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Original Research Article

EFFECT OF MALARIA INFECTION ON BLOOD PARAMETERS AND VIRAL LOAD IN HIV INFECTED CAMEROONIAN PATIENTS UNDER HAART: A HOSPITAL-BASED STUDY

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Abstract

Co-infections with malaria and HIV infection are common in Sub-Saharan countries. This study aimed at determining the effect of malaria infection on blood parameters and viral load of Cameroonian people living with HIV (PLWHIV) and under antiretroviral treatment. A cross sectional and prospective study took place at the District hospital of Deido. About, 8 mL of venous blood were obtained from each patient by venipuncture for performing complete blood count, thick blood smear and CD4 cells count. Sociodemographic data of participants were sought. In total, 723 patients were enrolled in the study with an average age of 39.49 ± 11.17 years old. The mean count of CD4 lymphocytes was 427 ± 257 (range: 6 - 1369 cells/µL). The prevalence of malaria was 16.7% (95%CI: 14.2%-19.6%). Hemoglobin and haematocrit were lower in malaria infected individuals (P-value < 0.0001). Viral loads were significantly higher in infected males compared to their uninfected counterparts (65195.20 ± 978.04 versus 540 ± 91.24 copies/µL; P-value < 0.0001). The risk of anemia was twofold and about threefold higher in males (OR = 2.28; 95%CI = 1.58 – 3.29; P-value < 0.0001) and malaria parasites infected individuals (OR = 2.85; 95%CI = 1.28 – 4.78; P-value < 0.0001) respectively. It is critical to take into account treatment of malaria episodes in PLWHIV during their management.

Keywords: Malaria, HIV, co-infection, Blood parameters, viral load, Cameroon

Introduction

Human immunodeficiency virus infection (HIV) and Malaria remain leading public health problems worldwide and are responsible for many millions and thousands of cases and deaths each year respectively. Malaria burden decreased by half for this last decade owing to advances made on prevention and management. Malaria is caused by protozoans belonging to genus Plasmodium. *Plasmodium falciparum* and *Plasmodium vivax* are the main species involved in malaria burden. These, especially *Plasmodium falciparum*, were responsible for about 212 million and 429,000 of cases and deaths respectively all

over the world. Africa concentrates 80% and 90% of these abovementioned figures respectively. Pregnant women and children aged 0-5 years old are the most at risk groups. [1] As for HIV infection, 40 million of individuals are newly diagnosed positive of which 3 million of deaths. In 2014, it was estimated 25.8 million people living with HIV (PLWHIV) in Sub-Saharan Africa (SSA) countries, [2] accounting for almost 70 % of the global total. Cameroon has one of the highest prevalence of HIV infection in Central and Western Africa with 600,000 PLWHIV. [3]

Malaria and HIV infection are well documented to be cause and consequence of poverty in developing countries where the probability of being co-infected is a high enough. Many researchers outlined a mutual interaction between the virus and the protozoan. Indeed, HIV infection may increase the risk of malaria episodes either by improving the susceptibility of host to the parasite or reducing the effectiveness of antimalarial drugs. [4] Importantly, side effects of HIV infection depend greatly on the nature of the host (child, pregnant woman and non-pregnant adult) and level of antimalarial immunity prior to HIV infection. [4, 5] Conversely, the effects of malaria parasites on natural history of the virus are more obscure in a mechanistic viewpoint. Notwithstanding a few authors reported higher viral loads, correlated with parasite density, in patients suffering from malaria. [5-7]

Prevalence of co-infection with these both pathogens was previously reported in the town of Douala [8] and others parts of Cameroon. [9, 10] Anemia was the leading deleterious effects encountered in co-infected individuals. Others authors reported no effects of malaria infection on hematological parameters. [11] The nature of the link between malaria and HIV infection seems therefore complex enough. In spite of the high prevalence of malaria and HIV infection, very little research addressed the topic in Cameroon especially in Douala. This study aimed at determining the prevalence and associated factors of malaria infection and its impact on blood parameters and viral load in HIV infected individuals.

