Haematological and Immunological Abnormalities in People Living With HIV: A Review

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Abstract

Haematological and immunological abnormalities abound in HIV infections. Reduced CD4+ T cells, changes in cytokine profiles, and impaired immunity are the key immunological changes seen in HIV infection. The immune system becomes dysregulated when HIV targets multipotent haematopoietic progenitor cells, which disrupts the bone marrow microenvironment. This affects proper haematopoiesis due to cytokine imbalances and disruption of other elements necessary for haematopoiesis. Hence, haematological abnormalities, especially cytopenias often manifest in HIV- infected individuals. A number of reasons contribute to the complicated pathophysiology of these disorders, including HIV's direct effects on haematopoiesis, suppression of the bone marrow due to cancer or infection, adverse effects of antiretroviral (ARV) medications, immune-related issues, and opportunistic infections. This research compiles and analyses regional data on the frequency of cytopenias in HIV-infected individuals, including anaemia, leukopenia, and thrombocytopenia and their causes. Additionally, it evaluates the effects of antiretroviral medication on cytopenias and CD4 counts, and investigates the connection between these cytopenias and immunological indicators like CD4 count. Also included are suggestions for future studies and areas where studies are lacking.

Key words: Haematological and Immunological abnormalities, HIV infections, CD4+ T cells, Cytopenias, Anaemia, Leukopenia, Thrombocytopenia.

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Introduction

When it comes to worldwide health concerns, the HIV epidemic ranks among the worst. Since the epidemic started, an estimated 78 million individuals have acquired HIV, and 35 million have died from AIDS-related causes (UNAIDS, 2016). With 2019 coming to a close, the Joint UN according to the Programme on HIV/AIDS, 38.0 million people are HIV positive. That that year, the global AIDS epidemic claimed the lives of over 690,000 people and infected almost 1.7 million more (UNAIDS, 2020). According to UNAIDS (2020), more than Two-thirds of HIV-positive people live in Sub-Saharan Africa, making this area the most burdensome. HIV primarily affects the immune system, resulting to a decline in immunological function and a wide range of haematological problems in infected individuals.

Haematological abnormalities in HIV infected patients

Cytopenias

HIV-related cytopenias, which affect any major blood cell lineage, are prevalent haematological abberations, causing reduction in the red blood cells, white blood cells and platelets (Vishnu & Aboulafia, 2015; Opie, 2012). Various underlying causes including inflammation, infections, malnutrition, cancer, and polypharmacy, may lead to these cytopenias (Redig & Berliner, 2013). These cytopenias are caused by either the direct effects of the HIV virus itself, or the indirect effects of the virus on haematopoiesis. Direct consequences include HIV infection on haematopoietic stem and progenitor cells (HSPCs) and indirect effects include those which are independent of HIV/HSPCs interactions e.g drug and/or coinfection induced, and indirect influence of HIV on HSPCs such as alterations in the cytokine signalling environment (Durandt et al., 2019).

Many negative consequences, including the development of AIDS, are linked to cytopenias in HIV-positive individuals, especially anaemia. Heightened mortality rates, mostly associated with anaemia, more hospitalisations caused by various forms of cytopenias, and an increased likelihood of secondary infections from fungus and bacterial infections associated to neutropenia as well as HIV drugs (Dai et al., 2016; Kuritzkes, 2000; Santiago-Rodríguez et al., 2014; Tamir et al., 2018; Gedefaw et al., 2013; Jacobson et al., 1997). Generally, combined antiretroviral treatment (cART) improves cytopenias and as the disease progresses, the frequency and intensity also increases. Higher morbidity and lower quality of life are associated with severe cytopenias, especially thrombocytopenia and anaemia (Fekene et al., 2018; Woldeamanuel & Wondimu, 2018a; Ndlovu et al., 2014). In African treatment-naive AIDS patients, anaemia and neutropenia were more common than in Asian or American populations, highlighting the importance of geographical disparities (Firnhaber et al., 2010; Vaughan et al., 2017).

