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To study the association of opportunistic infections in people living with HIV and its correlation with cd4 count and viral load in a tertiary care centre Kanpur

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Abstract

Background: Human Immunodeficiency Virus (HIV) infection continues to be a major global public health challenge, particularly in developing countries where opportunistic infections remain a significant cause of morbidity and mortality. Progressive destruction of CD4+ T lymphocytes leads to impaired immune function and increased susceptibility to opportunistic pathogens. CD4 cell count and plasma HIV viral load are important immunological and virological markers used for assessing immune status, monitoring disease progression, and evaluating response to antiretroviral therapy (ART). Understanding the relationship between opportunistic infections, CD4 count, and viral load is essential for improving clinical management and predicting disease outcomes among people living with HIV.

Aim: To study the association of opportunistic infections in people living with HIV and to evaluate its correlation with CD4 count and viral load in a tertiary care centre.

Methods: This hospital-based analytical case–control study was conducted at the Department of General Medicine, K.P.S. Institute of Medicine, G.S.V.M. Medical College, Kanpur. A total of 186 HIV-seropositive adult patients were included and divided into

two groups consisting of 93 cases with opportunistic infections and 93 controls without opportunistic infections. Demographic characteristics, clinical history, laboratory parameters, CD4 count, and plasma HIV viral load were recorded using a predesigned structured pro-forma. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 26. Continuous variables were expressed as mean ± standard deviation and categorical variables as frequency and percentage. Associations were assessed using Chi-square test and independent Student's ttest. A p-value less than 0.05 was considered statistically significant.

Results: The mean age of participants among cases was 42.86 ± 14.09 years, while among controls it was 44.44 ± 14.08 years. Males constituted 59.1% of cases and 48.4% of controls. The mean CD4 count among cases was 468.24 ± 125.35 cells/mm³ compared to 567.16 ± 130.43 cells/mm³ among controls. The mean minimum CD4 count recorded was 312.45 ± 118.52 cells/mm³ among cases and 401.28 ± 120.34 cells/mm³ among controls. Adequate CD4 recovery after ART was observed in 44.1% of cases and 73.1% of controls. The mean viral load among cases was 1.53 ± 1.65 lac copies/mL whereas among controls it was 0.43 ± 0.89 lac copies/mL. Viral suppression was observed in 31.2% of cases compared to 76.3% of controls. Tuberculosis was the most common opportunistic infection (36.6%), followed by bacterial pneumonia (17.2%), oral candidiasis (15.1%), cryptococcosis (9.7%), cryptosporidium infection (8.6%), aspergillosis (7.5%), and isospora infection (5.4%).

Conclusion: Opportunistic infections remain common among people living with HIV, particularly in patients with lower CD4 counts and higher viral load levels. Patients with opportunistic infections demonstrated poorer immunological recovery, higher viral replication, and lower rates of viral suppression compared to those without opportunistic infections. Regular monitoring of CD4 count and viral load is essential for early identification of patients at risk of opportunistic infections and for improving clinical management in HIV-infected individuals.

Keywords: HIV, Opportunistic infections, CD4 count, Viral load, Antiretroviral therapy

Introduction

Human Immunodeficiency Virus infection remains one of the most important infectious diseases affecting global public health. Since its recognition in the early 1980s, HIV infection has caused millions of deaths worldwide and continues to pose major healthcare challenges, especially in low- and middle-income countries. HIV primarily affects the immune system by targeting CD4+ T lymphocytes, which play a crucial role in maintaining cellular immunity. Progressive depletion of CD4 cells leads to impaired immune responses and increased susceptibility to opportunistic infections and malignancies.

The introduction of antiretroviral therapy has significantly improved survival and transformed HIV into a chronic manageable condition. However, opportunistic infections continue to remain common among individuals presenting late in the disease course, those with poor adherence to therapy, or patients experiencing treatment failure. Opportunistic infections contribute substantially to hospitalization, reduced quality of life, and increased mortality among HIV-infected individuals.

