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# Hematological Abnormalities in HIV/AIDS Patients and Their Correlation with CD4 Count: A Cross-Sectional Study from North Karnataka

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## Abstract

***Objective:*** This study is aimed to evaluate the spectrum of hematological abnormalities in HIV/AIDS patients with a special focus on the degree of association with CD4 cell counts among HIV patients in a tertiary care setting in North-Karnataka. ***Methodology:*** This descriptive cross-sectional study was conducted from March 2024-12 2025 at the ART Centre and Affiliated tertiary care hospital, Vijayapura, Karnataka. A total of 126 confirmed HIV positive patients 18 years of age or older were recruited based on predefined inclusion and exclusion criteria. We obtained detailed clinical histories and did physical examinations. Laboratory investigations included a complete blood count (CBC), peripheral smear examination, estimation of CD4 cell count and basic biochemical tests. Hematological abnormalities such as anemia, leukopenia, neutropenia, lymphopenia and platelets counts were characterized according to the usual reference ranges. The statistical analysis was conducted using the software package, Version 26 of the International Business Machine (IBM; Armon, NY) statistical package, Microsoft, and IBM's Statistical Package for Social Sciences. We tested the correlation between CD4 count and hematological parameters using Pearson's correlation coefficient, with p value < 0.05 measured hereby as being statistically significant. ***Results:*** The mean age of the study population was 40.5 ± 12.1 years and there was slight predominance of females. Anemia was the most common hematological abnormality found in 54.8 percent of the patients, primarily of the normocytic normochromic type. Lymphopenia (23% of the patients had lymphopenia scores), leukopenia (13.5% of the patients had leukopenia scores) neutropenia (12.7% of the patients had neutropenia scores) and thrombocytopenia (11.1% of the patients had thrombocytopenia scores) The mean CD4 count was 352.1 cells/µL. A statistically significant positive correlation between the CD4 count and hemoglobin, total leukocyte count and lymphocyte percentage demonstrated that the hematological abnormalities became more frequent and severe according to the decline of the immune status. ***Conclusion:*** Hematological abnormalities are common among those infected with HIV and the most common problem is anaemia. The worse the cytopenias are the lower the CD4 count, indicating worsening immunosuppression. Regular blood tests along with CD4 monitoring are indeed required for the early detection of problems, monitoring disease progress, and comprehensive care of HIV patients.

**Keywords:** HIV/AIDS, Hematological abnormalities, Anemia, CD4 count, Cytopenias, Immune suppression, Immune status



## INTRODUCTION

Human Immunodeficiency Virus (HIV) infection is one of the most important global public health challenges since the time of its discovery in 1983. Despite remarkable progress in antiretroviral therapy (ART), HIV has led to the death of millions of people around the world and continues to affect a significant number of people, especially in low and middle-income countries. Globally, around 39million people are living with HIV with a significant burden being concentrated in developing countries. India is one of the countries with the largest number of HIV infected people, and the estimated adult prevalence of HIV is approximately 0.22 percent, with some areas of the country characterized by high-risk clustered populations. Although ART has made HIV a manageable chronic disease, long-term complications and systemic manifestations of HIV infection are major reasons for concern. (1,2)

HIV primarily targets CD4+ (i.e. T-helper lymphocyte) which coordinate the cellular and humoral immune responses. The virus binds to the CD4 receptor and co-receptors like CCR5 and CXCR4, and is able to take entry into the host cells and multiply. Gradual destruction of CD4+ T cells results in gradual breakdown

of the immune system and individuals are vulnerable to opportunist infections, malignancies and systemic complications. Without effective therapy, declining CD4 counts eventually culminate in acquired immunodeficiency syndrome (AIDS), an immunosuppression state of great severity and life-threatening opportunistic diseases (3-5).