Several variables affect HIV-associated cytopenias; these include the rate at which the virus replicates, the consequences of HAART, cancer, liver cirrhosis, and opportunistic infections (OIs) (Kirchhoff & Silvestri, 2008; Choi et al., 2011). Female sex, a CD4 cell count below 200 cells/μL,

being classified in WHO stage IV, co-infection with hepatitis B virus (HBV), and a BMI below 18.5 kg/m², a viral load of 100,000 copies/ml or greater and age above 40 are all associated factors for cytopenias in HAART-naive individuals (Fan et al., 2020; Choi, 2011).

Table 1: Criteria used to define cytopenias by various studies

Criteria Used To Define Cytopenias by various studies		
Cytopenia	**Criteria**	**References**
Anemia Hb concentration; (g/dL)	<13 (males) <12 (females)	(Santiago-Rodríguez et al., 2015), (Fekene et al., 2018), (Enawgaw et al., 2014), (Woldeamanuel & Wondimu, 2018b), (Kyeyune et al., 2014a), (Dikshit et al., 2009)
	11.0–12.9 g/dl (mild anemia) - males	(Who & Chan, 2011)
	11.0–11.9 g/dl (mild anemia) females (non-pregnant women)	(Who & Chan, 2011)
	8.0–10.9g/dl (moderate anemia) - for both sexes)	(Who & Chan, 2011)
	< 8.0 g/dl (severe anemia)- for both sexes	(Who & Chan, 2011)
Leucopenia (WBC counts)	$< 4.0 \times 10^3/\mu L$.	(Santiago-Rodríguez et al., 2015), (Denue, Gashau, et al., 2013), (Talargia et al., 2021), (Dikshit et al., 2009)
Neutropenia (Neutrophil count; cells/µL)	<1 000	(Fekene et al., 2018), (Dikshit et al., 2009)
Thrombocytopenia (platelet count; $10^3/\mu L$)	$< 150 \times 10^3/\mu L$	(Denue, Gashau, et al., 2013), (Fekene et al., 2018), (Owiredu et al., 2011), (Santiago-Rodríguez et al., 2015),
Lymphopenia (lymphocyte count; cells/µL)	< 800 cells/µl.	(Fekene et al., 2018), Damtie et al. 2021

Anaemia

Many variables influence the survival and function of bone marrow haematopoietic stem/progenitor cells (HSPCs), which may lead to anaemia in HIV-positive individuals (Durandt et al., 2019; Marchionatti & Parisi, 2021). Considerations such as these include ART drugs, HIV-associated inflammatory mediators, and opportunistic or co-infections (Durandt et al., 2019; Marchionatti & Parisi, 2021). Myelosuppressive drugs like Zidovudine, infections or neoplasms infiltrating the bone marrow, the direct consequences of HIV infection, and decreased endogenous erythropoietin production are important causes of anaemia. (Volberding et al., 2004; Mata-Marín et al., 2010) and haemolytic anaemia caused by RBC auto-antibodies or drugs.

Haematologic progenitor cells are susceptible to many effects of cytokine dysregulation. Hepcidin, an important regulator of iron homeostasis, is produced in response to elevated IL-6 levels. The retention of iron in macrophages and enterocytes, caused by elevated hepcidin levels, decreases blood iron concentrations and, therefore, diminishes haemoglobin synthesis (Redig & Berliner, 2013; Vishnu & Aboulafia, 2015). Serum iron levels tend to be lower in HIV-positive individuals with severe anaemia (PLWHA) (Obirikorang et al., 2016). Furthermore, cytokines like IL-1β and TNF-α hinder the formation of erythropoietin, which in turn hinders the proliferation of precursor cells for erythrocytes (Parinitha & Kulkarni, 2012). Hepcidin stimulates the breakdown of ferroportin, an iron transport membrane protein mostly found in macrophages and duodenal enterocytes. Hepcidin inhibits iron absorption from food and mobilisation of iron from old erythrocytes, which in turn reduces serum iron concentrations and availability for haematopoiesis when levels are high. Hepcidin is a key hormone in iron regulation. Microbes need host-derived iron for growth, which leads to dysregulation of hepcidin synthesis and iron metabolism, which in turn causes numerous acute and chronic infections (Drakesmith & Prentice, 2012).

