South Asian Journal of Parasitology

5(4): 153-159, 2021; Article no.SAJP.81659

Plasmodium vivax Density and Haematological Profiles of Malaria Patients from North India- A Hospital-Based Prospective Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Somdet Srichairatanakool, Chiang Mai University, Thailand.
Reviewers:
(1) Obiora Osegboka Ikpeze, Nnamdi Azikiwe University, Nigeria.
(2) Rafael Abós-Herràndiz, Institut Català de la Salut, Spain.
Complete Peer review History, details of the editor(s), Reviewers and additional Reviewers are available here: https://www.sdiarticle5.com/review-history/81659

Original Research Article

Received 12 October 2021
Accepted 27 December 2021
Published 29 December 2021

ABSTRACT

Introduction: Malaria, the vector borne disease still remains one of the most deadly infections for many continents.
Aim: This hospital-based prospective study was conducted to correlate the *Plasmodium vivax* parasitic load with the haematological parameters of malaria patients.
Materials and Methods: A total of 200 patients of Acute Undifferentiated fever (AUF) were enrolled and screened for Malaria by microscopy of Peripheral blood smear (PBS) and Rapid malarial antigen test (RMAT). The parasitic load of the *Plasmodium vivax* infection was classified into low, moderate and high parasitic counts and was further correlated with the haematological parameters.
Results: A total of 150 cases were diagnosed as Malaria positive. Of these 139 (92.7%), 10 (6.7%) and 1(0.6%) were classified as due to *Plasmodium vivax*, undifferentiated and *Plasmodium falciparum* infections respectively. The parasitic load of *Plasmodium vivax* was found to be low, moderate and high in 66 (47.5%), 67 (48.5%) and 6 (4%) cases respectively. It was observed that low and moderate parasitaemia were associated with moderate anaemia and thrombocytopenia which was statistically significant ($p<0.05$).
Conclusion: The correlation between the haematological parameters with the parasitic load, in patients with *P. vivax* malaria, may aid the clinicians to determine the severity of the illness.

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Keywords: Plasmodium vivax; haematology; North India; Malaria.

1. INTRODUCTION

Malaria is still the leading cause of death in tropical countries like Africa and India. In 2017, there was an estimated 219 million patients of Malaria in 87 countries, with a mortality rate of 4,35, 000 malaria patients. *Plasmodium vivax* and *P. falciparum* are the predominant species causing Malaria as reported from India [1]. *Plasmodium vivax* alone accounts for 60-65% of the cases in India and more than 80% of the cases are in Delhi [2].

Severe malaria is defined based on the clinical symptoms and signs, the infecting species of the malarial parasite, the haematological abnormalities, parasitic load and various end organ dysfunction [1]. Most common complications observed in malaria is in the Haematological profile, as these changes involve the red blood cells, leukocytes and thrombocytes [3]. According to WHO? [1], the severity of malaria is defined by the haematological parameters like haemoglobin concentration <5g/dl and <7 g/dl or hematocrit of 15% and 20% in children younger than 12 years of age and in adults respectively along with a parasite count of >10000/µl. Though the severity of anaemia, thrombocytopenia and leukocytosis or leukopenia in malaria has been well studied for *P. falciparum*, however the extent of these alterations in *P. vivax* malaria is less well-known?.

In this prospective hospital-based study, the correlation between the load of parasitaemia by microscopy (i.e., Peripheral blood smear (PBS) and the haematological profile of patients with malaria was done. In addition, age-wise changes in the haematological values in relation to the parasitic load were analysed.

2. MATERIALS AND METHODS

2.1 Study Design

The present study was a hospital-based prospective study, conducted at a 2700 bedded tertiary care hospital in New Delhi, India. This tertiary care hospital caters to patients from whole of the northern zone of India, with a daily Out Patient Departments visit of 8000-10000 patients per day. This area experiences monsoon from July to September, which is the mosquito breeding season and so there is a spike in the mosquito borne illnesses like Malaria, Dengue and Chikungunya. Hence this study was conducted over a period of 4 months (from July 2017 to October 2017) when maximum number of malaria cases visit the hospital.

