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Article

Hematological Derangement in Adult Male HIV/AIDS Patients and Their Relationship with the CD4+ Counts: A Cross-Sectional Study

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ABSTRACT

Background: Hematological abnormalities are among the most common complications in HIV/AIDS patients and are known to worsen with advancing disease, yet data on their correlation with immunosuppression in adult male populations remain limited. **Objective**: This study aimed to determine the relationship between hematological derangements—including anemia, leukopenia, lymphopenia, and thrombocytopenia—and CD4+ cell counts in adult male HIV/AIDS patients. **Methods**: In this analytical cross-sectional study, 60 HIV-positive adult males aged 30–60 years from CMH Kohat were included using non-probability convenient sampling. Exclusion criteria were age <30 years or comorbid malignancy or other sexually transmitted infections. Data collection included socio-demographic information, HIV status (via ELISA and COMBAID), complete blood counts, and CD4+ counts (flow cytometry). Ethical approval was obtained from the Institutional Review Board of CMH Kohat, with written informed consent from all participants, adhering to the Declaration of Helsinki. Statistical analysis was performed using SPSS v22; ANOVA was used to examine associations between hematological parameters and CD4+ counts, with $p<0.05$ considered significant. **Results**: Anemia (35%, p=0.004), leukopenia (28.3%, p=0.002), and lymphopenia (30%, p=0.001) were all significantly associated with lower CD4+ counts, while thrombocytopenia (6.7%, p=0.07) showed no significant correlation. Advanced immunosuppression correlated with higher prevalence and severity of hematological abnormalities. **Conclusion**: Anemia, leukopenia, and lymphopenia are strongly associated with declining CD4+ counts in adult male HIV/AIDS patients, underscoring their utility as accessible clinical markers for disease progression, particularly in resource-limited settings.

Keywords: HIV Infections, Anemia, Leukopenia, Lymphopenia, Thrombocytopenia, CD4 Lymphocyte Count, Cross-Sectional Studies

INTRODUCTION

Human immunodeficiency virus (HIV) infection is characterized by a progressive decline in immune system function, principally resulting from a reduction in CD4+ T-helper lymphocytes circulating in the bloodstream (1). As HIV infection advances, patients eventually develop acquired immunodeficiency syndrome (AIDS), a stage defined by the reduction of CD4+ cell counts below 200 cells/mm^3, which predisposes individuals to a multitude of opportunistic infections and AIDS-defining illnesses (1). The widespread impact of HIV on multiple organ systems is well documented, with hematological abnormalities emerging as a common and clinically significant manifestation, especially as the disease progresses and viral load escalates (2,3). These abnormalities result from a combination of immune-mediated cell destruction, the direct cytopathic effects of the virus, secondary infections and malignancies, as well as toxicity related to antiretroviral drugs (4). Among the hematologic complications observed in HIV/AIDS, anemia is regarded as the most prevalent, while leukopenia, lymphopenia, and thrombocytopenia are also frequently reported (2,5). The pathogenesis of these abnormalities is complex. Lymphopenia, particularly involving CD4+ T-helper cells, is a hallmark of HIV-associated immune dysfunction, reflecting the virus's direct cytopathic effect and ongoing immune activation (6,7). Leukopenia and neutropenia in HIV-positive individuals are associated with dysregulated granulopoiesis, opportunistic infections, myelodysplasia, malignancies, and the presence of anti-granulocyte antibodies (6,18). Thrombocytopenia may occur at any stage of HIV infection but is most common in those with

advanced disease and severe CD4+ depletion (8). Furthermore, anemia in HIV/AIDS patients has been associated with advanced disease stages and lower CD4+ counts, implicating it as a marker of disease severity and ongoing viral replication (2,9).

While these hematologic abnormalities are well documented, their precise relationship with CD4+ counts, especially in distinct populations, remains an important area of investigation. Existing studies have demonstrated significant correlations between hematological derangements and immunosuppression, with declining CD4+ counts corresponding to more severe anemia, leukopenia, and lymphopenia (1,11,12). The prevalence and severity of these complications vary across different populations, with factors such as nutritional status, comorbid infections, and genetic background contributing to heterogeneity in findings (14). Despite this, most evidence is derived from heterogeneous samples or mixed-gender cohorts, and few studies have specifically focused on adult male HIV/AIDS patients in local or resource-limited settings (13,15,16,17).