Anaemia predominates among HIV-infected individuals (Tamir et al., 2019; Kyeyune et al., 2014; Assefa et al., 2015). With incidence rates reported in several research ranging from 1.3% to 95% (Belperio & Rhew, 2004). Anaemia, leukopenia, and thrombocytopenia are the most often reported cytopenias, affecting around half of patients, even though antiretroviral treatment (ART) has advanced (Kyeyune et al., 2014). Anaemia risk factors include ART regimen, opportunistic infections, education, duration, income,

antituberculosis treatment, advanced AIDS stage, gender, and low white blood cell, CD4+, and platelet counts (Gedefaw et al.; Tadesse et al.; Adeba, 2014). Research shows that HIV-positive women have a greater rate of anaemia than males (Thulasi et al., 2016; Sullivan, 1998).

Anaemia prevalence in HIV patients varies widely throughout Africa and Asia (Denue et al., 2013; Dikshit et al., 2009; Adane, 2012; Gunda, 2017; Enawgaw, 2014; Choi, 2011; Gedefaw, 2013). North Shewa Zone, Ethiopia (23.2%; Gebreweld et al., 2020), Gondar, Ethiopia (22.2%; Derisa et al., 2018), Northeastern Nigeria (24.3%; Denue et al., 2013), and Kaduna State (23%), are among the African nations where prevalence rates have been documented. According to several studies, the following percentages were found in various parts of Nigeria: 9.9% in Debre Tabor, In Cameroon's southwestern region, 58.6 percent, 37.5% in Benin City, Nigeria, and 11.7% at Gondar University Hospital, Ethiopia. 11.4 percent in Ethiopia's Black Lion Specialised Hospital (Woldeamanuel & Wondimu, 2018) and 14.3 percent at Zewditu Memorial Hospital (Assefa et al., 2015). On the other hand, Dai et al. (2016) found a prevalence rate of 9.74% in China. Potential factors contributing to these disparities in prevalence include discrepancies in ART status, study populations, diagnostic criteria for anaemia, and geographic location. Africans may be more prone to anaemia due to economic hardships, malnutrition, and poverty (Firnhaber et al., 2010). Serious anaemia, morbidity, and death are all greatly exacerbated in sub-Saharan Africa when HIV and malaria are co-infected. Pharmaceutical interactions that make treatment for both HIV/AIDS and malaria more difficult (Sanyaolu et al., 2013; Vishnu & Aboulafia, 2015).

Thrombocytopenia

The first haematological sign of HIV infection is often thrombocytopenia. Factors that impact its progression include age, CD4+ T lymphocyte count, opportunistic infections, age, and antiretroviral medication (ART). Patients with HIV/AIDS (PLWHA) have a higher risk of adverse health outcomes due to thrombocytopenia, which speeds up the development to AIDS (Vishnu & Aboulafia, 2015; Wondimeneh et al., 2014; Taremwa et al., 2015).

Among people living with HIV, the frequency of thrombocytopenia varies, according to global surveys. Two studies in China found different prevalence rates: one found 4.5% in ART-naive HIV patients and another found 1.6% in HAART-naive HIV patients (L. Fan et al., 2020). Thrombocytopenia affects 26% of Canadian HIV patients (Ambler et al., 2012), but 5.5% of Danish HIV patients with an undetectable viral load have this condition (Akdag et al., 2019).

Prevalence rates for thrombocytopenia vary across cross-sectional research conducted in Africa. Thrombocytopenic patients accounted inside northern Ethiopia, for 4.1% of HAART patients and 9.0% of HAART-naive patients (Enawgaw et al., 2014). Thrombocytopenia was seen in 8.3% of Ugandan participants, irrespective of their HAART status (Kyeyune et al., 2014). Akinbami et al. (2010) found a frequency of 16.1% among ART-naive patients in Lagos, Nigeria. Thrombocytopenic anaemia affected 11.1% of HIV-positive Ethiopians on HAART and those who had never taken the medication before (Fekene et al., 2018), At Dessie, Ethiopia, 18.7% of HIV-positive individuals who were not exposed to antiretroviral therapy also developed thrombocytopenia (Tamir et al., 2019). Thrombocytopenia seems to be more common in underdeveloped nations than in industrialised ones.