CD4 count and plasma HIV viral load are the two most important markers used in routine HIV care. CD4 count reflects the degree of immune suppression and helps predict the risk of opportunistic infections. Viral load reflects active viral replication and disease activity. Persistent viral replication leads to chronic immune

activation and progressive immune dysfunction. Combined evaluation of these parameters provides valuable information regarding disease progression and treatment response.

India has one of the largest populations of people living with HIV globally. The pattern of opportunistic infections in India differs from Western countries, with tuberculosis being the most common infection. Other commonly reported infections include bacterial pneumonia, candidiasis, cryptococcosis, and gastrointestinal protozoal infections.

Many patients in tertiary care settings present with advanced disease and severe immunosuppression, making early risk identification extremely important. Several studies have demonstrated a close relationship between declining CD4 count and occurrence of opportunistic infections. Similarly, elevated viral load has been associated with poor immune recovery and increased infection risk. However, limited data are available from North Indian tertiary care centres evaluating the combined role of CD4 count and viral load in predicting opportunistic infections. The present study was therefore undertaken to assess the association between opportunistic infections, CD4 count, and viral load among HIV-infected individuals attending a tertiary care centre in Kanpur, Uttar Pradesh.

Materials and Methods

This hospital-based analytical case–control study was conducted at the Department of General Medicine, K.P.S. Institute of Medicine, G.S.V.M. Medical College, Kanpur, after obtaining approval from the Institutional Ethics Committee. The study duration was eighteen months.

A total of 186 HIV-seropositive adults aged more than 18 years were enrolled. Patients were divided into two groups. Group A consisted of 93 HIV-positive patients diagnosed with one or more opportunistic infections, while Group B consisted of 93 HIV-positive patients without opportunistic infections at the time of evaluation. Patients were recruited from outpatient and inpatient services of the Department of General Medicine and associated hospitals attached to G.S.V.M. Medical College. HIV diagnosis was confirmed according to National AIDS Control Organization guidelines.

Patients with severe chronic systemic illnesses, incomplete clinical data, or unwillingness to participate were excluded from the study.

Consecutive sampling was used until the required sample size was achieved.

A detailed clinical history was obtained from all participants including duration of HIV infection, ART status, treatment adherence, presenting symptoms, and previous medical history. General physical examination and systemic examination were performed.

Laboratory investigations included complete blood count, liver function tests, kidney function tests, serum electrolytes, sputum examination, stool examination, urine examination, cerebrospinal fluid analysis where indicated, Gram staining, Ziehl–Neelsen staining, imaging studies, CD4 count estimation, and plasma HIV viral load testing.

Opportunistic infections were diagnosed based on clinical features supported by microbiological, radiological, or pathological investigations. Tuberculosis was diagnosed using sputum examination, radiology, or other confirmatory investigations. Fungal infections were diagnosed by microbiological evaluation and clinical findings.

Data were recorded using a structured proforma and analyzed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation, while categorical variables were represented as frequencies and

percentages. Student's t-test and Chi-square test were used for statistical comparison. A p-value of less than 0.05 was considered statistically significant.

Results

The study included 186 HIV-seropositive individuals divided equally into cases and controls. The mean age among cases was 42.86 ± 14.09 years, while among controls it was 44.44 ± 14.08 years. Male predominance was observed in both groups.

Table 1: Demographic Profile of Study Participants

Variable	Cases (n=93)	Controls (n=93)
Mean age (years)	42.86 ± 14.09	44.44 ± 14.08
Male	55 (59.1%)	45 (48.4%)
Female	38 (40.9%)	48 (51.6%)

Most participants were receiving antiretroviral therapy at the time of enrollment. However, adequate treatment adherence and immune recovery were significantly lower among cases compared to controls. Patients with opportunistic infections demonstrated poorer treatment response and delayed immune restoration.

