

Hematological Determinant of Viral Load Suppression among Children Living with Human Immunodeficiency Virus in Ile-Ife, Osun State, Nigeria

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Abstract

Introduction: Human Immunodeficiency Virus (HIV) often have pan-systemic manifestations, with the hematological system being one of the most affected. Viral load is the gold standard for monitoring the progress of HIV. This study aimed to determine the association between the hematological profile and the viral load among HIV infected children in Ile-Ife, Osun State, Nigeria

Methods: This is a cross-sectional study involving 155 HIV infected children (aged 6 weeks to 18 years) on Highly Active Anti-Retroviral Therapy (HAART). The hematological profile was determined using an automated hemoanalyzer, while viral load was estimated using COBAS[®]Ampliprep and the COBAS[®]Taqman[®]49 analyzer. A p-value of <0.05 was considered statistically significant.

Results: The mean (SD) for the hemoglobin concentration and platelet count were 11.4 (1.5) g/dL and 288.4 (118.5) $\times 10^9/L$ respectively. The median (IQR) viral load was 200.0 (<20.0–33,518.0) copies/mL with a range of <20 to 1,872,980 copies/mL and about 53.5% of the children were virologically suppressed. The hemoglobin concentration ($r = -0.271$; $p = 0.001$) and platelet count ($r = -0.188$; $p = 0.019$) showed statistically significant negative correlation with the viral load. Similarly, anemia ($\chi^2 = 7.835$; $p = 0.020$) and thrombocytopenia ($\chi^2 = 9.480$; $p = 0.009$) showed statistically significant association with viral load.

Conclusion: There was a notable relationship between hematological cell lines and viral load, which can be used to monitor treatment response and a surrogate to viral load where facilities for viral load were not readily available.

Keywords: Hematological profile, ILE-IFE, Nigeria, Viral load

Introduction

Human immunodeficiency virus (HIV) disease is a retroviral disease characterized by profound immunosuppression that leads to opportunistic infections (OIs), secondary neoplasia and multisystemic manifestations, in which hematologic

disorders are major features [1,2]. HIV infection is a global pandemic disease accounting for 2.6% and 3.2% of under-five mortalities in sub-Saharan Africa and West Africa, respectively [3]. Children, unlike adults, experience more rapid disease progression, with almost half of those untreated dying within the first two years of life [4,5].

The viral load estimation is widely regarded as the gold standard for monitoring response to Highly Active Antiretroviral Therapy (HAART) [6] and is a reliable predictor of risk of transmission of HIV and a measure of disease progression in HIV infected children [7]. Successful antiretroviral therapy (ART) is defined as suppression of plasma viraemia (viral suppression), which is defined as HIV plasma RNA measurements that are below the quantification limit of an approved viral load assay, which is less than 1000 copies/ml in the Nigerian program of HIV management [7].

Hematologic complications are common causes of morbidity and mortality in HIV-infected patients [4,8]. These often manifest as cytopenia such as anemia, neutropenia, lymphopenia and thrombocytopenia [8]. The hematological profile of HIV-infected children is strongly related to their viral load and may hold promise as a prognostic and disease monitoring marker, particularly in situations when the gold standard is not readily available. It is therefore attractive to examine the relationship between hematological profile and viral loads of HIV-infected children. There is a paucity of data on the association between viral load and hematologic parameters of HIV infected children in Nigeria. Against this backdrop, this study hopes to determine the hematological indices in children with HIV and the relationship between these indices and their viral load at the Obafemi Awolowo University Teaching Hospital Complex (OAUTHC), Ile-Ife, Southwest Nigeria.

Methodology

Study location

The study was conducted at the Children's HIV Clinic, OAUTHC, Ile-Ife, Osun State, Nigeria. The OAUTHC is a tertiary health institution located in Ile-Ife, Osun State, Nigeria [9]. The children's HIV Clinic runs three times a week and is overseen by a consultant pediatrician in the Infectious Disease Unit, assisted by resident doctors and nurses. The services provided at the clinic include follow-up care of children with HIV infection and prescription of HAART, care and monitoring of HIV-exposed children, adherence counselling, nutritional management, psychological support, and other necessary care. Mycological, parasitological and bacteriological services are provided by the laboratories.

Study design

This was a cross-sectional study.

Study population

Subjects were children aged 6 weeks to 18 years with confirmed HIV infection attending the children's HIV Clinics of OAUTHC and were on HAART. Children who had clinical

evidence of chronic diseases like renal/liver diseases, blood transfusion within three months before the study period, and were acutely ill-looking were excluded from the study.

