SAR Journal of Pathology and Microbiology

Abbreviated Key Title: *SAR J Pathol Microbiol*
Home page: https://sarpublication.com/journal/sarjpm/home
DOI: https://doi.org/10.36346/sarjpm.2025.v06i05.001

OPEN ACCESS

ISSN 2707-7756 (P)
ISSN 2709-6890 (O)

Original Research Article

Hematological Alterations in *Plasmodium falciparum* and *vivax* Malaria: A Case-Control Study in Shendi, Sudan

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Article History: | Received: 05.07.2025 | Accepted: 08.09.2025 | Published: 11.09.2025 |

Abstract: ***Background*:** Although it has been demonstrated that malaria, which causes a significant number of deaths in endemic countries, affects hematological parameters both directly and indirectly, certain hematological parameters among populations in malaria-endemic regions have not been consistently described as a standard for measuring malaria burden. A feverish condition with several blood cell parameter changes is caused by malaria. Among these alterations are anemia and thrombocytopenia. ***Objective*:** The objective is to assess the evaluation of Hematological Changes in Malaria Patients in Shendi Town, Sudan. ***Methodology*:** The study was conducted across sections. This study included 80 people, of which 30 were healthy for comparison and 50 had malaria. Each person who gave informed consent to participate in the study had approximately 5 milliliters of blood drawn. A complete blood count was carried out on their samples using a hematology auto-analyzer to ascertain their hematological parameters. The Statistical Package for Social Sciences (SPSS) version 23 was used to statistically evaluate the data collected from the study after it was entered into a database. ***Results*:** According to the study, the average age of the malaria patients was 29.8 years, with 48% of them being men and 52% being women. The mean values of Hb, PCV, RBCs, MCV, MCH, MCHC, and RDW were (11.2 g/dl), (33.5%), (4.1x1012/l), (80.7 fl), (42.3 pg), (33.0 g/dl), and (17.8), respectively, according to the complete blood count (CBC). The mean TWBCs, neutrophils, lymphocytes, mid-platelet count, and MPV were also higher, at 6.5 x 109 /l, 60.2%, 29.9%, 9.4%, 206.1 x 109 /l, and 8.7 x 109. ***Conclusion*:** Significant alterations in hemoglobin, packed cell volume, platelets, and neutrophils are caused by malaria.

Keywords: Malaria, Hematological Parameters, Hemoglobin, Shendi.

INTRODUCTION

Malaria is a parasitic disease caused by several Plasmodium blood parasites. Plasmodium parasites are protozoan parasites that cause malaria. *Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale, Plasmodium malaria,* and *Plasmodium knowlesi* are the five species of Plasmodium that are known to cause malaria in humans. The majority of malaria deaths are caused by P. falciparum. The infection may appear abruptly and result in several potentially fatal side effects [1]. Approximately 3.2 billion people worldwide reside in regions where malaria is a threat. Between 350 and 500 million cases of clinical malaria are thought to occur each year, with *P. falciparum* and *P. vivax* infections accounting for the majority of these cases. Every year, between 1.1 and 2.7 million people die from acute malaria. It is the second most common cause of death in Africa and the fifth most common infectious disease cause of death globally [2]. The parasite's medication resistance and the vector's pesticide resistance made controlling malaria challenging [3]. According to epidemiology, P. falciparum malaria accounts for 85% of all malaria cases globally. The most pathogenic

Citation: Tayseer Ahmed Ali Mohammed, Hamza Ahmed Hassan, Tibyan Abd Almajed Altaher, Ghanem Mohammed Mahjaf, Mosab Nouraldein Mohammed Hamad (2025). Hematological Alterations in *Plasmodium falciparum* and *vivax* Malaria: A Case-Control Study in Shendi, Sudan. *SAR J Pathol Microbiol*, 6(5), 200-203.

