

To investigate the impact of parasite load on hematological parameters

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Background: Malaria is a highly contagious illness that presents a substantial burden in terms of both morbidity and mortality. Consequently, India is confronted with a huge challenge in addressing this issue. Although the malaria eradication campaign achieved initial success in the 1950s and 1960s, there was a significant increase in cases to 6.74 million in 1976, which subsequently decreased to 2.1 million in 1984. In the year 1984, the incidence of malaria infection reached its nadir since the initiation of the program. Since then, it has reached a state of stability at this particular level.

Methods: This study was conducted from January 2011 to December 2011 at the Department of Pathology, SFTMC College & Dr. B. R. Ambedkar Memorial Teaching Hospital, Agartala, Tripura, India. A total of 220 malaria cases were selected from the Malaria Laboratory based on positive smear results, and their hematological changes were analyzed. The present study aimed to examine the hematological characteristics of malaria at a hospital affiliated with a medical school. A comprehensive analysis was conducted on several hematological parameters in all malaria cases that yielded positive results on a smear.

Results: Falciparum and vivax infections have the potential to induce a range of hematological abnormalities, with normocytic normochromic anemia and thrombocytopenia being the most commonly observed. In a general sense, there exists a correlation between parasite burden and the severity of anemia and thrombocytopenia. In a patient presenting with a feverish state, it is imperative to do a thorough investigation for the presence of the malarial parasite in order to detect the occurrence of thrombocytopenia. The alterations in white blood cells are less conspicuous, and the results of various tests differ. The observed alterations include leucopenia, leucocytosis, and in rare cases, the presence of abnormal lymphocytes.

Conclusion: The objective of the present study was to monitor hematological changes in a cohort of 220 individuals diagnosed with malaria who had tested positive for smear tests. The prevalence rates of vivax, falciparum, and mixed disease were 51%, 48%, and one, respectively. In the present investigation, the proportion of male participants was 58%, in contrast to 69% in previous investigations that yielded similar results. The current analysis revealed that leucocytosis was identified in 10% of the cases. Leucopenia was observed in 18% of the participants in the present investigation. Thrombocytopenia was observed in 83% of the malaria cases in the present investigation. The present study employed statistical analysis to establish an association between the severity of anemia and the number of parasites present.

Keyword: Malaria, plasmodium, parasite, hematological, normochromic anaemia

INTRODUCTION

The etymology of the term "malaria" can be traced back to its Italian origins, where it was attributed to

the presence of saline air in proximity to marshy regions. Over 2.4 billion individuals globally are susceptible to malaria, and over 100 countries worldwide are classified as malarious^[1].

The annual mortality rate of malaria ranges from 1.1 to 2.7 million individuals, with a significant proportion being children below the age of five.

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Several hematological abnormalities have been documented in association with malaria, including anemia, thrombocytopenia, leucocytosis, leucopenia, mild to moderate atypical lymphocytosis, monocytosis, eosinophilia, and neutrophilia. Both qualitative and quantitative platelet abnormalities can be observed. The incidence of thrombocytopenia is frequently found in cases of acute malaria, including both vivax and falciform infections [2]. Haematological changes may manifest during a malaria infection, encompassing anemia, thrombocytopenia, and either leukocytosis or leucopenia. These modifications are widely recognized. Several factors can influence the manifestation of these changes, including the level of malarial endemicity, background hemoglobinopathy, nutritional status, demographic features, and malaria immunity. For almost two decades, the World Health Organization (WHO) has used hyperparasitemia as a criterion for assessing the severity of falciparum malaria in patients [3]. Prior studies have established a positive correlation between the quantity of parasites inside a given region and the extent of the individual's malaria infection. The severity of parasitemia is also associated with mortality. There is a positive correlation between the levels of parasite density in patients and their mortality rates. Moreover, anemia represents a notable consequence that may manifest as a result of elevated parasitemia induced by a *Plasmodium falciparum* infection. Furthermore, anemia may arise as a consequence of heightened hemolysis of parasitized erythrocytes in individuals afflicted with malaria. Furthermore, a significant proportion of patients diagnosed with malaria exhibited thrombocytopenia. A significant decrease in platelet count was seen in cases of elevated parasitemia. The prevalence of falciparum parasites [4]. The significance of this link was determined. The objective of this study was to illustrate the impact of *Plasmodium falciparum* and *Plasmodium vivax* infections, together with different parasite densities, on the blood cell parameters of individuals afflicted with malaria. Haematological parameters of malaria-infected patients were analyzed. The criteria investigated in this study encompassed several blood components, such as red blood cells, white blood cells, platelets, leukocytes, haemoglobin level (Hb), mean

corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), and red cell distribution width (RDW) [5].

