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Hematological Changes in Patients Infected by *Plasmodium Falciparum* Versus Patients Infected by *Plasmodium Vivax*

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Abstract

Malaria is a major public health problem in tropical and subtropical countries. *P. falciparum* and *P. vivax* are the two major species of malaria infecting humans. Although emphasis on *P. falciparum* is appropriate, the burden of vivax malaria should be given due attention as almost 40% of the world population are at risk of vivax malaria. This study was aimed to assess the hematological changes in patients with *P. falciparum* and patients with *P. viva* malaria. A total of 264 participants (173 *P. falciparum* and 91 *P. vivax*) were enrolled in this study, all of them were randomly selected from Elnihoud Teaching Hospital, Elnihoud Locality, West Kordufan State, Sudan. Questionnaire was filled for every participant and thick and thin blood films for malaria were prepared and stained by giemsa stain and the CBC was done by sysmex automated hematological analyzer. The mean Hb level for *P. vivax* infected patients was significantly lower than that for *P. falciparum* infected patients (p-value = 0.037). Low TWBCs count was significantly higher among *P. vivax* infected patients compared to those with *P. falciparum* infection (p-value = 0.018). Low MCH was significantly higher among *P. vivax* infected patients compared to those with *P. falciparum* infection (p-value = 0.019). Hb was positively and significantly correlated with MCV and MCH (p-value < 0.0001 for both). Both *P. falciparum* and *P. vivax* can cause hematological changes. Leucopenia was significantly predominant among *P. falciparum* infected patients and hypochromic anemia was significant predominant among *P. vivax* infected patients.

Keywords

Falciparum Malaria, Thrombocytopenia, Leucopenia, Hypochromic Anemia

1. Introduction

Despite effective control measures, malaria remains a major public health concern, with 212 million new malaria cases and an estimated 429,000 malaria-related deaths globally, with sub-Saharan Africa accounting for approximately 90% of malaria cases and deaths [1]. Malaria is a major public health problem in endemic countries including Sudan, where about 75% of populations are at risk [2]. According to the 2015 annual estimate in Sudan, there were 586,827 confirmed cases and 3500 deaths due to malaria, and malaria represents 8.7% of total outpatient attendance and 12.2% of hospital admissions [3].

In 2016, more than 200 million cases of malaria were attributable to *Plasmodium falciparum* (*P. falciparum*) of which approximately 8% occurred in countries co-endemic for *P. falciparum* and *Plasmodium vivax* (*P. vivax*) [4]. Hence, in many co-endemic malarious areas, the most commonly transmitted plasmodium parasite after falciparum malaria is likely to be P vivax [5]. *P. falciparum* is responsible for more than 95% of malaria cases in Sudan. However, an increase in

P. vivax cases has been noticed in the last years. The primary vector is *Anopheles arabiensis* and is widely distributed in Sudan although An. *funestus* has been reported in some parts of Sudan [6].

The primary target of human Plasmodium species is the red blood cell the range of peripheral parasitemia in *P. vivax* infections is lower than in symptomatic *P. falciparum* malaria and parasitemia > 2% is rare [7]. Although parasitemia is typically lower in vivax compared with falciparum infections, the absolute number of red blood cells removed from circulation, and hence the degree of anemia resulting from infection by the two species, is often similar [8]. This is because in *P. vivax* malaria, approximately 34 non-infected cells are cleared for every one infected cell whereas in *P. falciparum* malaria, this ratio is closer to 8 to 1 [9]. Plasmodium vivax-infected red blood cells are minimally adherent and are more deformable than *P. falciparum* infected erythrocytes resulting in relatively little red blood cell sequestration in the microvasculature and marrow sinuses and passage of a greater proportion of red cells through the spleen and other reticuloendothelial organs [10].

Hematological changes are some of the most common complications in malaria and they play a major role in malaria pathology. These changes involve the major cell lines such as red blood cells, leucocytes and thrombocytes [11]. This study aimed to evaluate the hematological changes among *P. falciparum* and *P. vivax* infected patients.

2. Material and Method

This was cross sectional descriptive study carried out in Elnihoud Teaching Hospital, Elnihoud Locality, West Kordufan State, Sudan. From October 2018 to January 2019. Elnihoud Teaching Hospital is tertiary referring hospital receiving approximately about 15,000 patients suffering from Malaria annually. Total of 264 patients were enrolled in this study, 173 were positive *P. falciparum* and 91 were positive *P. vivax*. Institutional research and ethics approval was obtained before commencement of the study. All participants provide informed consent. Patients suffering from hematological disease, liver or renal impairment and different infection producing sepsis, dengue infection, viral hepatitis, leptospirosis during this period were excluded.

Blood samples were obtained for detection of malaria using giemsa stained thick and thin blood films and stander diagnostic (SD) ICT for malaria antibodies, the complete blood count (CBC) was analyzed by automated hematological analyzer (sysmex XP-300), also the peripheral blood film is stained by leishman's stain and screened by expert hematologist. The data were analyzed by SPSS program version 20.