Materials and Methods

Study sites

This study took place in the town of Douala (Littoral Region, Cameroon). Douala is the business city of the country and located 3°48'N, 10°08'E, near the Atlantic coast, within the Congo-Guinean phytogeographical zone. This area is characterized by a typical equatorial climate with two rainy seasons extending from March to June and from September to November. [12] The city is 1 m above sea level and receives over 3,500 mm rainfall annually. Douala is a port city where many worse behaviors (liquors consumption, prostitution) significantly increase the risk of sexually-transmitted diseases (STDs) such as Human immunodeficiency virus infection. Douala is ranked sixth (5.5%) in terms of HIV prevalence rate. [13]

Study population

The study population consisted of 723 patients aged 5-49 years old of both sexes, HIV infected and under HAART therapy. Any patient who did not meet any of these aforementioned criteria was excluded from the study. Participants were recruited at the district hospital of Deido which greets people coming from all parts of Cameroon owing to its strategic location and sustainable and constant supply with CD4 cells reagents and antiretroviral drugs for management of PLWHIV.

Study design

This hospital-based cross-sectional and prospective study was carried out from August 2015 to March 2016. Prior to their inclusion, participants were given information, education and communication on malaria and HIV infection. Afterwards, an informed consent form was signed by each participant following explanation of objectives of the study to them. Approval of

parents or guardians of children was also sought. Investigative methods included a questionnaire approach, clinical and parasitological analyses.

A structured questionnaire was used to collect socio-demographic, clinic and biological data. Blood samples were collected and transported to the Laboratory of the hospital for parasitological analyses.

Questionnaire

A structured questionnaire was used to collect patients' information. Patients or their parents/guardians were interviewed for 10-15 minutes upon obtaining informed consent forms.

Blood collection

About four milliliters (4 mL) of blood samples were collected from each participant by venipuncture and transferred into EDTA tubes for all biological analyses (malaria diagnosis, CD4 cells count and full blood count).

Malaria diagnosis

Thick blood films were performed using the protocol previously used by Koanga and colleagues. [14] Briefly, thick smears that were air-dried for 30 minutes, was stained with 10% Giemsa for 20 minutes. Slides were air-dried and stored not more than one day until microscopic examination. Microscopy was used for identification of malaria parasites by a skilled microscopist. Thick blood films were considered positive when asexual forms (trophozoites and schizonts) and or gametocytes were present in the blood film. Slides were declared negative after observing at least 100 high power fields without detecting any parasites. Thick smears-based results were categorized as valid (positive or negative slides) and invalid (not read slides) as previously described elsewhere. [14]

Complete blood count

Complete blood count was performed using an automated hematological analyzer Hema Screen18 (Hospitex Diagnostics, Sesto Fiorentino, Florence, Italy). Parameters of interest were hemoglobin, haematocrit, white blood cells and platelets and their normative values are presented as follows: Hemoglobin (Male: 12.5-16 mg/dL; Female: 12-16 mg/dL), Haematocrit (Male: 37.5- 48 %; Female: 37 – 45%), WBC (4 – 10 x 10^3/µL) and Platelets (150 – 400 x 10^3/µL).

Viral load

Viral load was determined using Abbott Realtime HIV-1 system which was used for extraction, preparation and amplification of viral RNA. This system allows determining viral loads ranging between 40 and 10, 000,000 copies/mL. Briefly, 4 mL of venous blood was centrifuged at 3000 rpm for 3 to 5 minutes and viral RNA extracted from obtained plasma. Results were expressed as number of copies of RNA per milliliters (copies/mL). Good clinical practices were respected during this activity.

CD4 cells count

Flow cytometer CyFlow® (Partec Görlitz, Germany) was used for counting these immune cells in accordance to the manufacturer's instructions. [15] Results were grouped into four categories namely < 200; 200-350; 350-500 and > 500 cells/µL.

Ethical considerations

An ethical clearance was obtained from the institutional review board (IRB) of the University of Douala (N° CEI-UD/273/10/2015/T). Administrative clearance was also obtained from the officials of the District hospital of Deido. Participation in the study was strictly voluntary and patients were free to decline answering any question or totally withdraw if they so wished at any time. Only individuals who signed an informed consent form for their participation were enrolled. Patients diagnosed with malaria were treated with Artesunate-Amodiaquine as first line treatment regimen used in Cameroon.