Materials and Methods

Between January 2011 to December 2011, a prospective study will be conducted at the Department of Pathology, SFTMC College & Dr. B. R. Ambedkar Memorial Teaching Hospital, Agartala, Tripura, India. A total of 220 malaria cases that yielded positive results for smears at the Malaria Laboratory were selected through a random sampling method and subsequently analyzed for any hematological abnormalities.

The patient underwent a thorough medical history, which encompassed details such as age, gender, illness kind and duration, prior blood transfusions, and past malaria treatments, in adherence to the prescribed protocol. Notable observations were made during the clinical evaluation. A blood sample was acquired for a haematological examination prior to initiating therapy with anti-malarial medication in any of these cases. EDTA Vacutainers were used to collect venous blood, together with 3.8% sodium citrate Vacutainers for estimating ESR. The parameters of interest include hemoglobin (Hb), hematocrit (HCT), red blood cell (RBC) indices such as mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), total leukocyte count, and absolute leukocyte counts. Thin blood smears were generated using a recently collected blood sample and subsequently subjected to leishman staining. These smears were then analyzed for blood picture, differential leucocyte count, species identification, and determination of parasitaemia. The determination of parasitaemia % in thin blood smears involved quantifying the proportion of infected red blood cells (RBCs) relative to the total number of RBCs in the sample, which was predetermined as 220.

Results

A comprehensive analysis was conducted on a total of one hundred instances of smear-positive malaria, examining several hematological parameters. The total number of vivax and falciparum infections

among the 220 patients tested was almost equal. Furthermore, it was observed that a single patient exhibited a mixed infection.

Table 1: Total number of cases with different Infections

Type of Parasites	Number of Patients	Percentage (%)
<i>P. vivax</i>	110	50%
<i>P. falciparum</i>	103	46%
Mixed	07	04%
Total	220	100%

There were almost equally as many vivax (50%) and falciparum (46%) infections. This is a manifestation of the general trend of rising and falciparum cases.

Table 2: Total Bilirubin

Total Bilirubin (mg/dl)	<i>P. vivax</i> (n=08)	<i>P. falciparum</i> (n=12)	Total (n=20)
<3	05	03	08
>3	03	09	12

Table 3: Serum Creatinine

Serum Creatinine	<i>P. vivax</i> (n=16)	<i>P. falciparum</i> (n=28)	Total (n=44)
Normal	03	11	14
Elevated	13	17	30

Table 4: Platelet Count

Platelet count/ mm ³	<i>P. vivax</i> (n=110)	<i>P. falciparum</i> (n=103)	Mixed (n=7)	Percentage (%)
<50,000	33	34	07	33.6
50,000-1.5 lacs	59	43	-	46.3
1.5-4.0 lacs	18	23	-	19
>4 lacs	-	03	-	1.3

Table 5: Parasite count with type of malaria

Parasite count in %	<i>P. vivax</i> (n=110)	<i>P. falciparum</i> (n=103)	P. Mixed (n=07)	Percentage (%)
<1	47	15	-	28.18
1-5	53	70	07	59
>5	10	18	-	13

Discussion

When an anopheles mosquito of the female species transmits malaria, the parasites infiltrate and proliferate inside the circulating red blood cells, leading to the manifestation of clinical illness and pathological irregularities in many organs of the body. Despite significant advancements in diagnostic methodologies and therapeutic strategies, the global incidence of malaria remains at a range of 300-500 million cases annually, leading to a mortality rate of 1.1-2.7 million individuals. Malaria is prevalent in numerous regions of India.

There has been a notable rise in the incidence of malaria cases in recent years. Several causes contribute to this phenomenon, including the emergence of insecticide-resistant mosquitoes, a surge in chloroquine-resistant malaria, and a higher incidence of falciparum infections compared to vivax cases^[6].

Anaemia and thrombocytopenia are the two primary hematological alterations induced by malaria. Malaria further aggravates the already fragile health condition of the people in India, whereby the haemoglobin concentration of the

population has already declined as a result of inadequate dietary intake and the prevalence of numerous ailments, particularly among the younger population.

