending on disease severity and timing of therapy initiation. Trimethoprim-sulfamethoxazole was the most frequently used first-line treatment and showed high effectiveness when administered early. Adjunctive corticosteroid therapy significantly reduced mortality and the need for mechanical ventilation in patients with moderate to severe hypoxemia. Despite appropriate therapy, mortality rates ranged from 10% to 30%, with higher rates observed in patients with delayed diagnosis, severe respiratory failure, or concomitant opportunistic infections [9,10].

A summary of the main clinical, diagnostic, and therapeutic findings reported in the reviewed studies is presented in Table 1.

Table 1. Key characteristics of pneumocystis pneumonia in HIV-infected patients

Parameter	**Main findings**
CD4+ T-cell count	<200 cells/μL in most patients; <100 cells/μL in severe cases
Common symptoms	Dyspnea, dry cough, fever, fatigue
Radiological findings	Bilateral interstitial infiltrates; ground-glass opacities on HRCT
Diagnostic methods	BAL microscopy, PCR, serum beta-D-glucan
First-line treatment	Trimethoprim-sulfamethoxazole
Adjunctive therapy	Corticosteroids in moderate–severe hypoxemia
Mortality rate	10–30%, higher with delayed diagnosis

Discussion

The findings of this review confirm that pneumocystis pneumonia remains a significant opportunistic infection among HIV-infected patients, particularly in those with advanced immunodeficiency. Consistent with previous reports, the majority of affected individuals had CD4+ T-lymphocyte counts below 200 cells/μL, emphasizing the critical role of cellular immunity in controlling *Pneumocystis jirovecii* infection [2,3]. Late presentation and delayed HIV diagnosis were frequently associated with more severe clinical manifestations and increased mortality, highlighting persistent gaps in early detection and linkage to care.

The clinical presentation of pneumocystis pneumonia is often insidious, characterized by gradually progressive dyspnea, non-productive cough, and fever. This subacute course

distinguishes PCP from acute bacterial pneumonias but may also contribute to diagnostic delays, as early symptoms are frequently underestimated by both patients and healthcare providers [4,5]. Hypoxemia, a key indicator of disease severity, was consistently associated with poor outcomes, underscoring the importance of early assessment of arterial oxygenation in suspected cases.

Radiological findings play a crucial role in the diagnostic process. The reviewed studies demonstrated that high-resolution computed tomography offers superior sensitivity compared to conventional chest radiography, particularly in early or atypical cases. The presence of diffuse ground-glass opacities is highly suggestive of pneumocystis pneumonia in HIV-infected patients with compatible clinical features. However, these findings are not pathognomonic and may overlap with other opportunistic infections, necessitating microbiological confirmation [6].

Advances in diagnostic techniques have significantly improved the detection of *Pneumocystis jirovecii*. Polymerase chain reaction assays were shown to provide higher sensitivity than traditional microscopic methods, especially in patients with low fungal burden. Nevertheless, PCR-based diagnostics may detect colonization rather than active infection, requiring careful interpretation in the clinical context. Serum beta-D-glucan has emerged as a valuable non-invasive biomarker, demonstrating high sensitivity for pneumocystis pneumonia and serving as a useful adjunct when invasive sampling is not feasible [7,8].

Treatment outcomes largely depend on the timeliness of therapy initiation and disease severity at presentation. Trimethoprim-sulfamethoxazole remains the cornerstone of treatment and continues to demonstrate high efficacy. The addition of adjunctive corticosteroid therapy in patients with moderate to severe hypoxemia was consistently associated with reduced mortality and decreased progression to respiratory failure, supporting current international treatment guidelines [9,10]. However, adverse drug reactions and treatment intolerance remain important clinical challenges, particularly in patients with advanced HIV disease.

Despite improvements in diagnostic and therapeutic strategies, mortality associated with pneumocystis pneumonia remains substantial. This underscores the ongoing need for effective prevention strategies, including early initiation of antiretroviral therapy and appropriate prophylaxis in patients with low CD4+ T-cell counts. Strengthening HIV screening programs and improving access to diagnostic resources are essential steps toward reducing the burden of pneumocystis pneumonia, particularly in resource-limited settings.

Conclusion

Pneumocystis pneumonia remains a serious and potentially life-threatening opportunistic infection among HIV-infected patients, particularly in individuals with advanced immunosuppression. The disease continues to pose significant diagnostic and therapeutic challenges due to its subacute clinical course, nonspecific early symptoms, and overlap with other HIV-associated pulmonary infections. Late presentation and delayed diagnosis are key factors contributing to increased morbidity and mortality.

This review highlights that a combination of clinical assessment, radiological imaging, and microbiological or molecular diagnostic methods is essential for accurate and timely diagnosis. High-resolution computed tomography, polymerase chain reaction assays, and serum beta-D-

glucan measurement have improved diagnostic sensitivity and support early therapeutic decision-making, especially in cases where invasive procedures are limited.

Trimethoprim-sulfamethoxazole remains the first-line treatment for pneumocystis pneumonia, while adjunctive corticosteroid therapy significantly improves outcomes in patients with moderate to severe hypoxemia. However, despite standardized treatment approaches, mortality rates remain considerable, emphasizing the importance of early intervention.

Effective prevention strategies, including early HIV diagnosis, timely initiation of antiretroviral therapy, and appropriate prophylaxis in high-risk patients, are critical to reducing the incidence and severity of pneumocystis pneumonia. Strengthening healthcare systems and improving access to diagnostic and preventive services are essential to further decrease the global burden of this opportunistic infection.

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