Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2297 – 2309
Received 05 March 2021; Accepted 01 April 2021.

Hematological profile in smear positive malaria cases: A cross sectional study

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Abstract

Background: Malaria is a global parasitic infection, being one of the leading cause of morbidity as well as mortality. Changes in the hematological profile are considered a hallmark of malaria, as these values increase the clinical suspicion. It also helps in initiating specific therapy even in the absence of a positive smear report. Objectives: (a) To detect the most common species of malaria in the region (b) Determine the various hematological changes seen in patients with malaria. (c) Compare the hematological changes among different species of plasmodium and (d) to find out the hematological changes that can help in diagnosis of malaria. Methodology: A total of 100 adult patients with a positive smear for malaria were included in this study. It was an institution based cross-sectional study. Malaria was diagnosed by microscopic examination of thick and thin smear. Hematological values were determined from the blood sample of the patient by using an automated hematology analyzer.Results: In this study of 100 patients, anemia was seen in 97 % of patients, thrombocytopenia in 95%, leucopenia in 42% and monocytosis in 19% cases. Mean RBC count, mean Hb level as well as hematocrit values were significantly lower among patients with P.falciparum infection compared to P.vivax cases. Leucopenia was more common with P. falciparum infection (P value of 0.009).Conclusion and Recommendation: Anemia and thrombocytopenia were the two most common hematological changes seen in malaria cases, followed by leucopenia and monocytosis. Patients with fever, having these hematological abnormalities should alert the clinician about the possibility of malaria and these cases should be managed for their hematological abnormalities in addition to the treatment for malaria.

Key Words: Malaria, Leucopenia, Plasmodium vivax, thrombocytopenia.

Introduction

Malaria (mala aria: “bad air”) is a portmanteau word from the 18th century, and is also known as ague, or swamp fever (1). It is a global parasitic infection, being one of the leading causes of morbidity as well as mortality with about half of the world population can be categorized as at risk (2). It is the 5th most common cause of death due to infections worldwide and the 2nd leading cause of death in Africa (3). World health organization (WHO) reported around 212 million malaria cases with estimated 490,000 deaths in 2015 globally (2). In Saudi Arabia, malaria is found mainly in the South Western region (4).Highest burden of malaria is seen in the Jazan district with 1.5 million people at risk of infection, major part being imported from Yemen (4). More than 40% of the world’s population is living in endemic areas with a prediction of 300-500 million cases and 1.5-2.7 million deaths annually (5).Malaria is caused by a protozoan parasite of genus Plasmodium with 5 species known to cause human infection, which includes Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale , Plasmodium malariae and Plasmodium knowlasi (3) . The major burden of the disease is caused by P.falciparum followed by P.vivax throughout the world (2). However, majority of cases in India are due to P.vivax (6).Malaria transmission occurs in nearly half of the world’s population including 100 countries from Africa, Asia, Middle East, Eastern Europe and

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2297 – 2309
Received 05 March 2021; Accepted 01 April 2021.

other parts of the world (7,8).Malaria transmission is seasonal and is more common during monsoon which falls from July to November (2). This seasonal incidence is because of the life span, population, and rate of survival of anopheles mosquito in these climatic conditions (2) .P.falciparum covers 85% of the cases globally and is the most pathogenic species, followed by P.vivax as the 2nd most common cause of malaria cases (3). However, in India, 60-65% of malaria cases are attributed to P.vivax followed by 30-35% due to P.falciparum infection(9, 10).Men have a higher prevalence of malaria as compared to women because of their increased exposure to malaria vector due to their outdoor activities (11, 12). Malaria effects people of all age groups. Adults in the age group of 30-45 are more often affected than children due to greater mobility and increased risk of exposure, though severity is higher in children because of the under-developed immune system compared to adults, and as well as due to more effective clearing of parasite in adults (13).

In tropical countries the clinical diagnosis of malaria is very difficult due to non-specific signs and symptoms which may overlap with other infections (6).

The various laboratory techniques available for diagnosis include:
a. Microscopic examination of thick and thin blood smear
b. Quantitative buffy Coat (QBC)
c. Molecular diagnostic methods
- Quantitative PCR(qPCR)
- Real time qPCR
- Droplet digital PCR(ddPCR)
- Loop mediated isothermal amplification(LAMP)

d. Rapid diagnostic tests (1).