2.2 Patients

During the study period, any patient having Acute Undifferentiated Fever (AUF) of more than 5 days, visiting the medicine or paediatric Out Patient Departments and/or admitted in the emergency ward were enrolled for the study. A predesigned standard proforma was used to record the socio-demographic details of the enrolled subjects. History of fever, jaundice, convulsions, nausea and vomiting along with the duration of illness was taken. The history of bleeding from any site as well as any drug intake, history of any similar complaints in the past and the family history were also taken.

2.3 Methodology

Laboratory investigation of Malaria:

Two - three ml of veni-puncture blood was collected in 2 EDTA vacutainer vials with aseptic precautions.

One EDTA vial was submitted to the Department of Microbiology of the Hospital.

It was tested for malarial parasite (MP) by microscopic examination of Peripheral blood smear (PBS) – a thin and thick smear after Giemsa staining and by Rapid Malarial Antigen Test (RMAT) (Medsource Ozone Biomedicals Pvt Ltd, India) which detects Histidine-rich protein 2(HRP-2) specific to *P. falciparum* and parasite specific Lactate De Hydrogenase (pLDH) specific to *Plasmodium* species in the human blood sample. Each microscopically positive peripheral smear was further evaluated for the *Plasmodium* species identification and the parasitic load by WBC tally method. They were further classified into low, moderate and severe parasitaemia depending on whether the parasite load was below 100/µl, 101 to 10000/µl and more than 10001/µl respectively [4].

For haematological investigation, a second EDTA vial was submitted to the Department of Laboratory Medicine. The following parameters were recorded namely Total RBC (x 10^6/µl), Total

leukocyte Count (TLC; x 10^3/µl), Platelet count (PC; x 10^3/µl), Haemoglobin level (Hb; g/dl), Mean corpuscular volume (MCV; fL), Mean corpuscular Haemoglobin (MCH; pg/cell) and Mean corpuscular haemoglobin concentration (MCHC; g/dl). Anaemia, Thrombocytopenia, Leukocytosis and Leukopenia. These were defined according to the WHO criteria and were further classified [5].

2.4 Data Analysis

All the data analysis was done using a copy of SPSS version 16. For correlation of the values: mean, median and odds ratio were calculated. P value <0.05 was recorded as statistically significant.

3. RESULTS

Of the 200 cases enrolled in the study with AUF, 150 were found to be positive for malarial parasite by both RMAT and Peripheral blood smear (PBS) examinations. Samples which were positive on PBS were considered as true positives. The age of the participants ranged from 1 to 58 years with a median age of 17 ± 14 years. Majority of patients, 92 cases (92/150; 61%) belonged to 0-15years age group while 58 cases (58/150; 39%) were above 15 years of age. The Male: Female ratio in the study was 1.3:1.

Of the 150 (n=150) patients with Malaria, 139 cases (139/150; 92.7%) were positive for *P. vivax*, 10 cases (10/150;6.7%) were positive for *P. falciparum* and 1 case (1/150;0.6%) was categorised as mixed *Plasmodium* species infections. As only ten (10) cases of *P. falciparum* and one (01) case of mixed infection were diagnosed; it was difficult to draw any statistically significant value for these cases. So only the *P. vivax* cases (n=139) were further studied in detail. Of the *P. vivax* positive cases (n=139), low, moderate and high parasite load was found in 66 (47.5%), 67 (48.2%) and 6 (4.3%) respectively as shown in Fig. 1.