Ethical clearance/approval

The study was approved by the Ethics and Research Committee of Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, Nigeria, with number IRB/IEC/0004553. The consent of parents/guardians was obtained, and consent/assent was obtained from the participating adolescents, following the provision of a detailed explanation of the study objectives, benefits and risks, as well as assurance of the freedom to participate or otherwise without any threat of sanction or unfavorable treatment. The data collection instrument had no personal identification information. All participants were identified using only serial numbers. Data were secured by password-protecting the research-related data.

Sample size determination

A total of 155 HIV-infected children were recruited for the study after assuming 10% for attrition.

Sampling technique

All children who presented to the children's HIV Clinic and met the inclusion criteria were enrolled consecutively by non-probability sampling until the sample size was achieved.

Study procedure

All consenting consecutive eligible children aged from 6 weeks to 18 years with HIV on HAART were recruited. An interviewer-administered questionnaire was used for the participants. The questionnaire included socio-demographic characteristics, such as age, sex, class in school, parental level of education and the occupation of parents and/or the caregivers. Further information obtained included the date of HIV diagnosis, drug history of participants, HAART regimen and time commenced.

Laboratory investigations

Venous blood was obtained from each participant using a standard method with strict adherence to WHO biosafety guidelines. The samples were collected into bottles containing ethylene di-aminetetra-acetic acid (EDTA) anticoagulant and were used to determine the hemoglobin (Hb) concentration, total WBC, neutrophils, lymphocytes and platelets count using ABX micro ES 60^R automated hemoanalyzer (Siemens, Vienna, Austria).

The HIV RNA (viral) load was determined using the COBAS^R Ampliprep and the COBAS^R Taqman^R 49 analyzer

(Roche Diagnostic System, Roche Germany), for automated sample preparation and amplification and detection at the Virology laboratory of OAUTHC, Ile-Ife.

Data analysis

Data were analyzed using the Statistical Product and Service Solutions (SPSS) IBM, version 25.0. Descriptive and inferential statistics were used to analyze variables. Continuous variables such as Hb concentration and viral load were summarized using the mean (Standard deviation). Differences between the mean (SD) of continuous variables were compared using the independent Student’s t-test. Spearman Rho correlation coefficient test was used to determine the degree of correlation between viral load and hematologic parameters. Statistical significance was established when the p-value was less than 0.05.

Definition of terms

- Anemia = hemoglobin concentration <110g/L (11 g/dL).
- Mild anemia = hemoglobin concentration of 70–109 g/L (7–10.9 g/dL).
- Moderate anemia = hemoglobin concentration of 50–69 g/L (5–6.9 g/dL).
- Severe anemia = hemoglobin concentration of <50 g/L (<5 g/dL).
- Leucopenia = total white blood cell counts of <4×10⁹/L.
- Neutropenia = absolute neutrophil count (ANC) of <1.5×10⁹/L.
- Mild neutropenia = absolute neutrophil count of 1.0 to 1.4 ×10⁹/L.
- Moderate neutropenia = absolute neutrophil count of 0.5 to 0.9×10⁹/L.
- Severe neutropenia = absolute neutrophil count of <0.5×10⁹/L.
- Lymphocytopenia = absolute lymphocyte counts of <1.2×10⁹/L.

- Thrombocytopenia = platelet count of <100×10⁹/L.
- Viral load less than 20 copies/mL – undetectable viral load
- Viral load less than 1000 copies/mL – suppressed viral load
- Viral load greater than 1000 copies/mL – unsuppressed viral load

Results

One hundred and fifty-five (155) HIV infected children were recruited. The ages of the study participants ranged from 6 weeks to 18 years with a mean (SD) of 11.4 (4.5) years. The majority 77 (49.7%) were school aged children, 17 (11.0%) were under-fives, while 16 (39.3%) were teenagers. There were 73 (47.1%) males and 82 (52.9%) females. The majority (80.7%) were diagnosed 10 years and below while only 19.3% were diagnosed more than 10 years ago. Similarly, 125 (80.7%) had been on HAART for 10 years and below while 30 (19.3%) had been on HAART for more than 10 years.

The mean (SD) for the hemoglobin concentration was 11.4 (1.5) g/dL and total leucocyte count was 5.7 (2.2) x10⁹/L. The hematological profile is shown in **Table 1**.

The range of the viral load among the participants was from <20 to 1,872,980 copies/ml with a median (IQR) of 200.0 (20.0–33,518.0) and the mode was <20 copies/ml.

The majority, 83 (53.5%) of the participants, were virally suppressed (**Table 2**).