Statistical analysis

Data were keyed in Excel spreadsheet and statistical analyses performed with

Graphpad Prism version 5.01 for Windows. Data were depicted in table as mean ± standard deviation (SD) or percentages for quantitative and qualitative variables respectively. Unpaired Student's test was used to compare mean values between two groups. Chi-square test (χ^2) or Fisher's exact probability were used to compare proportions. *P-value* less than 0.05 were considered significant.

Results

Baseline characteristics of the participants

Females accounted for 74.3% of the participants. The mean age was 39.49 ± 11.17 years old with a predominance of patients aged 20-49 years old (79.7%) who were followed by those older than 49 years (18.5%) and younger than 19 years old (1.8%). Mean CD4 count of 427 ± 257 cells/µL was found in patients with extremes values as 6 and 1369 cells/ µL. 122 (16.9%) patients had CD4 below 200 cells/µL, 192 (26.6%) between 200 and 350 cells/µL, 171 (23.7%) between 200 and 350 cells/µL and 238 (32.9%) had CD4 > 500 cells/µL (P-value < 0.0001).

Malaria prevalence

Blood thick smears revealed 16.7% (121/723; 95%CI: 14.2%-19.6%) were infected with malaria parasites. Malaria prevalence was higher in females (12.9%) and patients older than 49 years old (13.4%) although no statistically significant difference (P-value > 0.05) has been found as depicted in Table 1.

Table 1: Malaria prevalence with respect to gender, age and CD4 cells counts

Variables	Total	Positive§ (%)	P-value
Gender			
Female	541	70 (12.9)	0.6220
Male	182	21 (11.5)	
Age (years)			
≤ 19	13	0 (0)	0.3750
[20 - 50[	576	73 (12.7)	
≥ 50	134	18 (13.4)	
CD4 count (cells/µL)			
< 200	122	29 (23.8)	0.0991
200 - 350	192	32 (20.0)	
350 - 500	171	22 (12.9)	
> 500	238	38 (15.9)	

Data are presented as frequency (percentage). Independent chi square was used to compare proportions. P-value < 0.05 was considered as significant. §: malaria prevalence was calculated based on the gold standard (Giemsa-stained blood films).

Effect of malaria infection on CD4 blood count

As depicted in Figure 2, mean CD4 count was slightly higher in malaria uninfected patients compared to their infected counterparts (432.6 ± 249.2

cells/µL versus 400.7 ± 262.7 cells/µL respectively) although no statistically significant difference has been found (Student's test p-value = 0.2042).

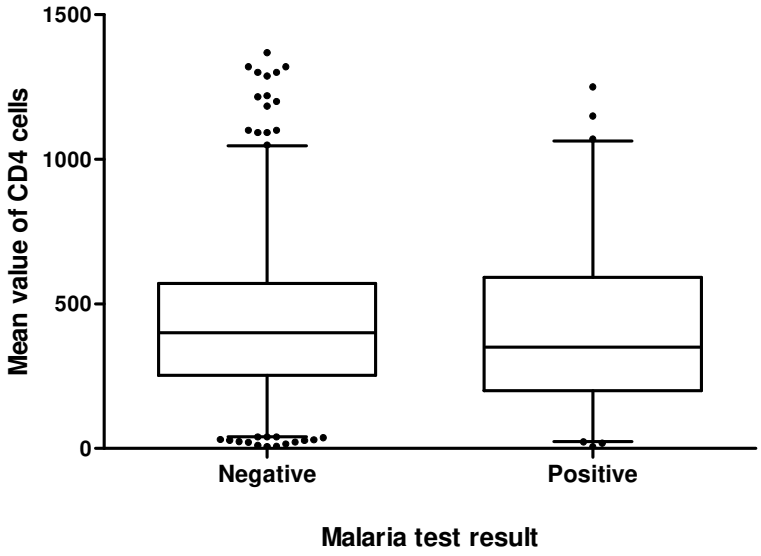

Figure 2: Association between malaria infection and CD4 cells count. Outliers are represented as dots.