Thrombocytopenia is affected by how rigorously a treatment program is followed. Thrombocytopenia is more common in those who aren't on antiretroviral medication than in those who are, perhaps because HAART improves disease control and decreases thrombocytopenia. According to Thulasi et al. (2016), thrombocytopenia is more likely in patients with low CD4 cell levels.

Leukopenia

Multiple factors contribute to leukopenia in HIV-positive individuals. The HIV-induced inhibition of bone marrow function, which lowers granulocyte colony-stimulating factor levels, is one such example, opportunistic infections including cryptococcosis, histoplasmosis, CMV, leishmaniasis, and mycobacterium tuberculosis; and the use of myelosuppressive medications (Geletaw et al., 2017; Enawgaw et al., 2014). Infections, reduced bone marrow activity as a result of infiltrations, faster apoptosis, direct HIV effects, poor granulopoiesis, cancers, granulocyte-targeting antibodies (Gunda et al., 2017; Donald, 1998), and the side effects of HIV medication (Thulasi et al., 2016) and other factors also contribute to leukopenia.

Among HIV patients with early symptoms, 5-30% have neutropenia, and among those with late AIDS, up to 70% may experience neutropenia which is the most common type of leucopenia. (Vishnu & Aboulafia, 2015). One Nigerian research found a prevalence incidence of 72.5% while another found a rate of 10.8% (Babadoko et al., 2015). (Samuel Kwadwo & Emmanuel Awusah, 2018), whereas another research out of Nigeria found 24% (Erhabor et al., 2005). Negene et al. (2018) and Dikshit et al. (2009) each discovered only one instance of neutropenia in their respective studies of 200 HIV patients in Ethiopia, respectively.

Low CD4+ cell counts, as well as HIV patients using first-line ART, especially AZT- based regimens are more likely to have neutropenia (Dikshit et al., 2009). Regional differences in the occurrence of neutropenia are substantial. Patients in India and Peru had a frequency of ≤5%, according to a worldwide research (Firnhaber et al., 2010), whereas patients in Malawi, Zimbabwe, South Africa, Haiti, and the US had a prevalence of ≥15%. Neutropenia is less common in patients who take combination antiretroviral treatment (cART) (Günthard et al., 2014).

A leukopenia prevalence of 10% to 44% has been reported in ART-naive individuals (Murphy et al., 1987), correlated with a higher risk of severe bacterial infections requiring hospitalisation (Gunda et al., 2017). Research on children has shown a wide range of prevalence rates: 4.5 percent in Northwest Ethiopia, 6.6 percent in Lagos, Nigeria, 10 percent in Kenya, 34 percent in West Bengal, India, and 2 percent in Mumbai, India. According to Tsegay et al. (2017), these disparities in prevalence might be caused by differences in age, HAART status, infectious and non-infectious illness prevalence, and ethnicity.

Leukopenia, neutropenia, and lymphopenia are more common after beginning HAART compared to other haematological problems (Duguma et al., 2021; Wisaksana et al., 2013; Ferede & Wondimeneh, 2013; Kathuria et al., 2016). Leukopenia may be caused by zidovudine-containing HAART regimens, which depress the bone marrow and have cytotoxic effects on T-cells (Servais et al., 2001). Neutropenia became more prevalent rising from72.5% to 85% in Ghana after HAART was initiated (Samuel Kwadwo & Emmanuel Awusah, 2018).

Immunologic marker of HIV infection

CD4 Cells

The immune system is substantially repressed and CD4+ T cells are gradually eliminated by chronic HIV infection, the susceptibility to opportunistic infections increases (Saharia & Koup, 2013). T helper (Th) cells, or CD4+ T cells, are essential for controlling innate immunity and the generation of chemokines and cytokines, which initiate adaptive immunity. An extensive immunological response is orchestrated by this mechanism (Rashighi & Harris, 2017; Boucau et al., 2020; Porichis et al., 2018).