Microscopic examination of thick and thin blood films stained with Giemsa stain is the most commonly used technique for the initial diagnosis of malaria and is considered the gold standard for malaria detection. This method allows a comparatively fast preparation and examination of the patient's blood (1). It is considered most suitable for malaria control as it is inexpensive, easily differentiates between malaria species, and quantifies parasites (14).The preparation of thick blood smear involves putting a blood drop obtained from patient's finger by pricking, on a glass slide, and diluting with water to cause hemolysis followed by staining with Giemsa's stain. This method allows only the visualization of leukocytes, platelets, and parasites. Whereas, in case of thin blood films, the patient's peripheral blood is spread on a glass slide in a manner similar to routine smears. The smears are then fixed with methanol, dried and stained with Giemsa's stain (1) . Thick blood smears help in detecting the presence or absence of the Plasmodium parasites and also to determine the parasitemia whereas thin blood smears are helpful in determining the type of Plasmodium species, and also the developmental stages present within the blood of the patient. The main advantage of thick and thin blood films is their fast preparation and examination of the patient's blood (15). Although trained microscope specialist is essential for this technique, and sensitivity and specificity varies in comparison with other techniques, it is inexpensive and reliable (15). Microscopy remains the reference standard and a better diagnostic tool for malaria diagnosis, with a high positivity value than rapid diagnostic tests (RDT) (16). Other recent advanced techniques for malaria diagnosis include microfluidic devices, Aptamer-mediated plasmodium-specific diagnosis of malaria, bloodless malaria diagnosis which involves examining bodily fluids and feces for parasite detection , Raman spectroscopy to identify plasmodium-infected erythrocytes via different parasite and host erythrocyte parameters and hemozoin-based detection of plasmodium parasites

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(1).

The objectives of this study include:
(a) To detect the most common species of malaria in the region.
(b) Determine the various hematological changes seen in patients with malaria.
(c) To compare the hematological changes among different species of plasmodium.
(d) To identify the hematological changes that can help in diagnosis of malaria.

Materials and Methods

The data for the study was collected from a medical college hospital from India over a period of 6 months. It was an institutional based cross-sectional study. Ethical clearance was obtained from the Ethical clearance committee of the institution. Informed consent was taken from the patients. The blood sample from the clinically suspected cases of malaria was collected and examined for the presence of malaria parasite on thick and thin smears.Patients with positive smears were separated and their hematological profile was recorded for the study.

Inclusion criteria: All adult patients with either thick or thin peripheral smear positive for malaria parasite were included.

Exclusion criteria: Patients who were on antimalarial drug based on clinical suspicion, those presenting with or positive for other infections and known cases of thrombocytopenia or platelet disorders were excluded

Data Analysis

The data analysis was done by using SPSS version 25.0. In order to determine the mean, standard deviation, and percentages of the various parameters used in the study, appropriate statistical tests were applied. Diagnosis of malaria was done by using peripheral smear examination as the gold standard. Kruskal –Wallis test, Chi square test and Wilcoxon sign rank test were used to analyze the continuous variables and a P value of <0.05 was considered as statistically significant.

Results

A total of 100 adult patients with a positive smear for malaria were included in this study. The number of male patients were 79(79%) whereas 21(21%) were female with a male to female ratio of 3.76:1. The mean age of the patients was 28 years (range from 13-75 yrs). Figure 1 shows the microscopic pictures of plasmodium vivax and plasmodium falciparum.P.vivax was the most common species found in 70 cases, followed by P.falciparum in 26 cases and mixed infection with P.vivax and P.falciparum was seen in 4 cases. No cases with P.ovale and P.malariae were noted.
Changes observed in the RBC parameters:
Anemia was seen in 97% of cases which includes 76 males and 21 females. The occurrence of anemia was equal among P.falciparum and P.vivax. However, it was more severe among patients with mixed infection with a mean Hb of 7.65 g/ dl. The mean hemoglobin for P.falciparum and P.vivax was 8.03g/dl and 9.72g/dl respectively. Showing a significant difference among different species (P value - 0.009).Anemia was more common among females with all female patients showing anemia with a hemoglobin level less than 12g/dl. RBC count was low in 79 cases (79%) with mean RBC count of 3.43x106/L among males and 2.89x106/L among females indicating hemolysis of RBCs resulting in normocytic normochromic anemia. Severity of hemolysis was more among patients with P.falciparum malaria with a mean RBC count of 2.99x 106/L as compared to a mean of 3.44 x106/L and 3.34x106/L among P.vivax and mixed infection respectively.Packed cell

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volume (PCV) was low in 67 cases and normal in 33 cases with a mean value of 28.25. This was significantly low among patients with P.falciparum infection compared to others (P value 0.018). Overall patients with normal and low MCV were 70 and 19 cases respectively, among the various species it was lowest with mixed infection cases. The values of MCH ranged from 13 to 38.5g/dl being lower in P.falciparum as compared to P.vivax cases. MCHC was normal in 42 and reduced in 54 cases respectively
(Table 1,2).