Each parasitic load sub-group was further analysed based on the age of the patient and divided into 2 groups - children (0-15 yrs.) and adults (>15 yrs.). In children, it was found that *P. vivax* infections caused low and moderate parasitaemia in 37 (37/73; 50.7%) and 36 (36/73; 49.3%) cases respectively. There were no cases of high load parasitaemia. Whereas in adults - low, moderate and high load parasitaemia was found in 29 (29/66; 43.9%), 30 (30/66; 45.5%) and 7 (7/66; 10.6%) respectively.

Out of the 139 *P. vivax* cases, anaemia, thrombocytopenia, leukopenia, leucocytosis, varied MCV and MCH were observed in 125 (125/139; 89.9%),116 (116/139; 83.4%), 33 (33/139; 23.7%), 20 (20/139; 14.4%), 34 (34/139; 24.5%), 6 (6/139; 4.3%), 42 (42/139; 30.2%) and 7 (7/139; 5%) cases respectively as shown in Fig. 2.

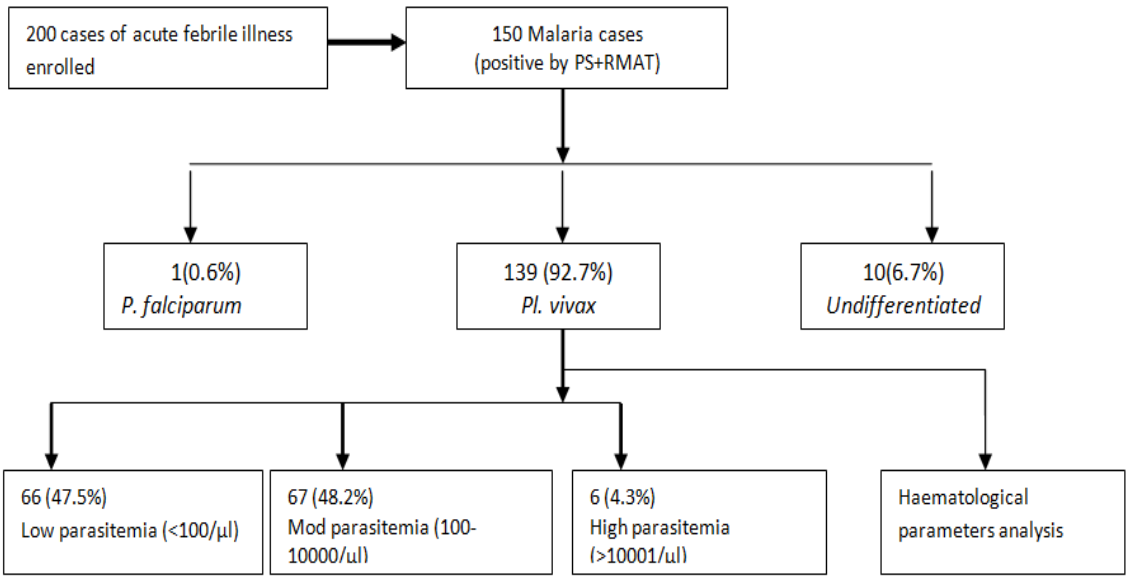

Fig. 1. Schematic diagram of the study

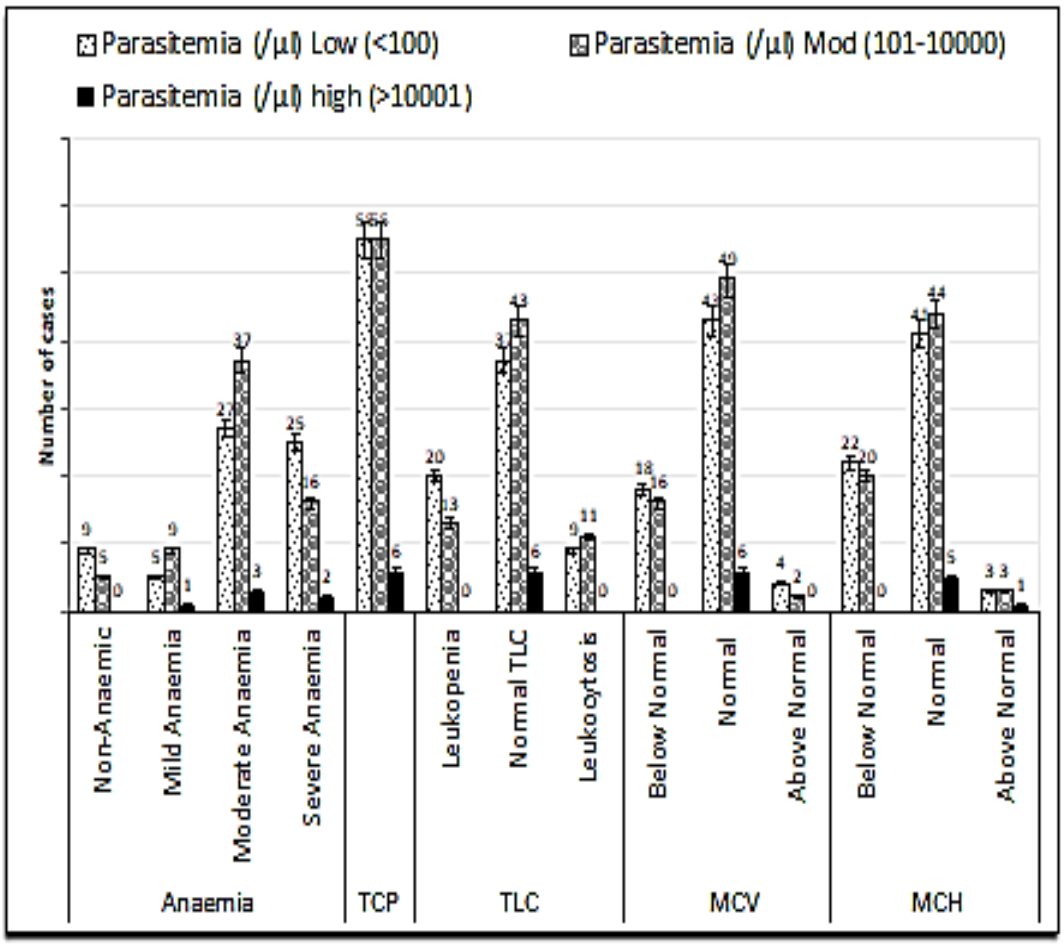

Fig. 2. Numbers of cases (n=139) of *Plasmodium vivax* in each parasitic load sub-group and haematological changes. Note: TCP – thrombocytopenia. Classifications are according to recommended guidelines by WHO[5]

The haematological profile of all 139 *P. vivax* cases were further analysed and correlated with the parasite load. It was observed that low and moderate parasitaemia were observed with moderate anaemia and thrombocytopenia, the association was found to be statistically significant ($p<0.05$).