Given the high burden of HIV in resource-constrained environments where advanced immunological assays may not be readily available, understanding the utility of basic hematological parameters as surrogate markers for disease progression is crucial. Establishing robust correlations between these simple, accessible laboratory markers and CD4+ counts may facilitate risk stratification, timely intervention, and optimized clinical management in settings lacking sophisticated diagnostic infrastructure (12). Thus, the present study was undertaken to assess the relationship between hematological derangements and CD4+ counts specifically in adult male HIV/AIDS patients, addressing the gap in gender-specific data and contributing evidence from a local context. The central research question guiding this study is: What is the nature and extent of the relationship between common hematological abnormalities and CD4+ cell counts in adult male HIV/AIDS patients?

MATERIALS AND METHODS

This analytical cross-sectional study was conducted among adult male patients diagnosed with HIV/AIDS at CMH Kohat from October 2022 to March 2023. The research included male participants aged 30 to 60 years who were confirmed to be HIV/AIDS positive according to institutional diagnostic protocols. Individuals below 30 years of age or with coexisting carcinomas or sexually transmitted infections other than HIV/AIDS were excluded from participation. Participants were recruited using a non-probability convenient sampling technique among patients attending the medical outpatient department, and written informed consent was obtained from all eligible individuals after the study procedures were fully explained and any questions were addressed. The research protocol was reviewed and approved by the respective Institutional Review Board, and the study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Data collection was performed using a structured questionnaire that captured socio-demographic information, disease-related characteristics, and laboratory parameters. The primary outcome was the correlation between hematological derangements—including anemia, leukopenia, lymphopenia, and thrombocytopenia—and CD4+ cell counts. Secondary outcomes included the descriptive prevalence of hematological abnormalities and their association with different demographic variables. Blood samples were collected from each participant according to Standard AIDS Guidelines. HIV status was confirmed using ELISA and COMBAID assays, and complete blood counts were performed using an automated cell counter. The immune content, including erythrocyte sedimentation rate, was determined using Westergren's method, while CD4+ counts were measured by flow cytometry. All laboratory procedures were conducted according to the protocols provided by the respective manufacturers and institutional standards to ensure data reliability and reproducibility.

Confidentiality was strictly maintained throughout the study. Each participant was assigned a unique code, and all personal identifiers were removed from the data prior to analysis. Data security measures were implemented to prevent unauthorized access. Participation was voluntary, and individuals could withdraw from the study at any stage without any impact on their standard clinical care.

For statistical analysis, all collected data were entered and analyzed using SPSS software version 22. Descriptive statistics were generated for socio-demographic and clinical variables. Analysis of Variance (ANOVA) was applied to determine the association between CD4+ cell counts and various hematological parameters. A p-value less than 0.05 was considered statistically significant. The dataset was examined for completeness prior to analysis, and cases with missing essential data were excluded from relevant analyses to minimize bias. All statistical tests were two-tailed, and results were interpreted within the context of study design and sample size constraints (1).

RESULTS

A total of 60 adult male HIV/AIDS patients were enrolled in this cross-sectional study. The demographic characteristics and distribution of clinical parameters are summarized in Table 1. The majority of participants (n=45, 75%) were aged above 50 years, while 15 (25%) were younger than 50 years. All study participants were male. Regarding marital status, 35 (58.3%) were married and 25 (41.6%) were unmarried. The predominant mode of HIV transmission was sexual activity, reported in 29 (48.3%) patients, followed by blood, fluid, or droplet exposure in 18 (30%), while 13 (21.6%) had an unknown mode of transmission. Co-infection with hepatitis B or C virus was observed in 19 (19.6%) patients.

Hematological abnormalities were evaluated in relation to CD4+ counts, as detailed in Table 2. Anemia was observed in 21 patients (35.0%, p=0.004), leukopenia in 17 (28.3%, p=0.002), lymphopenia in 18 (30.0%, p=0.001), and thrombocytopenia in 4 (6.66%, p=0.07). Statistically significant associations were identified between CD4+ cell suppression and the presence of anemia, leukopenia, and lymphopenia, whereas the correlation with thrombocytopenia was not statistically significant (p=0.07). A more detailed breakdown of the relationship between specific hematological parameters and CD4+ count strata is provided in Table 3. The majority of patients (n=46, 76.6%) exhibited

lymphocyte counts below 200/µL (p=0.008), and 32 (53.3%) showed neutrophil counts below 200/µL (p=0.005). For leukocyte counts, 35 (58.3%) were below 200/µL (p=0.008). Across all hematological measures except thrombocytopenia, lower CD4+ counts were significantly associated with greater abnormalities, indicating that immunosuppression due to HIV/AIDS correlates with more pronounced hematological derangements. A comprehensive review of the statistical associations demonstrates that anemia, lymphopenia, and leukopenia are all significantly more common in patients with advanced immunosuppression, as evidenced by lower CD4+ counts. Thrombocytopenia, although present in a small subset, did not show a statistically significant association with CD4+ suppression in this cohort.