The present study was carried out from, encompassing a cohort of 220 individuals who tested positive for smears. Among these patients, 50 were attributed to vivax infection, 48 to falciparum infection, and one to mixed infection. The most prevalent species of malaria in the present study was falciparum, accounting for 48% of cases, followed by vivax at 51%. In their observations, Jadhav *et al.* observed that vivax exhibited the highest prevalence among the species examined. However, Rojansthein *et al.* and Bashwari *et al.* reported a higher incidence of falciparum [6].

Vivax is the most commonly observed species in India, with falciparum being the subsequent species. Nevertheless, there has been a significant surge in the incidence of falciparum cases. This phenomenon can be attributed to various factors, such as the emergence of insecticide-resistant vectors and the ineffectiveness of vector control initiatives. Malaria can affect individuals of any age group. Most studies, however, primarily concentrate on adults rather than children. Similar to the study conducted by Potkar *et al.*, the present inquiry comprised a sample of 23 pediatric patients and 77 adult patients. The age group under investigation exhibited a mean value of 30.7. Most other research often falls during the age range of 25 to 40. The adult age group experiences a higher degree of impact due to their enhanced mobility and heightened susceptibility to exposure resulting from increasing engagement in outdoor activities. The present study had a male sample that was 58% larger than the female sample, precisely 42%. Other studies that have shown comparable results include the research conducted by Bashwari *et al.*, which involved 75.9% male participants, and Erhart *et al.*, which involved 69% male participants. The higher prevalence of male cases may be attributed to factors such as reduced mobility, a male-dominated society, and a lack of concern for the treatment of disorders in women [7].

Anaemia is an often observed complication in instances of malaria, particularly in regions characterized by limited development. The etiology of anemia encompasses a multitude of causes.

Parasitized red blood cells (RBCs) undergo destruction, but non-parasitized RBCs are destroyed at a faster rate, which is directly related to the severity of the sickness. Additionally, there is evidence of bone marrow dyserythropoiesis. In the present investigation, a majority of the cases (eight percent) had anemia. Sharma *et al.* observed anemia in 86.7% of the cases in their prior investigations, but Biswas *et al.* saw anemia in 94.4% of the cases. In a study conducted in Saudi Arabia, Bashwari *et al.* observed that 59.2% of the cases exhibited anemia, while Niazi's research revealed that 46% of the cases did. The extent of anemia resulting from malaria infection exhibits significant variation depending on the geographical location of the research [8]. Anemia was observed in just 15% of malaria cases in the study conducted by Richard *et al.* in London. Studies conducted in economically disadvantaged countries have revealed elevated prevalence rates of anemia. A significant proportion of individuals residing in these geographical areas experience iron and folate deficits due to inadequate dietary intake, parasitic infections, and bacterial ailments, all of which play a substantial role in the development of anemia. Consequently, determining the precise extent to which malaria is solely accountable for the prevalence of malaria in these regions poses a challenge. Numerous studies have identified the presence of anemia in instances of malaria; yet, the extent of anemia varies among different investigations. Malaria-induced anemia exacerbates pre-existing low levels, with severe anemia (5 gm %) being prevalent in impoverished countries [9]. Within the present investigation, 11% of participants had severe malaria, a potentially fatal outcome. Falciparum malaria was responsible for the majority of these substantial decreases in hemoglobin levels.

The current analysis revealed that leucocytosis was identified in 10% of the cases. The study conducted by Bashawari *et al.* revealed a prevalence rate of 7.2% for leucocytosis. The instances reported by Sharma *et al.* and Biswas *et al.*, which account for 13.3% and 12.2% respectively, are similar to the cases observed in the current study. Ladhani *et al.*, who only examined instances of falciparum, saw a more significant increase, but Echeverra *et al.*, who solely investigated cases of vivax, recorded a 5% rise. The alterations in white blood cell count