Tables 3 highlights the cytopenia and hematological parameters among the HIV infected children with viral suppression and those with unsuppressed viral load. More proportion of children with unsuppressed viral loads had anemia than those whose viral load were suppressed and the difference was statistically significant (x²=7.835; p=0.020). Similarly, more participants with unsuppressed viral load (8.3%) had thrombocytopenia than those with suppressed viral load (0.0%) and the difference was statistically significant (x²=9.480; p=0.009). There was no statistically significant difference with the other cytopenia.

Table 1. Hematological profile of the study participants.

Hematological variable	Mean (SD)
Hemoglobin Concentration (g/dL)	11.4 (1.5)
Total leucocyte count (×10 ⁹ /L)	5.7 (2.2)
Absolute neutrophil count (×10 ⁹ /L)	35.3 (12.4)
Absolute lymphocyte count (×10 ⁹ /L)	3.0 (1.4)
Platelet count (×10 ⁹ /L)	288.4 (118.5)

Table 2. Viral load classification in HIV infected children.

Viral load (copies/ml)	Number of children	Percentage (%)
Undetectable Viral load (<20)	62	40.0
Suppressed viral load (20–<1000)	21	13.5
Unsuppressed viral load (1000–100,000)	55	35.5
Unsuppressed viral load (>100,000)	17	11.0

Table 3. The association between cytopenia and viral load among the participants.

Hematologic parameters	Suppressed viral load n = 83 (%)	Unsuppressed viral load n = 72 (%)	χ^2	p-value
Anemia	23 (27.7)	35 (48.6)	7.835	0.020
No anemia	60 (72.3)	37 (51.4)		
Leucopenia	15 (18.1)	13 (18.1)	0.000	1.000
No Leucopenia	68 (81.9)	59 (81.9)		
Lymphocytopenia	3 (3.6)	4 (5.6)	0.337	0.562*
No lymphocytopenia	80 (96.2)	68 (94.4)		
Neutropenia	28 (33.7)	27 (32.5)	0.239	0.625
No neutropenia	55 (66.3)	45 (67.5)		
Thrombocytopaenia	0 (0.0)	6 (8.3)	9.480	0.009*
No thrombocytopenia	83 (100)	66 (91.7)		

The figures in parentheses are percentages along each column; * fishers' exact test applied

The comparison between the HIV viral loads and the types of cytopenia is shown in **Table 4**. Anemia ($U=1950.0$; $p=0.001$) and thrombocytopenia ($U=104.0$; $p=0.001$) had statistically significant association with HIV viral load.

The mean (SD) hemoglobin concentration of those with unsuppressed viral load was lower than those with suppressed viral load and the difference was statistically significant ($t=4.099$; $p=0.001$). Similarly, the mean (SD) of platelet count was higher among the virally suppressed participants, and the difference was statistically significant ($t=3.541$; $p=0.001$). The mean (SD) difference of the other cytopenia between

the virally suppressed and unsuppressed was not statistically significant (**Table 5**).

There was a statistically significant but weak negative correlation between hemoglobin concentration and viral load ($r=-0.271$; $p=0.001$). Likewise, a statistically significant weak negative correlation was demonstrated between platelet count and viral load ($r=-0.188$; $p=0.035$). There was weak positive correlation between viral load and leucocyte counts, neutrophil counts and lymphocyte counts, however, they were not statistically significant (**Table 6**).

Table 4. Comparison of HIV viral loads with the types of cytopenias among the subjects.

Hematological parameters	No (%)	Viral load Median (IQR)	Mann-Whitney U Test	p-value
Anemia	58 (37.4)	12,174 (20.0–81591.8)	1,950.0	0.001
Leucopenia	28 (18.1)	43 (20.0–47403.3)	1,764.0	0.946
Neutropenia	55 (35.5)	304 (20.0–22522.0)	2,722.5	0.915
Lymphopenia	7 (4.5)	22,565 (20.0–99768.0)	434.5	0.457
Thrombocytopaenia	6 (3.9)	104,833 (66,684.0–129,485.5)	104.0	0.001

IQR: Interquartile range

Table 5. Comparison of HIV viral loads with the types of cytopenias among the subjects.

Hematologic parameters	Suppressed viral load n = 83 mean (SD)	Unsuppressed viral load n = 72 mean (SD)	t-test	p-value
Hb conc. (g/dl)	11.8 (1.4)	10.8 (1.5)	4.099	<0.001
Total WBC ($\times 10^9$)	5.7 (2.2)	5.7 (2.2)	0.244	0.804
Absolute lymphocytes ($\times 10^9$)	3.2 (1.5)	2.9 (1.4)	1.081	0.281
Neutrophil count ($\times 10^9$)	2.0 (1.0)	2.1 (1.4)	0.408	0.689
Platelet count ($\times 10^3$)	318.7 (124.4)	253.4 (101.0)	3.541	0.001

WBC: White Blood Cells; Hb: Hemoglobin Concentration

Table 6. Correlation analysis between hematological indices and viral load.