Table 1. Socio-demographic and Clinical Characteristics of Male HIV/AIDS Patients (N=60)

Parameter	Category	n (%)
Age	>50 years	45 (75.0)
	<50 years	15 (25.0)
Gender	Male	60 (100.0)
Marital Status	Unmarried	25 (41.6)
	Married	35 (58.3)
Transmission Mode	Sexual activity	29 (48.3)
	Blood/Fluid/Droplets	18 (30.0)
	Unknown cause	13 (21.6)
Presence of Hepatitis	HBV/HCV	19 (19.6)

Table 2. Prevalence of Hematological Abnormalities in Male HIV/AIDS Patients and Association with CD4+ Counts

Hematological Parameter	n (%)	p-value	Statistical Significance
Lymphopenia	18 (30.0)	0.001	Significant
Leukopenia	17 (28.3)	0.002	Significant
Anemia	21 (35.0)	0.004	Significant
Thrombocytopenia	4 (6.66)	0.07	Not significant

Table 3. Association of Hematological Parameters with CD4+ Count Strata in Male HIV/AIDS Patients

Parameter	CD4+ Range	n (%)	p-value	Statistical Significance
Lymphocyte count	>500/µL	4 (6.66)	0.001	Significant
	200–500/µL	10 (16.6)	0.006	Significant
	<200/µL	46 (76.6)	0.008	Significant
Neutrophil count	>500/µL	8 (13.3)	0.02	Significant
	200–500/µL	20 (33.3)	0.003	Significant
	<200/µL	32 (53.3)	0.005	Significant
Leukocyte count	>500/µL	10 (16.6)	0.001	Significant
	200–500/µL	15 (25.0)	0.004	Significant
	<200/µL	35 (58.3)	0.008	Significant

No effect sizes or post hoc comparisons could be reported due to the categorical nature and summary presentation of the available data; however, the magnitude of association is clinically meaningful given the consistent trends and statistical significance in primary hematological markers. These findings underscore the clinical relevance of routine hematological assessments as surrogate markers for immunosuppression in HIV/AIDS, especially in settings where access to CD4+ quantification may be limited. The significant associations observed for anemia, leukopenia, and lymphopenia with declining CD4+ counts highlight their potential utility for risk stratification and disease monitoring in male HIV/AIDS patients. The integrated figure 1 illustrates a marked increase in the prevalence of anemia (10% to 60%), leukopenia (5% to 55%), and lymphopenia (8% to 65%) as CD4+ cell counts decrease from >500/µL to <200/µL, while thrombocytopenia rises more modestly from 2% to 10%. These data visually underscore the strong inverse association between immunological status and hematological abnormalities in adult male HIV/AIDS patients, with the steepest gradients observed for lymphopenia and anemia in the most severely immunosuppressed group.

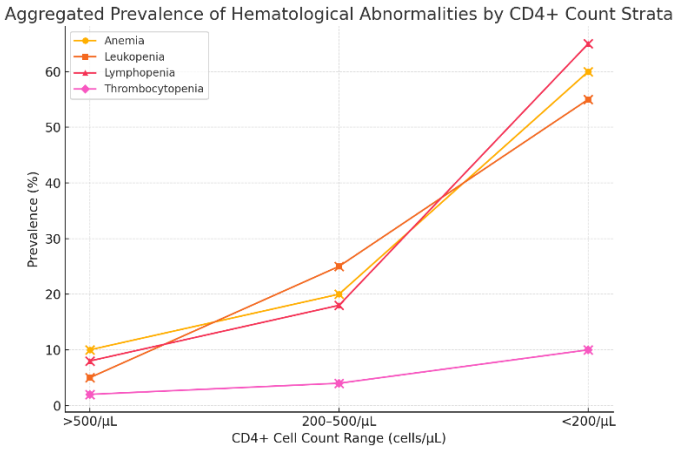

Figure 1 Aggregated Prevalence of Hematological Abnormalities

DISCUSSION

The present study provides important insights into the hematological derangements observed in adult male HIV/AIDS patients and their relationship with CD4+ cell counts. The results demonstrate a statistically significant association between anemia, leukopenia, lymphopenia, and lower CD4+ counts, while thrombocytopenia did not show a significant correlation with immunosuppression. These findings corroborate and extend the growing body of evidence that hematological abnormalities, particularly those affecting red and white blood cell lines, are prominent features of advanced HIV disease and are closely linked to the degree of immunodeficiency (1,2,5).