In addition to immune deficiency, HIV infection is a multisystem disorder that leads to a variety of hematological abnormalities. These blood disorders are one of the earliest and the greatest laboratory findings of HIV-infected patients and may be present at any disease stage. They tend to increase as the disease progresses as CD4 counts decline. The mechanisms underlying these hematologic changes are complex and include direct viral damage to bone marrow progenitor cells, immune mediated destruction of blood cells, chronic inflammation with cytokine dysregulated, nutritional deficiency, opportunistic infections infiltrating the marrow and drug mediated marrow suppression (6-9).

Anemia in HIV infection is the most frequent hematologic abnormality of HIV infection seen in 30-70% of HIV infected patients in different studies. It is associated with a high stage of the disease, low CD4 count, and increased risk of dying (10,11). Causes of anemia in HIV include chronic inflammation - mediated anemia, interleukin and hepcidin are high, direct suppression of erythropoiesis, nutritional deficiencies, marrow infiltration, opportunistic infections e.g., parvovirus B19 causing pure red cell aplasia, toxicity of drugs (12 - 16). Several studies have demonstrated improvement of hemoglobin by the initiation of effective ART underscoring the link between immune recovery and improvement of blood (17).

Leukopenia and neutropenia are also not uncommon in HIV infected patients, especially in late stages. Neutropenia may be due to bone marrow suppression, immune destruction, opportunistic infections and adverse drug reactions. Severe neutropenia increases the risk of bacteria infections and may further aggravate clinical outcomes (18). Lymphopenia, especially of CD4+ T cells, is the hallmark of HIV infection, and represents continued deterioration of the immune system (4,9). Thrombocytopenia, which is commonly immune mediated, may present as immune thrombocytopenic purpura (ITP) and sometimes may be the opening sign of HIV (12,18).

CD4 cell count is still the cornerstone in terms of immune assessment in HIV infection. Normal CD4 counts of healthy adults are between 500 and 1500 cells per cubic millimetre. A count below 200 cells/mm3 is considered to be indicative of having an HIV infection according to Centers for Disease Control and Prevention (CDC) criteria as the indicator of severe immunosuppression with the consequent increased opportunity for infection (16). The monitoring of CD4 count is important in staging disease, the choice of prophylaxis for the opportunistic infection, the choice of ART and also in the assessment of response to treatment (7,12). Multiple studies have demonstrated close interfacing of CD4 levels with the hematologic parameters (hemoglobin, total leukocyte, and platelet count), implying the possibility that blood abnormalities might be indirectly indicative of immune deterioration (12,18).

In the resource-limited settings where access to advanced immunologic testing may not always be available, routine hematologic studies such as complete blood count and peripheral smear may give valuable clues regarding the disease progression. Early detection of cytopenias is of significance in prognosis and prevention of complications such as infections, bleeding, and drug toxicity. Although the link between the presence of hematologic abnormalities and immune status is known, regional information about the status of the immune system from North Karnataka is scarce, especially from Vijayapura. Therefore, the present study was undertaken to assess the spectrum of abnormalities in hematologic examination in patients of HIV /AIDS and to determine the correlation between CD4 count and such abnormalities in a tertiary care setting.

**Aim of the Study**

To study the hematological abnormalities in patients with HIV/AIDS and evaluate their correlation with CD4 count.

**Objective**

- To determine the prevalence and pattern of hematological abnormalities in HIV-infected patients.
- To assess the relationship between various hematological parameters and CD4 cell count.

## MATERIALS AND METHODS

The present study was a descriptive cross-sectional study aimed to find out the frequency of hematological abnormalities among HIV infected patients and the relationship of these changes with CD4 counts. By gathering clinical data and laboratory info on the same point of time, we can see the relationship of the immune status using blood abnormalities in the study population. The study was carried out at the Antiretroviral Therapy (ART) Centre and the Department of General Medicine, a tertiary teaching hospital in Vijayapura in Karnataka.