The cytokine profiles of the two subtypes of T cells, Th1 and Th2, are different from one another (Carlberg et al., 1997). The Th1 cytokines IL-2, IL-12, and IFN-γ are linked to protective immune responses. Soufian et al. (2012) and Klein et al. (1997) found that Th2 cytokines, such as IL-4, IL-5, IL-6, IL-10, and IL-13, are associated with disease progression and may help HIV infection develop to AIDS.

Everyone infected with HIV should begin antiretroviral therapy (ART) immediately, according to 2016 treatment guidelines from the World Health Organisation (WHO), with precedence given to those with severe or advanced HIV clinical disease (WHO clinical stage 3 or 4) and those with less than 350 CD4 T cells/μL (WHO 2016). In the past, the World Health Organisation (WHO) established absolute CD4 T-cell counts of 500, 350, and 200 cells/μL as the cutoffs for ART start based on clinical evaluation (WHO 2013). The gold standard for tracking how well antiretroviral therapy is working in HIV patients is plasma viral load (Phillips et al., 2015). Regardless, CD4 count is still an important diagnostic tool, especially for patients with advanced HIV illness, and a sign of immune function, clinical state, and risk of opportunistic infections (Ford et al., 2017). In low-income locations, CD4 counts will likely be used as an alternate metric for viral load testing because of budgetary and technological restrictions (Kahn et al., 2011). HIV-positive adults and adolescents are categorized using the revised CDC classification system based on CD4+ T-cell counts and clinical conditions linked to HIV infection. Three CD4+ T-cell count ranges and three clinical categories serve as the foundation for the system as shown in Table 2.

Table 2: CDC classification system for HIV infection

	Clinical categories		
	A	**B**	**C**
CD4+ T-cell count (cells/μl.) (CD4%)	**Asymptomatic, acute (primary) HIV or PGL***	**Symptomatic, not A or C conditions†**	**AIDS-indicator conditions‡**
> 500 (28%)	A1	B1	C1
200–499 (15–28%)	A2	B2	C2
< 200 (14%)	A3	B3	C3

*Category A: asymptomatic HIV infection, persistent generalized lymphadenopathy (PGL).

†Category B: oropharyngeal and vulvovaginal candidiasis, constitutional symptoms such as fever (38·5°C) or diarrhea lasting >1 month, herpes zoster (shingles).

‡Category C: Mycobacterium tuberculosis (pulmonary and disseminated), Pneumocystis carinii pneumonia, candidiasis of bronchi; trachea or lungs, extrapulmonary cryptococcosis, CMV, HIV-related encephalopathy, Kaposi's sarcoma, wasting syndrome due to HIV.

Association of CD4 cells with cytopenias

In low-income locations, CD4 counts will likely be used as an alternate metric for viral load testing because of budgetary and technological restrictions (Kahn et al., 2011). In most cases, haematological diseases become more common when CD4+ T-cell counts decrease. Prior to beginning HAART, patients with CD4+ T-cell counts < 200 cells/μL are more likely to have anaemia, leukopenia, and neutropenia (Duguma et al., 2021). But after start of HAART, Duguma et al. discovered that HIV-positive people did not show a statistically significant correlation between various CD4+ T-cell count categories and haematological abberations (Duguma et al., 2021).

Thrombocytopenia has been reported to be more common among African HIV-infected people with CD4+ T-cell counts < 200 cells/μL, according to studies conducted in Ethiopia and Uganda (Marchionatti & Parisi, 2021). According to many studies (Dikshit et al., 2009; Alamdo et al., 2015; Assefa et al., 2015a; Tesfaye & Enawgaw, 2014), anaemia is more likely when CD4 counts declines, both before and after starting antiretroviral medication (ART). Furthermore, cytopenia has been found to be more common in people with advanced HIV, especially those with CD4 counts below 200 cells/μL Diakshit et al. (2009), Subbaraman et al. (n.d.), De Santis et al. (2011), Toure et al. (2006), and Kyeyune et al. (2014b)

Impact of antiretroviral therapy on the haematological and immunological abnormalities in HIV infected patients

Cytopenias

Standard treatment for HIV/AIDS patients has always included starting antiretroviral therapy. Among HIV-positive persons, early therapy HAART improves clinical, haemostatic, and immunological profiles, which in turn decreases disease progression and boosts survival rates.