Impact of malaria on hematological profile of the participants

Mean values of hemoglobin and haematocrit were significantly (p-value < 0.0001) lower in malaria infected patients. Indeed, hemoglobin was of 12.17 ± 1.82 mg/dL and 11.05 ± 2.31 mg/dL in malaria-related negative and positive respectively patients as presented in Table 2. Furthermore, the fraction of participants having low levels of hemoglobin (anemia) was higher in malaria infected participants compared to their malaria parasites uninfected counterparts (64.46% versus 44.19%, p-value < 0.0001). This trend was also observed when haematocrit has been investigated (82.64% versus 73.42%, p-value < 0.0001) (Table 3).

Table 2: Mean values of blood parameters with respect to malaria diagnosis

Blood parameters	**Negative (n = 602)**	**Positive (n = 121)**	**P-value**
Hemoglobin (mg/dL)	12.17 ± 1.82	11.05 ± 2.31	< 0.0001*
Haematocrit (%)	34.81 ± 5.01	31.93 ± 6.12	< 0.0001*
White blood cells (x 10^3/µL)	4.07 ± 1.46	4.18 ± 1.75	0.4455
Platelets (x 10^3/µL)	318.32 ± 85.88	304.82 ± 103.71	0.1286
CD4 (cells/µL)	432.60 ± 249.23	400.75 ± 262.74	0.2042

Data are presented as mean ± standard deviation; Unpaired Student's t test was used to compare groups; *: significant

Table 3: Variation of blood parameters with respect to malaria diagnosis and threshold

Hematological parameters	Categories	Negative (n=602)	Positive (n=121)	P-value
Hemoglobin (mg/dL)	Low (n = 344)	266 (44.19%)	78 (64.46%)	< 0.0001*
	Normal (n = 379)	336 (55.81%)	43 (35.54%)	
Haematocrit (%)	Low (n = 542)	442 (73.42%)	100 (82.64%)	0.0380*
	Normal (n = 181)	160 (26.58%)	17 (17.36%)	
Platelets (x 10^3/L)	Low (n = 16)	10 (1.91%)	6 (4.96%)	0.0795
	Normal (n = 652)	546 (90.69%)	106 (87.60%)	
	Elevated (n = 55)	46 (7.44%)	9 (7.44%)	
CD4 count (cells/µL)	<200	93 (15.45)	29 (23.96)	0.0991
	200-350	160 (26.58)	32 (26.45)	
	350-500	149 (24.75)	22 (18.18)	
	> 500	200 (33.22)	38 (31.41)	

Data are presented as frequency (percentage). Independent chi square was used to compare proportions. *: significant.

Effect of malaria on blood parameters with regard to gender

As depicted in Table 4, mean value of hemoglobin were significantly higher in males without regard to malaria infection (13.16 ± 1.90 mg/dL versus 11.84 ± 1.67 mg/dL and 12.49 ± 2.50 mg/dL versus 10.60 ± 2.06 mg/dL in malaria uninfected and infected patients respectively). A similar pattern was recorded for haematocrit.

Table 4: Effect of malaria infection on blood parameters with respect to gender

	Negative		Positive	
Parameters	**Female**	**Male**	**Female**	**Male**
Hemoglobin (mg/dL)	$11.84 \pm 1.67^{b\neq}$	$13.16 \pm 1.90^{a\neq}$	$10.60 \pm 2.06^{b\#}$	$12.49 \pm 2.50^{a\neq}$
Haematocrit (%)	$33.74 \pm 4.48^{b\neq}$	$37.96 \pm 5.15^{a\neq}$	$30.69 \pm 5.56^{b\#}$	$35.86 \pm 6.26^{a\neq}$
White blood cells (x 10^3/µL)	$4.00 \pm 1.47^{a\neq}$	$4.26 \pm 1.40^{a\neq}$	$4.14 \pm 1.81^{a\neq}$	$4.31 \pm 1.56^{a\neq}$
Platelets (x 10^3/µL)	$317.90 \pm 86.80^{a\neq}$	$319.57 \pm 83.40^{a\neq}$	$303.73 \pm 105.75^{a\neq}$	$308.28 \pm 98.65^{a\neq}$

Data are presented as mean ± standard deviation (SD). Two types of pairwise comparisons were used. The former consisted in comparison of the parameters between male and females with regard to malaria diagnosis result (negative or positive). Thus, values of the same line having the same letter were not statistically significant. The latter consisted in comparison of the parameters between uninfected and infected patients with respect to gender (male or female). Thus, values of the same column having the same symbol were not statistically significant. ANOVA, Mann Whitney and Kruskall Wallis tests were used to perform pairwise comparisons. Significance was set at P-value < 0.05.