The research span from March, 2024, to December 2025. Because the ART centre is the primary referral point for patients with HIV in the Vijayapura and surrounding districts, it offered a representative sample of the HIV population in the region. The study participants were adult HIV +ve patients attending the ART centre during the study window period. We recruited a total of 126 patients. The sample size was based on the number of eligible patients who met our predefined inclusion and exclusion criteria. Both newly diagnosed and individuals

under antiretroviral therapy were included so that a full assessment of hematological abnormalities at various disease stages is performed.

**Inclusion Criteria**

In order to be included, patients had to have a confirmed HIV diagnosis, in accordance with standard national guidelines. Only adults aged above 18 were eligible. Participants also had to be willing to participate and must have given informed written consent after having been fully explained on the study's purpose and procedures.

**Exclusion Criteria**

These exclusion criteria were applied to minimize confounding factors that could independently influence blood counts and interfere with accurate assessment of HIV-related hematological abnormalities.

- Patients were excluded from the study if they had:
- Known hematological malignancies
- Chronic renal failure unrelated to HIV infection
- Pregnancy
- Ongoing chemotherapy
- Any other established medical condition independently known to significantly alter hematological parameters

**Data Collection**

Data were obtained by using structured proforma. After we obtained written informed consent, we recorded information about the participants in detail, including their age, gender, and the length of time they have had HIV. The clinical history obtained were ART status, history of opportunistic infections, drug use and presenting complaints. A detailed physical examination was conducted which focussed on the examination of signs suggestive of haematological abnormalities including pallor, lymphadenopathy, hepatosplenomegaly, petechiae and bleeding manifestations.

All the participants were subjected to laboratory studies. A complete blood count (CBC) was done using an automated hematology analyzer for hemoglobin, total leukocyte count, differential leukocyte count, red cell indices (mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration) and platelet count. A peripheral smear was studied for red blood cell morphology and types of anemia. Estimates of CD4 cell count were made using standard flow cytometry at the ART center. We also carried out normal renal and hepatic function tests. Hematological abnormalities were based on normal values for adults. Anemia was diagnosed using haemoglobin values that are specific to males and females. Leukopenia, neutropenia, lymphopenia, and thrombocytopenia were determined using previously known laboratory cutoffs.

**Data Analysis**

All data collected are recorded in computerized database and analysis has been done with the help of the software of 26th version of Stats program (SPSS). Continuous variables like hemoglobin values and CD4 count were reported as Mean and Standard Deviation. Categorical variables, including the presence or absence of anemia, other white blood cell (leukopenia) and platelet (thrombocytopenia) discrepancies, were represented by frequencies and percentages. Correlation between CD4 count and hematological parameters was analyzed by using Pearson correlation coefficient. P-values that are less than 0.05 were considered statistically significant. Results were presented in table and graphic to show patterns and correlation.

**Ethical Considerations**

The study was conducted after getting the approval from the Institutional Ethics Committee. Written informed consent by patient and the guardian/next of kin was obtained before enrolment. Confidentiality of information about patients was strictly maintained and all the procedures met ethical guidelines for biomedical research with human subjects.

## RESULTS

**Table 1: Demographic Characteristics**

| Variable | Frequency (n) | Percentage (%) |
|---|---|---|
| Age (Mean ± SD) | 40.5 ± 12.1 years | — |
| 18–30 years | 22 | 17.5% |
| 31–50 years | 72 | 57.1% |
| >50 years | 32 | 25.4% |
| Gender | | |
| Male | 60 | 47.6% |
| Female | 66 | 52.4% |

Table 1 presents that more than half of the patients (57.1%) were between 31 to 50 years of age showing HIV infection predominately affected people in their most economically productive period. Females comprised 52.4% of the study population, which was a little higher than 47.6% of males.