Detailed analysis of *P. vivax* cases with haematological parameters in both the children and adults showed the following association (Table 1). It was found that in children with both low and moderate parasitaemia, the mean value of TRBC was 3.2±0.7 $x10^6$/µl, which is below the normal value of 4.5$x10^6$/µl as per national guidelines [6].

As shown in Table 1, the mean haemoglobin in cases with low and moderate parasitic count was calculated and found to be 8.3±2.4 and 8.4±2.4 g/dl. This is also very low as compared to the reference standard (which is 14mg/dl in children) [6]. The mean values of TRBC and Hb indicate that moderate anaemia was associated significantly with low and moderate parasitaemia in children. The mean values of TLC (i.e., 8.1±6.9 $x10^3$/µl) with low parasitic counts were much nearer to the normal values than with the moderate parasitic counts, where mean TLC was 7.5±6.9 $x10^3$/µl. However this correlation was not found to be statistically significant. The mean value of total platelet count in cases having both low and moderate parasitic count (i.e., 111±99 $x10^6$/µl and 91.8±99$x10^6$/µl) respectively was much lower than the normal count of 150 $x10^6$/µl found in the healthy children. This clearly indicates that with increase in parasitic count, the platelet count decreases ($p<0.0001$). The mean MCV, MCH and MCHC were found to be lower than the standard cut off. Statistically significant lowering of these parameters was observed with increase in parasitic count.