species are found in the world's hotter and more humid regions. Malaria caused by *P. vivax* is the second most significant public health issue. Malaria relapses brought on by the hypnozoites' reactivation in the liver cells are its defining feature. Even while *P. vivax* infections seldom result in complications, but they can occasionally cause life-threatening rupture of the enlarged spleen [4, 5]. Nearly 90% of all malaria deaths worldwide take place in Africa, according to WHO research. Malaria is thought to kill one million Africans annually. The foundation of malaria management is early diagnosis and timely, efficient treatment, which is the most effective strategy to lower malaria morbidity and mortality. Although most hospitals and clinics still rely on microscopy for parasite-based diagnosis, the quality of microscopy-based diagnosis is insufficient to guarantee positive health outcomes [6, 7]. Antimalarial treatment was successful in returning abnormal blood counts to normal values two weeks after the end of treatment, according to a recent study conducted among falciparum malaria patients in West Kordufan state. This suggests that patients with falciparum malaria should be treated regardless of whether they test positive for malaria parasites [8]. The degree of malaria endemicity, preexisting hemoglobinopathy, demographics, and malaria immunity can all affect the hematological changes linked to malaria infection. Leucopenia or leukocytosis, anemia, and thrombocytopenia are examples of these hematological alterations. Malaria hematological alterations are caused by several intricate and poorly understood pathophysiological pathways [9].

MATERIALS AND METHODS

This descriptive cross-sectional case-control study was conducted to evaluate hematological parameters among malaria patients in the Shendi locality, River Nile State, Sudan. Shendi is a town located in northern Sudan on the east bank of the Nile, approximately 150 km northeast of Khartoum. The study population comprised all malaria patients who attended hospitals in the Shendi locality during the study period.

Study Population and Data Collection

The study included a total of 80 participants, consisting of 50 malaria-positive patients and 30 healthy individuals who served as controls. Inclusion criteria were restricted to patients with confirmed malaria infection. Exclusion criteria involved individuals with typhoid fever, pregnant women, and patients diagnosed with any other diseases. Data were collected using a pre-coded, self-administered questionnaire specifically designed to obtain relevant demographic and clinical information to support the objectives of the study.

Quality Control

Quality control was implemented at each step and throughout all procedures of this study to ensure reliable performance and accurate reporting of results.

Data Analysis

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) software.

Ethical Considerations

The study was approved by the Department of Haematology, College of Medical Laboratory Sciences, Shendi University, and complied with the requirements of the institutional ethical review committee. Sample collection was carried out only after obtaining informed consent from all participants. The aims and potential benefits of the study were clearly explained, and the confidentiality of participants' information was assured. All procedures were conducted in accordance with the Declaration of Helsinki (1964).

RESULTS

This study included a total of 80 participants, comprising 50 confirmed malaria patients and 30 healthy individuals as a control group—the demographic and clinical distribution of the study population is shown in Table 1.

Table 1: Demographic and Clinical Characteristics of the Study Population

Variable	Category	Frequency	Percent (%)
Total Sample	Malaria Patients	50	62.5%
	Control Group	30	37.5%
Sex (Patients)	Male	24	48%
	Female	26	52%
Age Group (Patients)	15–29 years	24	48%
	30–44 years	26	52%
Parasite Species	*P. falciparum*	38	76%
	P. vivax	12	24%

A comparative analysis of hematological parameters between malaria patients and the healthy control group revealed significant alterations (Table 2). Patients with malaria exhibited significantly lower mean values of hemoglobin (Hb), packed cell volume (PCV), mean corpuscular volume (MCV), and platelet count (Plt) compared to the controls ($p < 0.01$). Conversely, the total white blood cell count (TWBCs) and neutrophil percentage were higher in the patient group, with the increase in neutrophils being statistically significant ($p < 0.001$). Lymphocyte percentage was significantly lower in malaria patients ($p = 0.001$). No statistically significant differences were observed in Red Blood Cell count (RBCs), Mean Corpuscular Hemoglobin (MCH),

Mean Corpuscular Hemoglobin Concentration (MCHC), Red Cell Distribution Width (RDW), and Mean Platelet Volume (MPV) between the two groups.

Table 2: Comparison of Hematological Parameters between Malaria Patients and Control Group

Parameter	Malaria Group	Control Group	P-value
Hemoglobin (g/dL)	11.2 ± 2.63	13.6 ± 1.60	0.000
PCV (%)	33.5 ± 7.64	39.6 ± 4.64	0.000
RBCs ($\times 10^{12}$/L)	4.13 ± 0.91	4.69 ± 2.08	0.102
MCV (fL)	80.7 ± 12.7	90.4 ± 7.09	0.000
MCH (pg)	42.3 ± 113.4	30.9 ± 2.43	0.587
MCHC (g/dL)	33.0 ± 3.74	34.3 ± 1.77	0.074
RDW	17.8 ± 13.01	15.4 ± 4.25	0.341
TWBCs ($\times 10^9$/L)	6.5 ± 3.31	5.7 ± 1.75	0.201
Neutrophils (%)	60.2 ± 14.6	48.5 ± 10.6	0.000
Lymphocytes (%)	29.9 ± 14.8	40.6 ± 10.1	0.001
Platelets ($\times 10^9$/L)	206.1 ± 92.7	268.8 ± 62.6	0.002
MPV (fL)	8.7 ± 1.36	11.1 ± 13.5	0.238