3. Results

Figure 1 shows the ages groups of participants. Children (17.8%), adults (70.8%) and overages (11.4%). From the total of study group (65.6%) were *P. falciparum* infected patients while (34.4%) were *P. vivax* infected patients. Sex for study group was shown in figure 2. Males (56.8%) and females (43.2%). (65.5%) were P. falciparum infected patients while (34.5%%) were *P. vivax* infected patients.

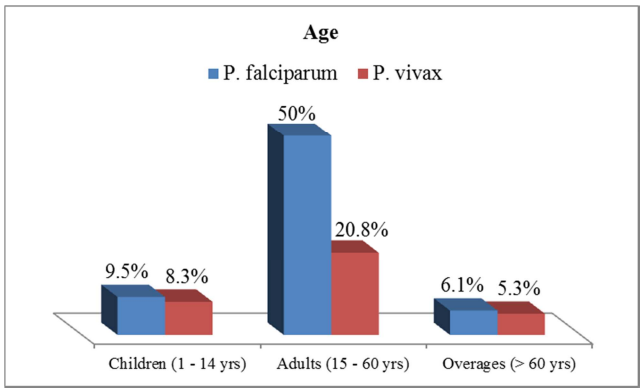

Figure 1. *Ages groups of the study group.*

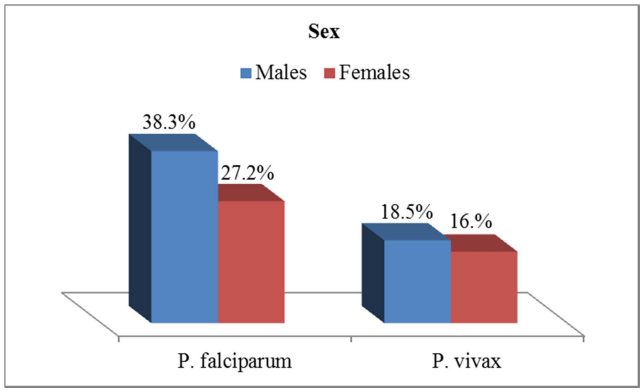

Figure 2. *Sex for study group.*

Table 1 shows the hematological parameters of study group. The mean Hb level for *P. vivax* infected patients was significantly lower than that for *P. falciparum* infected patients (*p*-value = 0.037). For TWBCs and PLT, their counts mean were slightly decreased among *P. falciparum* infected patients compared to P. vivax infected patients but with no significant values (p-values = 0.185 and 0.677 respectively). The mean levels of MCV and MCH were slightly lower among *P. vivax* infected patients versus *P. falciparum* infected patients but there were no significant differences (p-values = 0.349 and 0.245 respectively).

Table 2 reveals the comparison of some hematological parameters of study group. Low Hb level (20.1%), normal Hb level (79.5%) and high Hb level (0.4%) and there was no significant difference between *P. falciparum* infected patients and those infected by *P. vivax* (*p*-value = 0.144). For TWBCs, low count (9.1%), normal count (81.8%) and high count (9.1%). Low TWBCs count was significantly higher among *P. falciparum* infected patients compared to those with *P. vivax* infection (*p*-value = 0.018). Regarding PLT, low count (16.3%), normal count (81.8%) and high count (1.9%) and there was no significant difference between *P. falciparum* infected patients and *P. vivax* infected patients. Concerning MCV, low (31.8%), normal (67.4%) and high (0.8%) and there

was no significant difference between *P. falciparum* infected patients and *P. vivax* infected patients. For MCH, low (21.6%), normal (75%) and high (3.4%). Low MCH was significantly higher among *P. vivax* infected patients compared to those with *P. falciparum* infection (*p*-value = 0.019).

Correlation of Hb with TWBCs, PLT, MCV and MCH was shown in table 3. Hb was negatively but not significantly correlated with TWBCs count and positively but not significantly correlated with PLT (*p*-values = 0.390 and 0.884 respectively). Hb was positively and significantly correlated with MCV and MCH (p-value = < 0.0001 for both).

Table 1. *Hematological parameters of study groups presented as mean ± SEM.*

Parameter	P. falciparum (N = 173)	P. vivax (91)	*p*-value
Hb	13.90 ± 0.18	13.22 ± 0.28	0.037
PLT	242.10 ± 8.04	247.60 ± 9.87	0.677
TWBCs	6.91 ± 0.25	7.46 ± 0.29	0.185
MCV	81.33 ± 0.43	80.56 ± 0.78	0.349
MCH	28.20 ± 0.21	27.73 ± 0.40	0.245