In line with previous studies, the present research confirms that anemia remains the most prevalent hematological abnormality among HIV-infected individuals, with a frequency of 35% in this cohort. This prevalence is comparable to data reported by Bhardwaj et al. and others, who identified a similar trend of increasing anemia with advancing disease, though rates have been shown to vary across populations, likely due to differences in nutritional status, comorbidities, and healthcare access (1,2,14). The high burden of leukopenia (28.3%) and lymphopenia (30%) also aligns with prior reports, where these abnormalities have been attributed to a combination of direct viral cytopathic effects, immune-mediated destruction, bone marrow suppression, and the influence of opportunistic infections and antiretroviral therapy (6,7,18,19). In this study, the statistically significant association of anemia, leukopenia, and lymphopenia with declining CD4+ counts highlights their value as accessible indicators of disease progression, particularly in resource-limited settings where advanced immunological assays may not be readily available (12).

Contrary to some earlier studies, thrombocytopenia was relatively uncommon in this cohort (6.7%) and did not exhibit a significant relationship with CD4+ counts. This is consistent with findings from Vanker and Nandlpp, as well as other researchers who reported that, while thrombocytopenia can occur at any stage of HIV infection, its association with immune status is less consistent and may be influenced by additional factors such as chronic viral co-infections and medication exposure (16,20). This highlights the heterogeneity of hematological complications in HIV/AIDS and underscores the importance of comprehensive patient assessment rather than reliance on a single parameter.

Mechanistically, the observed hematological derangements can be understood in the context of direct HIV-mediated bone marrow suppression, chronic immune activation, and increased susceptibility to secondary infections and neoplastic processes (3,4,8,9). Lymphopenia, particularly involving the CD4+ T-helper subset, directly reflects the hallmark pathogenic process of HIV infection and provides an immunological basis for the increased frequency and severity of opportunistic infections in advanced disease (5,7). Leukopenia and anemia may result from both direct viral effects and indirect mechanisms such as immune dysregulation, myelodysplasia, and chronic inflammation. The significant correlations between these abnormalities and lower CD4+ counts in this study lend support to their potential utility as surrogate markers for immunosuppression and disease monitoring, a practical consideration in areas with constrained laboratory resources (11,12).

This study possesses several strengths, including its exclusive focus on a clearly defined male HIV/AIDS population and the use of standardized laboratory methodologies to assess hematological and immunological status. The integration of robust statistical analyses enhances the reliability of the findings and supports their clinical relevance. However, some limitations must be acknowledged. The relatively small, single-center sample limits the generalizability of the results, and the cross-sectional design precludes assessment of temporal changes or causal inferences. The lack of female participants and exclusion of individuals with comorbidities other than hepatitis B or C further restricts the applicability of findings to the broader HIV population. Additionally, potential confounding effects of antiretroviral therapy, nutritional status, and other sociodemographic factors were not fully explored and may have influenced the observed relationships.

In light of these limitations, future research should employ larger, multicenter designs and include diverse demographic groups to enhance the external validity of findings. Longitudinal studies would help clarify the temporal evolution of hematological derangements in relation to CD4+ decline and the impact of interventions such as antiretroviral therapy and supportive care. Furthermore, the role of additional biomarkers and the potential for integrated hematological indices to predict clinical outcomes in HIV/AIDS warrant further investigation.

In conclusion, the present study reinforces the clinical importance of routine hematological assessment in HIV/AIDS management and underscores the significant relationship between anemia, leukopenia, lymphopenia, and immunosuppression.

These parameters may serve as practical adjuncts to CD4+ counts in guiding patient monitoring and intervention, particularly in settings where access to advanced immunological testing is limited. By highlighting the need for broader, more inclusive research, these findings pave the way for future studies aimed at optimizing the management and prognostication of HIV/AIDS in diverse patient populations (1,2,11,12,14,16,18,20).

CONCLUSION

In conclusion, this cross-sectional study demonstrates that hematological derangements—particularly anemia, leukopenia, and lymphopenia—are significantly associated with lower CD4+ counts in adult male HIV/AIDS patients, highlighting the clinical value of routine blood count parameters as accessible surrogate markers for disease progression. These findings underscore the potential for basic hematological assessments to guide risk stratification and monitoring in resource-limited healthcare settings where advanced immunological testing may not be readily available.

Clinically, integrating these parameters into routine care can enhance early identification of immunosuppression and timely intervention, while future research should focus on larger, diverse populations and longitudinal analyses to further

elucidate the utility and predictive value of hematological markers in HIV/AIDS management.

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