Table 1. Haematological profile of children and adults cases of *Plasmodium vivax* at low, moderate, and high parasitic loads

Lab Parameters	*Children (n=73)*			*Adults (n=66)*		
	Low PL (37)	**Mod PL (36)**	**High PL**	**Low PL (29)**	**Mod PL (30)**	**High PL (7)**
Total RBC ($x10^6$/µl)	3.2±0.7	3.2±.7	-	3.1±0.8	3.5±.7	2.8±.9
Total LC ($x10^3$/µl)	8.1±6.9	7.5±6.9	-	5.8±3.3	6.9±7	6.3±3.4
Platelet count ($x10^6$/µl)	111±99	91.8±99	-	67.2±57.1	81.7±99	69±98.9
Hb(g/dl)	8.3±2.4	8.4±2.4	-	9.4±2.6	9.8±2.4	9.0±2.4
MCV (fl)	81±9.6	82.1±9.7	-	86.8±8.6	88.4±9.7	90.8±9.7
MCH (pg/cell)	27.1±5.1	25.7±5	-	27.7±4.4	29.5±5	29.5±5.0
MCHC (g/dl)	34.1±3.6	31.2±3.2	-	31.2±3.8	33.3±3.2	32.4±3.2

Note: In children none of the malaria case diagnosed with high parasitaemia. Numbers in brackets represent numbers of cases in each parasitic count range. Low PL- low parasitic load (<100/µl); Mod PL- moderate parasitic load (100-10000/µl); High PL- high parasitic load (>10001/µl)

When haematological parameters of adults were compared with the different parasitic load, the following findings were noted as shown in Table1. The mean of total RBC, Haemoglobin level and platelet count decreased with increase in the parasitic count and this association was found to be statistically significant. The pattern of TLC and MCV did not correlate well with the parasitic count.

4. DISCUSSION

Malaria is a major cause of morbidity and mortality in developing countries like India. In this study on Malaria the incidence of *P. vivax* was found to be 92%. Similar findings have been observed in other studies from North India with incidence rates of 85% and 63% respectively [7, 8]. We found that *P. vivax* infections caused more number of cases of low and moderate parasitaemia in both children and adults. Various other studies have also reported *P. vivax* to cause malaria with low parasite counts [3,9]. On the contrary, *P. vivax* has been reported causing severe malaria with a high parasitic count [10]. Although haematological abnormalities are considered to be a hallmark of malaria especially in *P. falciparum* infections, but these abnormalities were also seen in *P. vivax* infections. In our study we observed that anaemia, thrombocytopenia, leukopenia, leucocytosis, decreased and increased MCV and MCH were found in 89.9%, 83.4%,23.7%, 14.4%, 24.5%,4.3%, 30.2% and 5% cases respectively. We also found a statistically significant association of thrombocytopenia and anaemia with moderate and high load of parasite count in 31% and 83.3% cases respectively. These findings are in accordance with other studies done across the world, which have also shown a strong association between *P. vivax* malaria with anaemia and thrombocytopenia [11,12]. The presence of thrombocytopenia can be explained by the immune-mediated platelet destruction, adherence of platelets to parasitized RBC and oxidative stress to membrane components which occurs in malaria, whereas sequestration of blood cells in the spleen may contribute to both anaemia and thrombocytopenia [3].