DISCUSSION

Malaria is a parasitic disease caused by several Plasmodium blood parasites. Plasmodium parasites are protozoan parasites that cause malaria [1]. Hemoglobin (Hb), packed cell volume (PCV), mean corpuscular volume (MCV), neutrophils, lymphocytes, and platelets (Plt) were all significantly lower in the current study's results than in the control group ($P > 0.05$). These results contrast with a study by Nutan Agrawal *et al*., [12], in Jhansi that found a decrease in total white blood cell count (TWBC), normal mean corpuscular hemoglobin (MCH), and increased mean platelet volume (MPV), MCV, and red cell distribution width (RDW). Though the presence of monocytosis varied, the results are consistent with research by Ahmed Saleh Abdou *et al*., in Dubai and Shamim Akhter *et al*., [11], in Nagpur, which also observed anemia, thrombocytopenia, and lymphopenia. When compared to the control group, this study similarly demonstrated a decrease in the mean of MCHC and red blood cells (RBCs), but no statistically significant connection was discovered ($P < 0.05$). Furthermore, RDW had a higher mean than the control group, but this difference was not statistically significant ($P = 0.000$). These findings are in line with those of Ahmed Abdou *et al*., [10], who found a strong correlation between malaria patients' hemoglobin, platelets, and lymphocytes. Additionally, we found that the mean values of neutrophils and total white blood cell count (WBC) increased, whereas lymphocyte and mid-range values decreased. There was a statistically significant correlation between the research population's neutrophils and lymphocytes ($P = 0.000$). The results of the laboratory tests also showed that the means of MCH, RDW, and TWBC were higher than those of the control group, but these differences were not statistically significant ($P < 0.05$). Finally, compared to the control, there was a decrease in MPV, but this difference was not statistically significant ($P < 0.05$) [12]. Another study by Ghanem mahjaf and his colleague revealed that routinely used laboratory findings such as hemoglobin, leukocytes, platelet counts, and even red cell distribution width values can provide a diagnostic clue in a patient with acute febrile illness in endemic areas, thus increasing the probability of malaria and enhance prompt initiation of treatment [13]. The pathophysiology of malaria is responsible for these hematological changes. Anemia results from the invasion and destruction of red blood cells by Plasmodium parasites. Malaria also impairs bone marrow function, which lowers red blood cell production. Thrombocytopenia is also a result of disseminated intravascular coagulation (DIC), which causes platelet breakdown and increased consumption. Additionally, the virus lowers mid and lymphocytes, which could weaken the immune system.

CONCLUSIONS

Compared with healthy individuals in the control group, malaria patients exhibited significantly reduced levels of hemoglobin (Hb), packed cell volume (PCV), red blood cells (RBCs), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), lymphocytes, monocytes, platelets (Plt), and mean platelet volume (MPV). In contrast, they demonstrated elevated levels of neutrophils, mean corpuscular hemoglobin (MCH), red cell distribution width (RDW), and total white blood cell count (TWBC).

Recommendations

It is recommended that malaria patients undergo routine complete blood count (CBC) testing to monitor hematological parameters, particularly leukocyte changes, thrombocytopenia, and anemia. Anemia associated with malaria should be managed with caution, and depending on its severity, treatment may involve erythropoiesis-stimulating agents, blood transfusions, or iron supplementation. Furthermore, future studies with larger sample sizes and broader study areas are encouraged to provide more accurate and reliable results. To achieve this, hematology laboratories should

maintain rigorous quality control standards throughout all procedures.

Acknowledgment

The authors would like to thank the ethical review committee, as well as the Department of Hematology, Faculty of Medical Laboratory Sciences, for providing the research facilities used in this study.

Consent: The patient's written consent has been collected.

Sources of Funding: There was no specific grant for this research from any funding organization in the public, private, or nonprofit sectors.

Conflict of Interest: The authors declare that there are no conflicts of interest.

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