Hematological profile	Spearman's correlation with Viral load (r)	p-value
Packed cell volume (%)	-0.261	0.001
Hemoglobin concentration (g/dL)	-0.271	0.001
Total leucocyte count (/L)	0.051	0.526
Absolute neutrophil (/L)	0.024	0.764
Absolute Lymphocyte (/L)	0.002	0.980
Platelet count (/L)	-0.188	0.019

Discussion

This study highlighted the association between the hematological profile and viral load of children with HIV infection on HAART at the OAUTHC, Ile-Ife. More than half of the subjects were virally suppressed, and among them, more than 75 per cent had undetected viral load in this study. This is due to effective HAART, which reduces viral replication; therefore, reduces the risk of virological failure and subsequently prevents immunological and clinical failure [6]. Worthy of note, however, is the fact that about 46.5% of the participants were virally unsuppressed. This may be due to various known causes of virological failure such as virological resistance to HAART and non-adherence to HAART medications (dosage and irregularity in timing) [6].

The prevalence and severity of anemia were significantly associated with higher viral load in this study. This was similar to that reported by Tsegay et al. [10] in Ethiopia. Similar studies have explained that anemia may be directly related to the level of viral load as the virus suppresses the bone marrow [11–13]. HAART is known to significantly reduce viral replication and viral load, increase CD4+ lymphocyte count and immunity, and delay disease progression clinically and death [6,14]. It has been found to reduce the destruction of mature hematopoietic cells in multiple lineages and improve the blunted erythropoietin response caused by HIV [6,14].

Studies have confirmed that HAART corrects and improves anemia and other hematological anomalies [6,14,15]. By reducing viral load, HAART diminishes the anti-proliferative activities of cytokines released by HIV on the bone marrow hematopoietic cells, thus reducing the risk and allowing recovery from anemia [14,15].

In this study, we observed that HIV-infected children with leucopenia, neutropenia and lymphocytopenia had higher viral load than those with normal counts; however, the difference in viral load was not statistically significant. These findings further stress the fact that all white blood cells count, and their cell lines decrease as HIV disease progresses. This finding agrees with that reported by Umar et al. [16].

In this study, a significant difference was observed when the mean viral load of HIV-infected children with thrombocytopenia and those without thrombocytopenia were compared. This is contrary to the finding by Umar et al. [16], which reported a statistically non-significant association between the viral load and prevalence of thrombocytopenia. This variation may be due to the fact that the children in the study were on HAART, which reduced the viral load and, as such, those with persistently higher viral load may be truly suggestive of advanced disease.

In this present study, the hemoglobin concentration and platelet count were significantly associated with HIV viral load.

This is in concordance with other studies where the platelet count, hemoglobin concentration, and total leukocyte count were associated with HIV viral load [17–19]. The hemoglobin concentration and platelet count could possibly be a hematological marker for HIV viral load. The severity of anemia was an indicator of high HIV viral load and low absolute CD4 count [19].

Effective and prompt detection and treatment of common causes (and associated factors) of cytopenia, especially anemia and thrombocytopenia in HIV-infected children should be emphasized. This can be achieved through various levels of prevention, which include health education, free health care and screening for primary HIV infection and other associated diseases. In addition, adequate counselling of parents and caregivers on diet and introduction of locally available food that could provide essential and needed micronutrients, vitamins and minerals for these HIV-infected children are essential.

The limitation of this study is the cross-sectional design, which made it difficult to establish causality of the hematological cytopenias observed among the HIV infected children. Similarly, this study did not check for viral resistance to HAART, as it was possible that some HIV-infected children with cytopenia might not be responding adequately to HAART because of drug-resistant viral strains.

In conclusion, more than half of the HIV infected children on HAART had suppressed viral load, while anemia and thrombocytopenia were significantly associated with viral load. There was a significant weak negative correlation between the viral load and hemoglobin concentration as well as the platelet counts of the participants. Therefore, the hemoglobin concentration and platelet count of HIV-infected children could be used to monitor treatment response to highly active antiretroviral therapy where facilities for viral load are not available.

Declarations

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicting interest

The authors declared that they have no conflicting interests.

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Authors' contribution

HHA, BPK, MOA: Concept and design of the study, acquisition of data, analysis of data, interpretation of data, drafting the article, and final approval of the version to be published.

TAO, EA, AJK: Concept and design of the study, interpretation of data, drafting the article, revising it critically for important intellectual content, and final approval of the version to be published.

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