Table 2. *Comparison of some hematological parameters of study groups.*

Character	P. falciparum	P. vivax	Total	*p*-value
Hb				
Low	29 (16.8%)	24 (26.4%)	53 (20.1%)	
Normal	143 (82.7%)	67 (73.6%)	210 (79.5%)	0.144
High	1 (0.5%)	0	1 (0.4%)	
Total	173 (100%)	91 (100%)	264 (100%)	
PLT				
Low	30 (17.3%)	13 (14.3%)	43 (16.3%)	
Normal	139 (80.4%)	77 (84.6%)	216 (81.8%)	0.626
High	4 (2.3%)	1 (1.1%)	5 (1.9%)	
Total	173 (100%)	91 (100%)	264 (100%)	
TWBCs				
Low	22 (12.7%)	2 (2.2%)	24 (9.1%)	
Normal	136 (78.6%)	80 (87.9%)	216 (81.8%)	0.018
High	15 (8.7%)	9 (9.9%)	24 (9.1%)	
Total	173 (100%)	91 (100%)	264 (100%)	
MCV				
Low	51 (29.5%)	33 (36.3%)	84 (31.8%)	
Normal	121 (69.9%)	57 (62.6%)	178 (67.4%)	0.461
High	1 (0.6%)	1 (1.1%)	2 (0.8%)	
Total	173 (100%)	91 (100%)	264 (100%)	
MCH				
Low	32 (18.5%)	25 (27.5%)	57 (21.6%)	
Normal	138 (79.8%)	60 (65.9%)	198 (75%)	0.019
High	3 (1.7%)	6 (6.6%)	9 (3.4%)	
Total	173 (100%)	91 (100%)	264 (100%)	

Table 3. *Correlation of Hb with TWBCs, PLT, MCV and MCH.*

Parameter	Correlation coefficient	*p*-value
TWBCs	- 0.053	0.390
PLT	0.009	0.884
MCV	0.334	< 0.0001
MCH	0.521	< 0.0001

4. Discussion

Most of infected patients in the current study were adults males. The present study revealed that there was significant decrease in mean Hb level among *P. vivax* infected patients compared to patients infected by *P. falciparum*. Consistently, study carried out by Gurjeet *et al*. stated similar finding [12]. The significant decrease in mean Hb level exposed by the this study among *P. vivax* infected patients might indicates that *P. viva* has more predominant effect than *P. falciparum*.

The present study disclosed slight decrease in mean PLT count among *P. falciparum* infected patients compared to *P. vivax* infected patients but with no significant value. The researchers Gurjeet *et al*. reported similar finding, *P. falciparum* showed statistically significant low PLT count as compared to *P. vivax* [12]. The current result disagree with previous study carried out by Ameekumari *et al*. who reported contrasted finding [13]. Slight decrease in mean TWBCs count among *P. falciparum* infected patients compared to *P. vivax* infected patients but with no significant value. Similarly, Gurjeet *et al*. reported significant decrease in mean TWBCs count in *P. falciparum* infected patients compared to those with *P. vivax* infection [12]. Study conducted by Jason *et al*. revealed a significant decrease in mean TWBCs count in *P. vivax* infected patients than *P. falciparum* infected patients [14].

The current study exhibits slight decrease in MCV mean among *P. vivax* infected patients versus *P. falciparum* infected patients but there was no significant difference. Similarly, Pradhan *et al*. stated no significant decrease in MCV mean among patients suffering *P. vivax* infection compared to patients with *P. falciparum* [15].

Slight decrease in MCH mean among *P. vivax* infected patients versus *P. falciparum* infected patients but there was no significant difference as it is disclosed by this study. In contrast Pradhan *et al*. reported no difference in MCH mean between *P. falciparum* and *P. vivax* infected patients [15].

The present study shows that patients infected by *P. vivax* have anemia more than *P. falciparum* infected patients but with no significant variation. This finding was inconsistent with finding reported by Shraddha *et al*. and Ameekumari *et al*. who stated that anemia was significantly higher among *P. falciparum* infected patients compared to patients infected by *P. vivax* [13, 16]. Thrombocytopenia was higher among *P. vivax* infected patients compared to patients infected by *P. falciparum* but with no significant value [16]. In contrast, this study revealed that patients infected by *P. falciparum* have thrombocytopenia more than *P. vivax* infected patients but without significant variation. Leucopenia was significantly higher among *P. falciparum* infected patients compared to those with *P. vivax* infection. Contrary, Shraddha *et al*. reported an increase leucopenia with no significant value among *P. vivax* infected patients versus those infected by *P. falciparum* [16].

Previous study carried out by Shraddha *et al*. and disclosed an increase in microcytic anemia with no significant variation among *P. falciparum* infected patients versus those with *P. vivax* infection [16]. The current study exhibits an increase in microcytic anemia among *P. vivax* infected patients compared to *P. falciparum* infected patients but not significant. Hypochromic anemia was significantly higher among *P. vivax* infected patients compared to those with *P. falciparum* infection, and previous study supports or disagree this result. Hb was positively and significantly correlated with MCV and MCH.

5. Conclusion

The study concludes that both *P. falciparum* and *P. vivax* can cause hematological changes. *P. vivax* mostly affects Hb level, MCV and MCH, while *P. falciparum* mostly affects PLT and TWBCs counts. Leucopenia was significantly predominant among *P. falciparum* infected patients and hypochromic anemia was significant predominant among *P. vivax* infected patients.

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