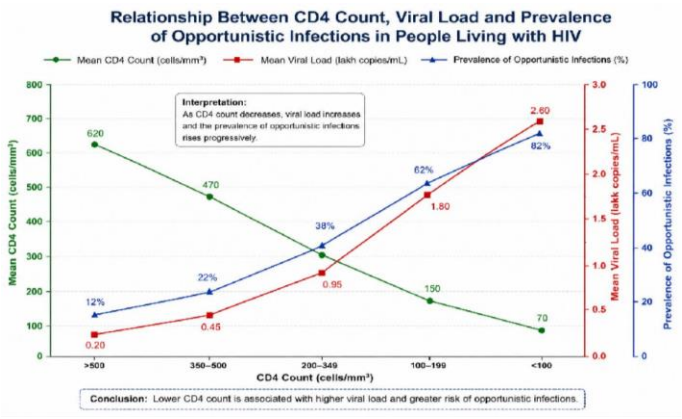
The mean CD4 count among cases was 468.24 ± 125.35 cells/mm³ compared to 567.16 ± 130.43 cells/mm³ among controls. The minimum CD4 count recorded was also significantly lower among cases. These findings indicate that progressive immune suppression remains strongly associated with occurrence of opportunistic infections.

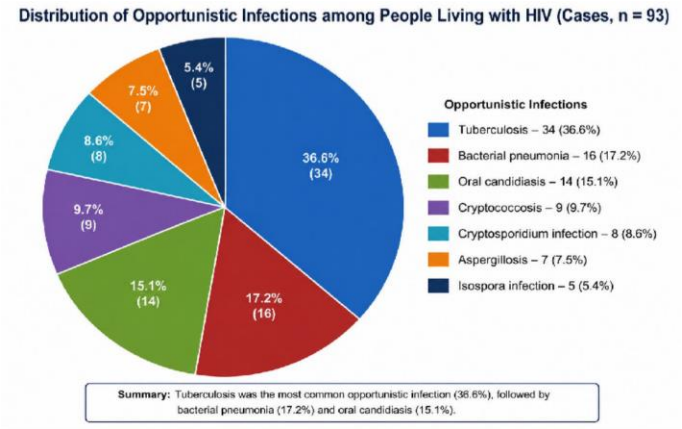
Table 2: Comparison of Immunological and Virological Parameters

Parameter	Cases (n=93)	Controls (n=93)	p-value
Mean CD4 count (cells/mm³)	468.24 ± 125.35	567.16 ± 130.43	<0.001
Mean viral load (lakh copies/mL)	1.53 ± 1.65	0.43 ± 0.89	<0.001
Viral suppression achieved	29 (31.2%)	71 (76.3%)	<0.001
CD4 recovery after ART	41 (44.1%)	68 (73.1%)	<0.001

Mean viral load among cases was 1.53 ± 1.65 lakh copies/mL, whereas among controls it was 0.43 ± 0.89 lakh copies/mL. Viral suppression was achieved in only 31.2% of cases compared to 76.3% of controls.

Patients with higher viral load levels demonstrated increased susceptibility to opportunistic infections and poorer clinical outcomes.





Tuberculosis was the most common opportunistic infection and accounted for 36.6% of all cases. Bacterial pneumonia was observed in 17.2% of patients and oral candidiasis in 15.1%. Other infections included cryptococcosis, cryptosporidium infection, aspergillosis, and isospora infection.

Table 3: Association of CD4 Count with Opportunistic Infections

CD4 Count (cells/mm³)	Number of Cases (%)	Common Opportunistic Infections
>500	18 (19.4%)	Tuberculosis, bacterial pneumonia
200–500	49 (52.7%)	Tuberculosis, candidiasis
<200	26 (27.9%)	Cryptococcosis, aspergillosis, protozoal infections

Respiratory system involvement was the most frequent clinical presentation because of the high prevalence of tuberculosis and bacterial respiratory infections. Patients with multiple opportunistic infections had lower mean CD4 counts and higher viral loads compared to those with single infections.

A significant inverse relationship was observed between CD4 count and occurrence of opportunistic infections. Similarly, higher viral load levels showed positive correlation with increased frequency and severity of opportunistic infections. Patients with severe immune suppression experienced greater morbidity and more complicated clinical courses.