Changes observed in white blood cells counts and morphology:

In our study 56 cases presented with normal leucocyte count, 42 with leucopenia and leukocytosis was seen in 2 cases.There was variation in the WBC differential count. Neutrophil count was normal, low and high in 83, 7 and 10 cases respectively. Lymphocytopenia and lymphocytosis were seen in 19 and 11 cases, with 5 of them showing presence of atypical lymphocytes on peripheral smear. Eosinophilia was seen in 28 cases, eosinopenia in 29 cases and monocytosis in 19 cases.When hematological values were compared among malaria species, leucopenia, eosinopenia and monocytosis were more marked in cases with P.falciparum infection.

Table 1: Changes in the hematological profile in malaria infected patients

S.NO	**Hematological Parameters**	**Classification**	**Frequency of *P.vivax* (%)**	**Frequency of *P.falciparum* (%)**	**Frequency of mixed infection**	***p* value**
1	RBC count	NORMAL	16	4	1	0.712
		LOW	54	22	3	
		HIGH	-	-	-	
2	Hemoglobin	NORMAL	3	0	0	0.15
		LOW	67	26	4	
		HIGH	-	-	-	
3	Platelets	NORMAL	3	1	0	0.96
		LOW	66	25	4	
		HIGH	1	0	0	
4	TLC	NORMAL	39	14	3	0.009
		LOW	30	12	0	
		HIGH	1	0	1	
5	Neutrophils (%)	NORMAL	61	19	3	0.41
		LOW	4	3	0	
		HIGH	5	4	1	
6	Lymphocytes(%)	NORMAL	50	17	3	0.88
		LOW	13	5	1	
		HIGH	7	4	0	
7	Eosinophils(%)	NORMAL	32	10	1	0.23
		LOW	17	9	3	
		HIGH	21	7	0	
8	Monocytes (%)	NORMAL	55	14	3	0.13
		LOW	6	3	0	
		HIGH	9	9	1	
9	MCV	NORMAL	52	15	3	0.166
		LOW	9	9	1	
		HIGH	9	2	0	
10	MCH	NORMAL	45	14	2	0.702
		LOW	21	9	2	

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		HIGH	4	3	0	
11	MCHC	NORMAL	28	12	2	0.742
		LOW	38	14	2	
		HIGH	04	0	0	

Table 2: Species-wise changes in hematological profile in malaria infected patients

Parameter	**Species**	**Number**	**Mean**	**Std Deviation**	**P value**
Hb	PF	26	8.0269	2.44648	0.009
	PV	70	9.7214	2.61672	
	PF+PV	4	7.6500	1.27148	
	Total	100	9.1980	2.64262	
TLC	PF	26	4608.12	1776.795	0.0001
	PV	70	4860.87	2222.526	
	PF+PV	4	10302.50	8335.932	
	Total	100	5012.82	2745.096	
Neutrophils	PF	26	57.3885	16.35573	0.514
	PV	70	61.0686	12.82017	
	PF+PV	4	60.5500	14.47400	
	Total	100	60.0910	13.82228	
Lymphocytes	PF	26	31.9115	12.32374	0.385
	PV	70	28.3971	11.2834	
	PF+PV	4	26.7000	12.58809	
	Total	100	29.2430	11.62903	
Eosinophils	PF	26	3.8615	4.21417	0.4
	PV	70	4.5129	4.50989	
	PF+PV	4	1.6500	2.90345	
	Total	100	4.2290	4.39056	
Monocytes	PF	26	6.3308	6.13493	0.181
	PV	70	5.6271	4.85326	
	PF+PV	4	10.5000	3.93362	
	Total	100	6.0050	5.22829	
Basophils	PF	26	.5077	.80842	0.656
	PV	70	.3943	0.58058	
	PF+PV	4	.6000	0.761158	
	Total	100	.4320	0.64899	
PCV	PF	26	24.7231	7.62088	0.018
	PV	70	29.9290	8.35412	
	PF+PV	4	25.9250	2.25592	
	Total	100	28.4153	8.30143	
RBC	PF	26	2.9927	0.88098	0.095
	PV	70	3.4424	0.90505	
	PF+PV	4	3.3475	0.60539	
	Total	100	3.3217	0.9375	
MCV	PF	26	80.5808	18.14817	0.026
	PV	70	88.4371	11.39715	
	PF+PV	4	78.4000	16.65253	
	Total	100	85.9930	14.01261	
MCH	PF	26	26.342	5.7192	0.113
	PV	70	27.657	4.2598	
	PF+PV	4	23.025	7.4567	
	Total	100	27.130	4.8613	
MCHC	PF	26	31.3731	3.77747	0.419
	PV	70	30.9086	2.66750	
	PF+PV	4	29.2750	3.43062	
	Total	100	30.9640	3.01342	
	PF	26	70423.08	42795.489	