**Table 2: Hematological Parameters**

| Parameter | Mean ± SD |
|---|---|
| Hemoglobin (g/dL) | 10.8 ± 2.1 |
| Total Leukocyte Count (cells/µL) | 5,620 ± 1,980 |
| Absolute Neutrophil Count (cells/µL) | 2,890 ± 1,120 |
| Lymphocyte Percentage (%) | 28.4 ± 8.6 |
| Platelet Count (×10³/µL) | 2.10 ± 0.75 |
| CD4 Count (cells/µL) | 352.1 ± 186.4 |

Table 2 shows that mean hemoglobin value was 10.8 g/dL showing a high burden of anemia in the study population. The mean total leukocyte count and platelet count were within the lower range of the normal but this may represent subclinical cytopenias in some patients. The mean CD4 count was 352.1 cells/ul representing moderate immunosuppression in the majority of the participants.

**Table 3: Prevalence of Hematological Abnormalities**

| Abnormality | Frequency (n) | Percentage (%) |
|---|---|---|
| Anemia | 69 | 54.8% |
| Lymphopenia | 29 | 23.0% |
| Leukopenia | 17 | 13.5% |
| Neutropenia | 16 | 12.7% |
| Thrombocytopenia | 14 | 11.1% |

Table 3 shows that the most common abnormality was anemia that occurred in 54.8% of the patients. Lymphopenia was observed in 23% of participants which is consistent with the pathophysiology of HIV disease. Leukopenia and neutropenia were seen in 13.5% and 12.7% of the cases respectively, and thrombocytopenia in 11.1% of patients. These results demonstrate that cytopenias are still common among patients with moderately low CD4 count. Peripheral smear analysis showed that there was more normocytic normochromic anemia followed by microcytic hypochromic anemia.

**Table 4: Correlation of CD4 Count with Hematological Parameters**

| Parameter | Correlation Coefficient (r) | p-value |
|---|---|---|
| Hemoglobin | +0.42 | <0.001 |
| Total Leukocyte Count | +0.31 | 0.002 |
| Lymphocyte Percentage | +0.48 | <0.001 |
| Platelet Count | +0.15 | 0.087 |
| Absolute Neutrophil Count | +0.18 | 0.065 |

A statistically significant positive correlation was observed between CD4 count and hemoglobin levels (rributors to "0.42" p synthesis to 0.001) which indicates that the lower the CD4 count, the more severe the associated anemia is. Likewise, there was a positive correlation between total leukocyte count and lymphocyte percentage with CD4 count suggesting there is a close association between a weakening immune system and deterioration of cytopenias. Although platelet count and absolute neutrophil count were trending towards positive direction with CD4 count, their relation had not reached statistical significance.

## DISCUSSION

The present study assessed the range of hematological abnormalities among HIV striped groups people and investigated the connection of these changes with CD4 count, which is a gauge of your immunological status. The results indicated that hematologic problems were very frequent with the most common being anemia. There was a significant positive value in the correlation with CD4 counts and hemoglobin level. Total Leukocytes Count and lymphocyte percentages indicating the correlation between suppression of immune and blood disorders. The mean age of participants was 40.5 years with the majority of them in the 31-50 years age group. This age pattern is in line with the known epidemiology of HIV, which affects mostly people in the economically productive years. Similar age distributions were reported by Dhal et al. and Patil et al. Both of them reported a peak number of patients in their third and fourth decades. The slightly higher prevalence that is observed in females may reflect local demographic trends and healthcare-seeking behaviour (12,14).

Anemia was observed in 54.8 per cent of patients and thus, was the most frequently occurring blood abnormality for this sample. This rate is comparable to that of 58.7% by Jain et al., (13) and 65% by Vanisri et al., (11) and is generally little less than the over 70% reported by Bhardwaj et al., (6). Difference in the prevalence between the studies probably subculture by variations in disease stage, nutrition, antiretroviral therapy coverage and regional epidemiology. The predominance of normocytic, normochromic anemia

suggests the predominance of anemia of chronic disease as the main mechanism. The chronic immune activation that occurs in HIV increases the level of inflammatory cytokines such as interleukin-6 that increases hepcidin production and inhibits iron usage. Direct suppression of bone marrow progenitor cells by viruses also suppresses red cell production. Importantly, the result of the study showed a statistically significant positive correlation among the CD4 count and hemoglobin level ($r=0.42$, $p<0.001$), meaning that the lower the CD4 count, the more severe the anaemia is. Similar correlations have been reported in other studies by Nacher et al., and Kirchhoff et al., in which hemoglobin always decreases with worsening immune suppression (7,5). This makes the prognostic significance of anemia in HIV eminent, because low hemoglobin is independently associated with increased morbidity and mortality (19).