Furthermore, it aids in lowering viral transmission rates (Woldeamanuel & Wondimu, 2018a; Group, 2017). The immune system can be restored and HIV-related cytopenias, such as anaemia, may be improved with antiretroviral therapy (ART) (Johannessen et al., 2011; Odunukwe et al., 2005; Harris et al., 2015). Anaemia was shown to be less common in individuals who had not previously received antiretroviral therapy (ART) after 12 months of treatment (Johannessen et al., 2011). Also, after starting antiretroviral therapy, the prevalence of anaemia dropped from 69.17% to 51.15% in a Nigerian research study (Omoregie et al., 2009). Antiretroviral treatment's (ART) beneficial impacts on RBC survival and differentiation, viral load decrease, and opportunistic infection incidence are responsible for this improvement (Fokouo et al., 2015; Denue, Kida, et al., 2013b).

ART significantly improved haematological markers in HIV-infected individuals in Nigeria. As a result of ART treatment, the frequency of anaemia dropped from 57.5% to 24.3%, leukopenia from 6.1% to 1.7%, and thrombocytopenia from 9.6% to 1.2% (Denue, Kida, et al., 2013a). Similarly, Kibaru et al. found that within six months of starting antiretroviral therapy (ART), haematological indices of HIV-positive children in Kenya changed significantly. Haemoglobin levels, mean corpuscular volume (MCV), WBC and RBC levels decreased, whereas platelet, mean corpuscular haemoglobin (MCH), and other blood cell counts increased. It has been shown that HAART successfully treats cytopenias such anaemia, thrombocytopenia, and neutropenia in HIV-1 infected individuals. Levine et al. (2006), Duguma et al. (2021), Deressa et al. (2018), Woldeamanuel & Wondimu (2018b)

Among HIV-infected patients on antiretroviral therapy (ART), zidovudine leads to a higher rate of anaemia. (Kuwalairat & Winit-Watjana, 2014; Curkendall et al., 2007). Inhibition of bone marrow erythroid precursor cells and subsequent reduction in red blood cell formation may be the cause of AZT-induced anaemia, according to certain studies (Marchionatti & Parisi, 2021; Agarwal et al., 2010; Berhane et al., 2020). Although AZT has the ability to inhibit bone marrow, other investigations have failed to find a correlation between AZT and anaemia (Assefa et al., 2015a; Kiragga et al., 2010; Renner et al., 2013). Future studies which are longitudinal in nature should be done in order to clear this controversy.

Anaemia is common among those living with HIV and according to studies it decreases six months after starting antiretroviral therapy (ART) (Alamdo et al., 2015; Gedefaw et al., 2013; Daka et al., 2013; Woldeamanuel & Wondimu, 2018c). Also, in individuals who hadn't had therapy before, Duguma et al. found that beginning HAART successfully restored haematological abnormalities, especially cytopenias (Duguma et al., 2021).

CD4 cell count

Kaufmann et al. (2000) found that HIV plasma viral loads rise and CD4 levels fall in untreated HIV infection. Usually, viral loads decrease and CD4 counts rise after ART is started. At first, CD4 cells are redistributed from lymphoid organs, the CD4 count rapidly recovers after beginning ART. As more CD4 cells are produced by thymic activation, the rate of recovery decreases with time (Gaardbo et al., 2012; Gazzola et al., 2009). Keeping CD4+ T-cell numbers stable requires a steady equilibrium between their generation and depletion; According to Gaardbo et al. (2013) and Okoye and Picker (2013), CD4+ T-cell numbers will decrease if destruction outpaces creation.