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2297 – 2309
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Platelets	PV	70	74228.57	74176.674	0.482
	PF+PV	4	33000.00	26356.530	
	Total	100	71590.00	66210.575	

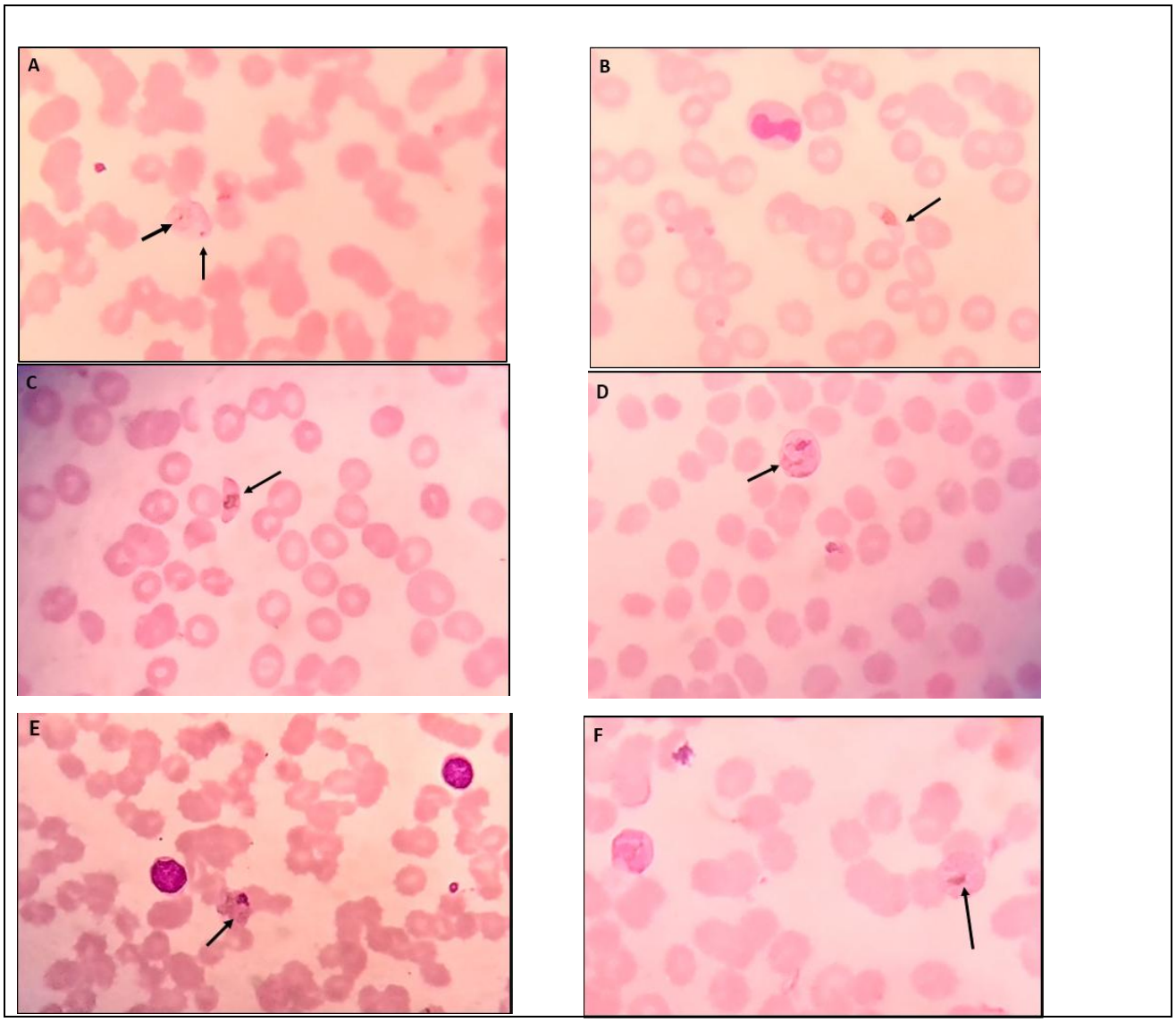

Figure 1: Different stages of *Plasmodium vivax* and *plasmodium falciparum* on smear (arrows) A.PF trophozoites; B & C.PF Gametocyte; D&F. PV Gametocyte; E. PV amoeboid form. (Giemsa.Magnification:100x)

Changes observed in platelet count:

The incidence of thrombocytopenia was 95% in our study and only 4% had normal platelet count, with one case of thrombocytosis. Species-wise, (25/26) of P.falciparum patients and (66/76) of P.vivax patients had thrombocytopenia. Among mixed infection, all 4 patients had thrombocytopenia.

Mean platelet count in the cases and species wise distribution is depicted in the table 4 and 5.

Thrombocytopenia was more severe with mixed infection with a mean platelet count of 33,000 /cumm, followed by P.falciparum with 70,423/cumm and P.vivax with 74,228/cumm.

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Discussion

Malaria is a major health problem in India due to the poor sanitation, geographical expansion and climatic change which influences mosquitoes and its existence. It is considered as a serious blood disease that can affect all blood components (9, 12). This study included 100 confirmed malaria cases. There was a male preponderance with 79 cases and the remaining 21 were female patients. This male predominance was also evident in other studies

The most common plasmodium species in our study was P.vivax with 70 cases, followed by 26 cases of P.falciparum and 4 cases of mixed P.vivax and P.falciparum infection. P.vivax has been reported as the most common species in the Indian subcontinent by many other studies as well (12, 18, 19, 20). Anemia in our study was high affecting 97% of the patients and most common type was normocytic normochromic anemia, a finding consistent with other authors.(Table 3)