Effect of malaria infection on blood parameters with respect to age

Mean values of haematocrit were significantly increasing with respect to age group irrespective of malaria infection as presented in Table 5. The same pattern was observed for hemoglobin in malaria uninfected patients only. Furthermore, haematocrit was significantly lower in patients aged 20-49 years old and malaria infected than their counterparts of same age group but uninfected with malaria parasite (Table 5).

Table 5: Effect of malaria infection on blood parameters with respect to age group

	Negative				**Positive**		
Parameters	**[0 - 19]**	**[20 - 49]**	**≥ 50**		**[0 - 19]**	**[20 - 49]**	**≥ 50**
Hemoglobin (mg/dL)	$10.65 \pm 2.05^{a\neq}$	$12.13 \pm 1.77^{b\neq}$	$12.50 \pm 1.96^{b\neq}$		$10.65 \pm 2.48^{a\neq}$	$10.87 \pm 2.32^{a\neq}$	$11.72 \pm 2.22^{a\neq}$
Haematocrit (%)	$32.68 \pm 3.52^{a\neq}$	$34.74 \pm 5.10^{b\neq}$	$35.36 \pm 4.61^{b\neq}$		$31.27 \pm 7.86^{ab\neq}$	$31.27 \pm 6.50^{a\#}$	$34.32 \pm 6.10^{b\neq}$
White blood cells (x $10^3/\mu L$)	$5.31 \pm 2.01^{a\neq}$	$4.01 \pm 1.43^{b\neq}$	$4.19 \pm 1.46^{b\neq}$		$4.00 \pm 1.13^{a\neq}$	$4.15 \pm 1.77^{a\neq}$	$4.29 \pm 1.76^{a\neq}$
Platelets (x $10^3/\mu L$)	$313.36 \pm 69.45^{a\neq}$	$319.20 \pm 86.51^{b\neq}$	$314.91 \pm 85.13^{b\neq}$		$364.00 \pm 217.79^{a\neq}$	$306.48 \pm 13.85^{a\neq}$	$294.31 \pm 98.14^{a\neq}$

Data are presented as mean ± standard deviation (SD). Two types of pairwise comparisons were used. The former consisted in comparison of the parameters between the three age groups with regard to malaria diagnosis result (negative or positive). Thus, values of the same line having the same letter were not statistically significant. The latter consisted in comparison of the parameters between uninfected and infected patients with respect to the same age group. Thus, values of the same column having the same symbol were not statistically significant. ANOVA, Mann Whitney and Kruskall Wallis tests were used to perform pairwise comparisons. Significance was set at P-value < 0.05.

Viral load and malaria prevalence with respect to gender and age

As summarized in Table 6, viral loads were significantly (P-value < 0.0001) higher in infected males compared to their uninfected counterparts (65195.20 ± 978.04 versus 540 ± 91.24 copies/µL). In addition, viral loads were significantly higher in males compared to females in infected patients group only (P-value = 0.02026). Conversely, this relation was inverted in uninfected patients (P-value = 0.00166). As to age groups, viral loads were significantly higher (P-value < 0.0001) in malaria infected patients aged over 49 years old (Table 6).