Several variables impact the extent to which CD4 counts rebound once ART is started. Among these factors are the following: the patient's age, gender (men may occasionally have a slower CD4 recovery than females both the duration and specific antiretroviral treatment (ART) regimen used. A number of environmental and genetic variables that influence immune activation (Maman et al., 2012; Fatti et al., 2014; He et al., 2016; Gazzola et al., 2009).

People who begin antiretroviral treatment (ART) earlier had higher CD4+ T-cell counts, according to studies by Le et al. (2013) and W. Cao et al. (2015) rather than later. For instance, 59.3% of CD4 cells were able to recover after starting HAART, according to research out of Goba, Ethiopia (Duguma et al., 2021).

The rapid viral turnover, high mutation rates, and retroviral recombination make HIV-1, like other human RNA viruses, display extensive genetic heterogeneity (Taylor et al., 2008; de Cock et al., 2021; Bbosa et al., 2019; Thomson et al., 2002). The development of HIV vaccine and antiretroviral medicines and diagnostic and viral load tests is hindered by the worldwide genetic diversity of HIV-1, as it is essential that vaccines provide protection against a diverse array of HIV genotypes (Hemelaar et al., 2021; Girard et al., 1996).

Evidence from many international research suggests that variations in HIV-1 genotype influence disease progression and ART effectiveness (Kiwanuka et al., 2008). Baseline CD4+ numbers of cells and mortality rates prior to beginning antiretroviral treatment (ART) in newly diagnosed patients are significantly impacted by HIV-1 genotype, according to recent research. Patients with various HIV-1 genotypes do not vary significantly in mortality outcomes after the commencement of antiretroviral therapy (ART) (Z. Cao et al., 2020).

Future research areas

Haematological abberations in HIV infection have a complex and poorly understood pathogenesis that involves numerous variables. Cytopenias and impaired haematopoiesis might result from one important mechanism: the increased secretion of inflammatory cytokines caused by HIV. It is well-established that chronic immunological activation and alterations in the cytokine profile are major contributors to how HIV infection develops into AIDS. Despite the fact that variations in HIV-1 genotype impact pathogenicity, illness course, and ART responsiveness, its effects on baseline cytokine profiles and baseline markers have not been thoroughly investigated. Clarifying these impacts requires more study, which is critical for creating tailored treatments and efficient vaccine against the many HIV genotypes.

The most common cytopenia in HIV-infected individuals is anaemia, which may have many different reasons. Antiretroviral medication effects, both direct and indirect, on haematopoietic stem/progenitor cells (HSPCs) in bone marrow, HIV-associated inflammatory mediators, as well as those caused by opportunistic or co-infected illnesses. A critical regulator of systemic iron homeostasis, haematopoietic progenitor cells are vulnerable to disruptions in cytokine profiles, which may also affect hepcidin synthesis. Low serum iron levels, which are necessary for haemoglobin formation, may lead to anaemia if elevated hepcidin levels prevent the body from absorbing iron from food and recycling iron from old red blood cells. Although previous studies have have examined hepcidin's levels of PLWHIV, data on the impact of different antiretroviral treatment regimens on hepcidin levels remain unclear. New therapeutic targets, including genetically engineered cell treatments, for treating anaemia in HIV-infected individuals might be discovered using this information.

Conclusion

Common complications of HIV infection include haematological abnormalities, most notably cytopenias. Both HIV-infected patients who have been treated with antiretroviral therapy (ART) and those who have not yet received ART often present with cytopenias especially anaemia. Several factors, such as HIV's direct impact on haematopoiesis, reaction to antiretroviral (ARV) medication, cytokine imbalances, subsequent infections, and immune system compromise contribute to the development of these abnormalities. In general, haematological complications are more common and more severe as the disease advances and CD4+ T-cell counts falls. As viral load and CD4 count assays may not be available in areas with limited resources, simple haematological markers may be crucial in revealing the progression of HIV disease. Clinical management choices about an HIV-positive patient's care may be better informed by keeping an eye on these metrics.

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