Discussion

The present study demonstrates a strong association between opportunistic infections, CD4 count, and viral load among people living with HIV. Opportunistic infections continue to remain a major cause of morbidity despite significant advances in antiretroviral therapy.

The demographic profile observed in the study was comparable to findings from previous Indian and international studies. Middle-aged males constituted the majority of participants. This pattern may be related to differences in exposure risk, healthcare access, and healthcare-seeking behaviour.

One of the most important findings of the study was the significantly lower CD4 count among patients with opportunistic infections. CD4 lymphocytes play a central role in maintaining cellular immunity and coordinating host defense against intracellular pathogens. Progressive depletion of CD4 cells impairs immune surveillance and predisposes individuals to opportunistic infections.

The study also demonstrated significantly higher viral load levels among patients with opportunistic infections. Persistent viral replication causes chronic immune activation and progressive immune dysfunction. Patients with poor viral suppression showed delayed immune recovery and increased vulnerability to infections. These findings emphasize the importance of effective ART adherence and regular virological monitoring. Tuberculosis was the commonest opportunistic infection observed in the present study. This finding is consistent with epidemiological data from India and other developing countries. HIV-induced impairment of cellular immunity significantly increases susceptibility to tuberculosis. Tuberculosis may occur even at relatively higher CD4 counts, although risk increases substantially with progressive immune suppression.

Bacterial pneumonia was another major opportunistic infection identified in the study. HIV-related immune dysfunction predisposes patients to recurrent and severe bacterial respiratory infections. These infections contribute substantially to hospitalization and healthcare burden.

Oral candidiasis was also commonly observed and often reflected advanced immune suppression. Fungal and protozoal infections such as cryptococcosis, aspergillosis, cryptosporidium, and isospora infections were more common among patients with severe immunodeficiency and uncontrolled viral replication.

The study findings support previous evidence suggesting that combined evaluation of CD4 count and viral load provides better understanding of disease progression than either parameter alone. Some patients with moderately preserved CD4 counts still developed opportunistic infections in the presence of elevated viral load, indicating ongoing immune dysfunction despite relatively preserved CD4 levels.

The findings of the present study have important clinical implications. Regular monitoring of CD4 count and viral load allows early identification of patients at increased risk of opportunistic infections. Early intervention,

optimization of ART, and initiation of prophylactic therapy can significantly reduce morbidity and improve outcomes.

The study had certain limitations. Being a single-centre study, the findings may not be fully generalizable to all populations. The moderate sample size and exclusion of certain comorbid conditions may also affect interpretation. However, the study provides valuable regional data regarding opportunistic infections and immunological status among HIV patients attending a tertiary care centre in North India.

Conclusion

Opportunistic infections continue to remain common among people living with HIV, particularly among individuals with advanced immune suppression and uncontrolled viral replication. Patients with opportunistic infections demonstrated significantly lower CD4 counts, higher viral load levels, poorer immune recovery, and lower rates of viral suppression compared to those without opportunistic infections.

Tuberculosis remained the most common opportunistic infection in the study population followed by bacterial pneumonia and oral candidiasis. Both CD4 count and plasma viral load were strongly associated with occurrence and severity of opportunistic infections. Regular monitoring of immunological and virological markers is essential for early identification of high-risk patients and evaluation of treatment response. Strengthening ART adherence, promoting early diagnosis, and ensuring timely management of opportunistic infections are critical for improving long-term outcomes among people living with HIV.

Key implications

- CD4 count and viral load are strong predictors of opportunistic infections
- Regular monitoring is essential for early risk identification
- Strengthening ART adherence and early diagnosis can significantly reduce disease burden

Limitations

- Single-centre study
- Moderate sample size
- Study was conducted in multi-departmental hospital
- Exclusion of comorbid conditions may limit generalisability

Recommendations

- Routine combined monitoring of CD4 and viral load
- Early screening for opportunistic infections
- Strengthening ART adherence programs
- Multi-centric studies for broader applicability

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