Table 6: Effect of malaria infection on viral load with respect to gender and age

		Malaria diagnosis		
Variables	**Categories**	**Negative**	**Positive**	***P-value***
Gender	Female	130403.16 ± 470.98	12217.79 ± 661.14	*0.0751*
	Male	540 ± 91.24	65195.20 ± 978.04	*< 0.0001*
	P-value	*0.00166*	*0.02026*	
Age (Years)	[0 - 19]	/	20924 ± 144.19	Not available
	[20 - 49]	146053 ± 3613.19	13725.45 ± 43.04	*< 0.0001*
	> 49	44 ± 0.00	46445.87 ± 263.60	*< 0.0001*
	P-value	*0.4921*	*0.7111*	

Data are presented as mean ± standard deviation (SD). ANOVA, Mann Whitney and Kruskall Wallis tests were used to perform pairwise comparisons. Significance was set at P-value < 0.05.

Factors associated with anemia in PLWHIV

All factors tested were found significantly (P-value < 0.0001) associated with the higher risk of anemia in persons living with HIV. For instance, the risk of anemia was twofold and about threefold higher in males (OR = 2.28; 95%CI = 1.58 – 3.29) and malaria parasites infected people (OR = 2.85; 95%CI = 1.28 – 4.78) respectively. In addition, the risk of anemia was positively correlated with CD4 counts and age (Table 7).

Table 7: Factors associated with anemia in PLWHIV

Factors	**Categories**	**Raw OR (95%CI)**	**P-value**	**Adjusted OR (95%CI)**	**P-value**
Gender	Female	1		1	
	Male	2.34 (1.65 - 3.31)	< 0.0001	2.28 (1.58 - 3.29)	< 0.0001
Age (years)	≤ 19	1		1	
	[20 - 50[	3.80 (1.04 - 13.97)	0.0441	4.07 (1.04 - 16.35)	0.0478
	≥ 50	3.54 (0.93 - 13.43)	0.0633	4.08 (0.98 - 16.98)	0.0529
CD4 count (cells/µL)	< 200	1		1	

	200 - 350	2.94 (1.79 - 4.82)	< 0.0001	2.84 (1.71 - 4.74)	< 0.0001
	350 - 500	4.13 (2.49 - 6.88)	< 0.0001	3.77 (2.24 - 6.35)	< 0.0001
	> 500	5.19 (3.19 - 8.43)	< 0.0001	5.05 (3.06 - 8.34)	< 0.0001
Malaria infection#	Uninfected	1		1	
	Infected	2.43 (1.29 - 4.65)	< 0.0001	2.85 (1.28 - 4.78)	< 0.0001

Univariate and multivariate regression models were used to perform this association analysis. PLWVIH = Person living with human immunodeficiency virus; OR = Odds ratio, 95%CI = Confidence interval with 95%, P-value < 0.05 are considered statistically significant. Hemoglobin was used for the diagnosis of anemia.

Discussion

Most of participants were females. This result is in line with previous reports that outlined a "feminization" of HIV infection especially in Cameroon. Indeed, this finding previously reported in Cameroon through a nationwide health study [13] and some authors in the country. [16, 17]

The malaria prevalence was 16.7% in the participants. This value is lower than that found by many reports. [18-20] These authors found 31.76%, 24.0% and 74.3% respectively. Conversely, our value is higher than the 11.75% found in Ghana. [21] Differences in sample size, study design, study period, study area along with genetic background and behavioral patterns of individuals can explained the discrepancies observed. These factors are well known modulate the malaria epidemiology in general population along with HIV-infected population. [22-24]

Hemoglobin and haematocrit were significantly lower in malaria infected people on average (p-value < 0.0001). Furthermore, the fraction of participants having low levels of hemoglobin was higher in malaria infected participants compared to their malaria parasites uninfected counterparts (64.46% versus 44.19%, p-value < 0.0001). This pattern was also observed for haematocrit (82.64% versus 73.42%, p-value < 0.0001). These findings outline that the both pathogens can induce anemia each. Physio pathological mechanisms associated with anemia elicited by the virus consist of I) induction of gastric disorders which are consequently responsible for malabsorption of nutrients as Vitamin B12 and iron that essential for hemoglobin production, ii) infiltration of the virus in bone marrow responsible for production of all cells of the body especially blood cells; and iii) HAART treatment especially Tenofovir is known induce deleterious effects such as anemia in the body. [25] The anemia-induced physiopathology of malaria parasites mainly involves the destruction of red blood cells following the liberation of newly produced merozoites from these blood cells. This need hemoglobin for their nutrition and thus the lifecycle is maintained. [26] These results also mean that deleterious effects on hemoglobin and red blood cells are more important in co-infected individuals.