Lymphopenia was found in 23% of patients, and represents the basic pathophysiology of HIV: progressive loss of CD4 and T lymphocytes. A strong positive correlation was found between CD4 count and lymphocyte percentage ($r=0.48$, $p<0.001$). As CD4 is a major type of lymphocytes, this relation is to be expected. Suja et al., and Bhardwaj et al., also found significant associations between lymphocyte indices and CD4 levels which suggests that lymphocyte counts could be used as an indirect biomarker of immune status, particularly in settings where resources are limited (15,6). Leukopenia and neutropenia were found in 13.5% and 12.7%, respectively. These abnormalities can be the result of direct bone marrow suppression by viruses, destruction of peripheral bone marrow because of immunological disorders, opportunistic infections, or drug toxicity. Although absolute total leukocyte count was also significantly correlated with CD4 count, correlation between absolute neutrophil count and CD4 was not statistically significant. Similar results have been reported by other studies by Dikshit et al., and Li et al., in which leukopenia is known to increase in advanced HIV but is not always correlated to CD4 levels (4,8).

Thrombocytopenia was detected in 11.1% of the patients. HIV-associated thrombocytopenia, as the name implies, is typically immune mediated and can appear at even an early stage of the infection, reflecting the multisystem nature of HIV disease (20). Platelet count showed a trend towards the upward direction with increasing CD4 counts, but the correlation was not statistically significant. Previous research by Graham et al., and Olaniy et al., has shown similar trends with thrombocytopenia being less associated with reduction in CD4 than anemia. However, it is still considered clinically important because of the bleeding risk that it has (9,16). The mean CD4 count was 352.1 cells/ul, which indicated that the majority of participants were moderately immunosuppressed and not so much advance HIV patients. Patients with CD4 counts less than 200 cells/ul had higher rates of anemia and other cytopenias, confirming the well documented association between immune deterioration and abnormalities of the blood. Cytopenias not only increase in frequency and severity with decrease of CD4 counts, as demonstrated in numerous prior studies by Alam et al., and Satpute et al., (17,18)

The results of the study have important clinical implications. A complete blood count is inexpensive, easy to get, and can help provide valuable information as to the severity and progression of the disease. In settings with limited access to more costly laboratory tests, where CD4 testing is not always readily available, the identification of hematologic parameters as surrogate measures of immune health may be practical. Early detection and treatment of cytopenias may improve quality of life, lessen complications and perhaps improve survival. However, the design in cross section does not allow to draw causal conclusions and none can be made regarding changes in blood parameters following the initiation of antiretroviral therapy. Additionally, because this study was single-center research, consisting of a moderate sample size, it is possible that the outcomes cannot be generalized to the community worldwide. Future longitudinal studies on larger cohorts will help resolve the question of how immune restoration is linked to hematologic enhancement. Overall, this study strengthens the important association between hematologic abnormalities and immune status in HIV infection, and thus denies the value of routine blood counts as an integral part of comprehensive HIV care.

## CONCLUSION

The results of the study indicate that blood test defects are very common among people living with HIV, the most common is anaemia, followed by low lymphocyte, white blood cell, neutrophil & platelets, and most of the anaemia is normocytic, meaning that it is anaemia of chronic disease, there is a strong positive relationship between CD4 count and haemoglobin (primary blood cells), total white cells, neutrophils and platelets, so the lower the CD4 count the more serious is the blood abnormality, this shows that discrepancies in blood tests are not only a mark of disease progression, but they also provide additional warning signs of immune deterioration, therefore.

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