Anemia is one of the most common complications in malaria and the underlying mechanism is multifactorial including ineffective erythropoiesis, increased hemolysis and splenic phagocytosis and pooling of RBCs (20). In heavily endemic areas, malaria infection is often associated with anemia, although malaria may not be the prime cause of it, due to concurrent iron deficiency and thalassemia (21). WBC count was normal in 56% of the patients in our study. Leucopenia was seen with 42 % of patients, a finding consistent with that of (3, 22). Neutrophil count was normal in 83% of cases, a finding consistent with other studies.

Monocytosis was noticed in 19% patients which is in concordance with the previous studies (5, 23). High monocyte count is often associated with uncomplicated malaria and is considered most important leucocytic change in malaria (24).

Lymphocytosis and lymphocytopenia were seen in 11% and 19% cases respectively. Lymphocyte and monocyte counts are significantly higher in patients with low parasitemia compared to high parasitemia (25).

Another important finding was the presence of eosinopenia in 29% of the cases. This has also been reported by a study in western Kenya (24). Possible explanation is suppressed production and release from marrow as well as increased removal in the periphery (24).

Overall, 95 (95%) cases presented with thrombocytopenia and 4 (4%) with normal platelet count and 1 case had thrombocytosis. The mean platelet count was 71,590 cells/cumm. The reduction in platelet count is consistently reported in 80-85% cases by many studies in relation with malaria infection. However, the percentage is much higher in our study, a finding in concordance with the results of (26) who reported thrombocytopenia in 93.3%. The mechanism of severe thrombocytopenia in malaria include anti-platelet antibody mediated lysis of platelets, oxidative stress, altered splenic functions and a direct interaction between the parasite and platelets (26). There is inverse relation between the parasite index and the platelet count; higher the parasitic index, lower the platelet count (2, 3). Thrombocytopenia is usually seen in about 85% of patients with uncomplicated malaria and all patients with severe P.falciparum malaria. It is such a characteristic of malaria that sometimes it is used as an indicator of malaria in patients presenting with fever of unknown origin (21).