associated with malaria are not clearly defined, and there is considerable variation among different research. The total counts of the majority of patients generally fall within acceptable values. The recent study found that 72% of the subjects had normal counts. Malaria has the potential to lead to an elevation in the occurrence of leucocytosis, particularly with subsequent bacterial infections. In the present study, it was shown that 7.8% of vivax cases had an elevation in leucocyte count, whereas 10.4% of falciparum patients displayed a similar trend. Leucopenia was observed in 18% of the participants in the present investigation. The percentage of leucocytes decreases in 19.6% of patients with vivax, whereas leucopenia is observed in 16.6% of cases with falciparum. Sharma *et al.* demonstrated that Falciparum malaria resulted in a leucopenia rate of 6.6%, while Ladhani *et al.* reported a leucopenia rate of 10.29%. Bashwari *et al.* reported that leucopenia was observed in 13.3% of all malaria cases. The study conducted by Echeveria *et al.* revealed that leucopenia was observed in 29% of the patients diagnosed with vivax malaria. Variations in total white blood cell (WBC) counts have been observed, despite the presence of certain modifications throughout all investigations. While the extent of alteration may vary, it is not uncommon for both *P. falciparum* and *P. vivax* to experience a change in the white blood cell count. The present analysis indicates that neutropenia is observed in 13% of cases, whereas an elevation in neutrophil levels is observed in 6% of instances. Bashwari *et al.* conducted a study that yielded comparable findings, with a prevalence of 8.3% for neutropenia and 11.6% for neutrophilia^[10]. The study conducted by Biswas *et al.* revealed that neutropenia was observed in 14.4% of the cases, whereas neutrophilia was found in just 0.6% of the cases. Lymphocytosis was observed in 8% of the cases in the present investigation. In line with the findings of Bashwari *et al.*, Biswas *et al.* observed a prevalence of 13.6% for lymphocytosis, whereas both groups reported a prevalence of 8.5% for this particular disorder. Atypical lymphocytes were detected in 18% of the cases during the ongoing examination. The prevalence of atypical lymphocytes was found to be 20.2% in the study conducted by Jain *et al.*, and 38.7% in the study conducted by Bashwari *et al.* Roy also found

comparable findings, as he noticed elevated erythrocyte sedimentation rate (ESR) in 81.6% of the falciparum cases. The present inquiry indicates elevated ESR levels in 79% of the instances. The ESR readings of patients exhibit a modest to moderate increase as a result of the acute character of malaria. Thrombocytopenia was observed in 77% of patients diagnosed with falciparum malaria and 84% of patients diagnosed with vivax malaria in the present investigation, which involved a total of 1.5 million persons. Various studies have reported different proportions of thrombocytopenia in cases of both vivax and falciparum infections. The present investigation aligns with previous research conducted by Bashwari *et al.* and Jhadav *et al.*, which indicate a higher prevalence of thrombocytopenia in cases of vivax malaria. Conversely, studies conducted by Horstmann *et al.* and Erhart *et al.* propose that thrombocytopenia is more frequently observed in cases of falciparum malaria^[11]. Thrombocytopenia is commonly observed in cases of both vivax and falciparum malaria, according to most investigations. Thrombocytopenia was observed in 81% of the malaria cases in the present investigation. Thrombocytopenia is observed in 80% of patients and 67% of cases, as reported by Kueh *et al.* and Richards *et al.*, respectively. Thrombocytopenia is the most commonly observed finding, irrespective of the specific kind of malaria exhibited by patients. Patients with acute febrile diseases in tropical regions have a higher probability of developing malaria^[12, 13]. The presence of thrombocytopenia can be a valuable clinical indicator for starting therapy. Thrombocytopenia does not serve as a distinguishing factor between the two types of malaria. The etiology of malarial thrombocytopenia remains uncertain. Possible explanations encompass immune-mediated destruction, confinement in the spleen, and a dyspoietic mechanism in the bone marrow characterized by diminished platelet production. There exists a correlation between malaria and deviations in platelet morphology and functionality, with occasional instances of malarial parasites infiltrating platelets^[14, 15].

Conclusion

Falciparum and vivax infections have the potential to induce a range of hematological abnormalities,

with normocytic normochromic anemia and thrombocytopenia being the most commonly observed. In a general sense, there exists a correlation between parasite burden and the severity of anemia and thrombocytopenia. In a patient presenting with a feverish state, it is imperative to do a thorough investigation for the presence of the malarial parasite in order to detect the occurrence of thrombocytopenia. The alterations in white blood cells are less conspicuous, and the results of various tests differ. The observed alterations include leucopenia, leucocytosis, and in rare cases, the presence of abnormal lymphocytes. Additional investigation and analysis of the white blood cell parameters in individuals with immune and semi-immune conditions afflicted by endemic diseases, along with other unresolved matters, would be beneficial. These encompass alterations in the bone marrow and the properties related to blood clotting. In summary, the timely identification of malaria, taking into account various hematological abnormalities, and the implementation of effective and proactive treatment strategies can effectively decrease fatality rates and prevent further complications.

Funding Source

None.

Conflict of Interest

None.

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