Besides, mean values of hemoglobin and haematocrit were significantly higher in males than females irrespective of malaria infection. This could be explained by the fact females periodically face blood lost at the time of their period. In addition, statistically significant difference was found for these both blood parameters in females only.

Indeed, hemoglobin and haematocrit were lower in malaria infected females compared to their uninfected counterparts. None difference was found to be statistically significant. These results strengthen our assumption about a greater susceptibility to malaria infection in females.

Mean values of haematocrit were significantly increasing with respect to age group irrespective of malaria infection. The same pattern was observed for hemoglobin in malaria uninfected patients only. Furthermore, haematocrit was significantly lower in patients aged 20-49 years old and malaria infected than their counterparts of same age group but uninfected with malaria parasite. These results outline the confounding effect of age on relationship between malaria infection and blood parameters especially hemoglobin and haematocrit.

We have reported a higher proportion of thrombopenia in co-infected people (4.96% versus 1.91%) even though no significant difference was found (P-value = 0.0795). Platelets play an important role wound healing and therefore the risk of hemorrhages might be higher in HIV-infected people co-infected with malaria parasites. This assumption is worth investigating in depth in further studies.

Besides, the mean CD4 count was slightly higher in malaria uninfected patients compared to their infected counterparts (432.6 ± 249.2 cells/µL versus 400.7 ± 262.7 cells/µL respectively, Student's test P-value = 0.2042). The role of these cells as helpers for immune response acting in its development, regulation and effectiveness outline the need for treating all cases of malaria in PLWHIV given the increased risk for opportunistic diseases as tuberculosis, toxoplasmosis and pneumonia in these patients.

The inclusion of malaria diagnosis in PLWHIV during their management seems to be selected for because we observed a few participants having detectable viral load. Most of them were malaria parasites infected (P-value < 0.0001). This finding is in line with many reports on the topic. Indeed, many stidues outined viral load was found increases in malaria infected individuals a few weeks after an effective antimalarial treatment. This increasing was found to be correlated with parasite density. Many mechanisms have been proposed to explain this relationship. In vitro studies assumed improved susceptibility to infection and viral replication due to malaria parasites. *Plasmodium falciparum* can increase expression of CCR5, a membrane co-receptor crucial to allow the penetration of the virus into its host cells. Besides, malaria parasites can elicit the production of tumor necrosis factor alpha (TNF-α) which may boost the ability of infected cells to produce more viral particles. Furthermore, malaria pigment so called hemozoin is responsible for increasing in the production of TNF-α and therefore would be also involved in an enhanced production of viral particles. [4, 7] Urban and colleagues reported malaria infection was found associated with functional impairing of dendritic cells. These immune cells are important antigen presenting cells (APCs) which are cells a heterogeneous group of immune cells that mediate the cellular immune response by processing and presenting antigens for recognition by certain lymphocytes such as T cells. Thus, their alteration might negatively have affected the immune response against HIV and create a favorable environment for its replication and survival. [6] To be noted, studies reported contradictory results on relationship between viral load and malaria infection. [5] Thus, this relationship is may be more complex than expected and further studies are needed to enlighten the current state of the art about the topic.

To be noted, viral loads were significantly higher in malaria infected males compared to their female counterparts (P-value = 0.02026). Conversely, the pattern was inverted in malaria uninfected patients (P-value = 0.00166). these findings tend to mean that malaria infection increase the risk of viral replication in male and that once malaria parasites cleared from host, females become more at risk. We think that sample siez and factors such as those related to behavior, genetic background and treatment regimen could be explain this finding. Further studies are needed to confirm or infirm this assumption.

Conclusion

This study pointed out malaria-induced impairment in blood parameters, especially hemoglobin and haematocrit, of patients along with boosting in replicative process of the virus proxied by increased viral loads. Clinicians should be routinely included diagnosis and treatment of malaria infection during management of HIV infected patients. This will probably improve the prognosis of these patients.

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