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On comparing the different species, there was no significant difference in the changes in most hematological parameters, except for the total leucocyte count, with leucopenia is more common with P. falciparum infection showing a P value of 0.009. While both P.falciparum and P.vivax infections are reportedly associated with changes in total WBC count, lymphocyte and granulocyte subsets; and monocyte counts, severity of these changes is variable in different studies. There is significantly higher association of leucopenia in P. falciparum malaria as compared to P.vivax malaria (22).Eosinopenia was seen in 29 cases, with 9/26 patients of P.falciparum showing this change.P.falciparum infection can suppress the preexisting eosinophilia (25).

On observing the RBC parameters, severity of anemia was more among patients with mixed infection followed by P.falciparum infection. Mean RBC count, mean Hb level as well as hematocrit values were significantly lower among patients with P.falciparum infection compared to P.vivax cases.There is increased hemolysis in patients with P.falciparum infection due to high parasitemia level (28). Species wise there was no significant difference in the incidence of thrombocytopenia with 66/70 P.vivax, 25/26 p.falciparum and all 4 cases of mixed infections showing low platelet count in our study.

Malaria infection is often associated with various abnormalities in number and/or morphology of blood cells. These changes though well recognized, vary with the level of endemicity, associated hemoglobinopathy, nutrition of the infected persons, their demographic profile and immunity (17).

The hematological changes reported from various sources include anemia, thrombocytopenia, leukocytosis, leukocytopenia, atypical lymphocytes, neutrophilia, neutropenia, eosinophilia, monocytosis and rarely DIC (6, 27). Changes in the hematological profile are considered a hallmark of malaria, as these values increase the clinical suspicion. It also helps in initiating specific therapy even in the absence of a positive smear report. Such an early therapeutic intervention prevents the occurrence of major complications associated with malaria (6).Anemia in malaria is very common finding and is caused due to a combination of factors. These include hemolysis of parasitized RBC, enhanced removal of parasitized and unparasitized RBCs, ineffective erythropoiesis and anemia of chronic disease (28). Tumor necrosis factor and IL-10 also play an important role in the development of anemia with P.falciparum infection (3). Anemia in malaria is often normocytic normochromic type due to increased hemolysis (5). Some studies have also reported microcytic hypochromic anemia in malaria patients, probably due to the higher incidence of nutritional deficiencies or concomitant thalassemia in their study population and region (27).There are conflicting reports regarding the severity of anemia among different species. High parasitemia level in P.falciparum infection is often associated with increased hemolysis (28). P.vivax has always been associated with severe type of anemia (29).

Malaria related anemia is severe in intense malaria transmission areas and in younger children (30). Although low hemoglobin and low platelet count is seen more in relation to P.falciparum malaria, degree of anemia and thrombocytopenia does not differ among the two plasmodium species (22). Lower RBC count is seen with P.falciparum than in cases of P.vivax infection, whereas RBC indices including MCV, MCH and MCHC are higher among patient with P.falciparum infection. This relative difference in the indices is explained by release of more number of immature RBC in P. falciparum infection (31).

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Table 3: Comparison of data between present study and previous studies

Parameter	Our study	Hussain Haroon (2013)	Ali Hassan Abro, et al (2008)	Awoke aorta (2019)	Nutan Agrawal (2015)	Irumlatef (2015)	Khalid Khan (2013)	Inamullah (2018)	Myriam Arevelo, (2015)	Seema (2014)
M:F	3.76:1	3:1	12:1	2.1:1	1.4:1	1:1.03	1.2:1	1.12:1	-	2.17:1
M/C species (%)	vivax (70)	-	falciparum (54)	falciparum (61.7)	vivax (70)	vivax (53)	vivax (54)	vivax (56.6)	vivax(50.7)	falciparum (61)
Anemia	97%	71%	64%	60%	94%	97.3%	66%	77.2%	19.7%	83.1%
Type of Anemia	NNA	MiHA	NNA	NNA	NNA	-	NNA	MiHA	-	NNA
Thrombocytopenia	95%	87%	83%	84%	85.5%	86%	68%	54.4%	48.6%	73.4%
Leucocytosis	2%	3%	3%	_	9%	4%	12%			8.6%
Leucopenia	42%	18%	11%	48%	26%	39%	15%	8.8%	27.3%	12.4%
Neutrophilia	10%	2%	-	26.5%	-	-	-	-	60.8%	25%
Neutropenia	7%	5%	-	30%	-	-	-	-	-	-
Eosinophilia	28%	20%	-	-	-	-	-	-	-	-
Eosinopenia	29%	-	-	-	-	-	-	-	-	-
Lymphocytosis	19%	15%	-	-	-	-	-	-	-	-
Lymphopenia	11%	0%	24%	54%	-	-	-	-	-	43.5%
Monocytosis	19%	3%	10%	_	-	-	-	-	21.3%	-
MCV (low)	20	-	-	44.7	-	-	-	57.3%	-	-
MCH (low)	32	-	-	36	26	-	-	52.9%	-	-
MCHC (low)	54	-	-	10	15	-	-	39%	-	-

Changes in the total WBC count are highly variable as reported by different studies (28). Immune status of the patient, sex, and ethnicity are the factors which influence leucocyte count in malaria (32). Majority of cases at the time of presentation have a normal total WBC count. Leucopenia may be seen in around 15% of the adult patients in association with moderate or severe P.falciparum infection (32). This reduction in the WBC count in malaria can be explained by their relocation to the spleen and other marginal pool rather than actual reduction (33). Leukocytosis may be seen in up to 7% of the adults and is often associated with simultaneous infection of poor prognosis (32, 33). Changes in WBC differential count such as neutrophilia, neutropenia, lymphocytosis in addition to lymphopenia, atypical lymphocytes, monocytosis , lymphocytopenia, a post treatment eosinophilia and leukemoid reaction are all well documented (32). During severe P. falciparum and P. vivax infection neutrophils will be in great demand resulting in the increase in their number in peripheral blood (3). High neutrophil count, lymphopenia and monocytopenia is often associated with high parasitemia than with low or moderate parasitemia (31). Lymphocytopenia occurs with equal incidence among P.vivax and P.falciparum cases. The mechanism of lymphocytopenia is probably sequestration of lymphocytes in lymph node resulting in their abnormal death through apoptosis (3). Malaria naive population presents with higher lymphocyte count compared to malaria immune P.vivax patient probably due to increased inflammatory response by non-immune individuals (32). P.falciparum infection can suppress previous eosinophilia resulting in eosinopenia whereas P.vivax infection has low effect on eosinophil count (31). Reticuloendothelial system

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hyperplasia is noted in the form of hepatosplenomegaly and monocytosis (27).

Incidence of thrombocytopenia in malaria is well documented ranging from 24 to 98% in different studies. Most of them have reported it to be the commonest hematological change as well as a strong predictor of malaria infection (27, 18). Thrombocytopenia can be used as a marker to determine the presence and severity of infection in patients of malaria (3). Platelet counts in both P.falciparum and P.vivax infection are inversely related to the parasitemia level in peripheral blood (3). Mechanism of thrombocytopenia in malaria include immune mediated destruction of platelets, splenic pooling and excessive consumption due to DIC (13). Mild to moderate thrombocytopenia is more common than severe form in both species of malaria. There are conflicting reports regarding the severity of thrombocytopenia in association with different species, some of the studies strongly support it in favor of P. falciparum infection whereas others with P.vivax infection. Profound thrombocytopenia in vivax malaria could be explained by increased cytokine production or emergence of a new genotype of P.vivax which is more virulent (27, 18).Whatever is the severity, thrombocytopenia in malaria does not cause significant mortality and disappears with treatment. It acts as helpful indicator for starting the therapy (34). Qualitative abnormality seen along with thrombocytopenia is the formation of giant platelets released from premature megakaryocytes(27).Anemia and thrombocytopenia are considered the most significant diagnostic hematological parameter in malaria infected individuals (27). Platelet counts can be used as a guide and help the clinicians in triaging the patients to provide better and cost-effective management (18).

Conclusion

We conclude that P.vivax as well as P.falciparum can cause hematological changes in the effected patients , the most significant being anemia, thrombocytopenia, leucopenia and monocytosis. These changes are so characteristic that the diagnosis of malaria should always be considered in the presence of such findings. Early diagnosis of malaria will lead to early intervention and prevent major complications associated with the disease. The main limitation of this study is the small sample size and microscopy was the only method used for the diagnosis of malaria cases.

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Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 2297 – 2309
Received 05 March 2021; Accepted 01 April 2021.

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