In the present study, it was found that in both children and adults, the total RBC, Haemoglobin, Platelet count, MCH and MCHC significantly decrease with increase in the parasitic load, thereby increasing the severity of malaria. These findings are in concordance with the findings of other authors which showed significant correlation of these haematological parameters in the malaria patients [11,13]. On the other hand there was no significant change in the Total leucocyte count (TLC) with increase in the parasitic load, contrary to findings from similar studies [11,12]. On comparison of the parameters, it was also noted that even though TLC was comparable to the parasitic load but the differential white blood cell count (DLC) was not comparable with the parasitic load. Another limitation of this study was the relatively small number of patients in this group. As malaria spikes are seen only once in a year, during the monsoon season, hence collection of more number of samples during this period would have greatly increased the validity of the study.

The present study has laid emphasis on the severity of malaria in patients with *P. vivax*

infection. Till date most of the literature on malaria focus on effect of the malaria parasite on the haematological parameters but this study tried to emphasise on the haematological parameters which can gives an insight into the prediction of the parasitic load, the severity of malaria as well as the prognosis of the patients in the remote areas where there may not always be facility and expertise to report on the parasite load except that of conducting a complete blood count (CBC).Many more studies are needed in the near future to conclude at a final recommendation which can be given to the treating physicians on predicting parasitic load based on haematological parameters.

5. CONCLUSION

The patients infected with *P. vivax* exhibit important changes in many haematological parameters especially total red blood cell count, haemoglobin level and platelet count, which determine the severity of the infections. The correlation between the haematological parameters with the parasitic load, which are both diagnostic as well as prognostic markers in patients with *P. vivax* malaria, often helps the clinicians to determine the severity of the illness.

CONSENT AND ETHICS APPROVAL

Ethical clearance was taken from the Ethics Committee of the institute (IEC/SJH/ VMMC/Project/August-2017/983). A written informed consent was obtained from each adult study participant and a Legal Authorized Representative consent form was signed by the guardian of the minor.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. World Health Organization. Fact sheet: World Malaria report;2017. Available:https://www.who.int/malaria/publications/world-malaria-report-2017/en/.
2. Kaul A, Bali P, Anwar S, Sharma AK, Gupta BK, Singh OP *et al.* Genetic diversity and allelic variation in MSP3α gene of paired clinical *Plasmodium vivax* isolates from Delhi, India. Journal of Infection and Public health. 2019;12(4): 576-84.
3. Wickramasinghe SN and Abdalla SH. BaillieÁ re's Clinical Haematology. 3rd ed. Harcourt Publishers Ltd;2000.
4. World Health Organization. Malaria Parasite Counting. Malaria microscopy standard operating procedure – mm-sop-09;2016.
5. World Health Organization. Vitamin and Mineral Nutrition Information System. Geneva. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity;2011. Available:http://www.who.int/vmnis/indicators/haemoglobin.
6. Nathan, David G, Oski, Frank A. Hematology of Infancy and Childhood.7th ed. Aaundera Publishers; 2007.
7. Sharma R, Gohain S, Chandra J, Kumar V, Chopra A, Chatterjee S et al. *Plasmodium vivax* malaria admissions and risk of mortality in a tertiary-care children's hospital in North India. Paediatr Int Child Health. 2012;32(3):152-7.
8. Kochar DK, Tanwar GS, Khatri PC and Kochar SK. Clinical Features of Children Hospitalized with Malaria - A Study from Bikaner, Northwest India 2010. Am. J. Trop. Med. Hyg.2010;83(5): 981-9.
9. World Health Organization. Tropical Medicine and International Health. John Wiley & Sons Publisher;2014.
10. Birhanu M, Asres Y, Adissu W, Yemane T, Zemene E and Lealem Gedefaw. Hematological Parameters and Hemozoin-Containing Leukocytes and Their Association with Disease Severity among Malaria Infected Children: A Cross-Sectional Study at Pawe General Hospital, Northwest Ethiopia. Interdisciplinary Perspectives on Infectious Diseases ;2017.
11. Kotepui M, Piwkham D, Phuech BP, Phiwklam N, Chupeerach C, Duangmano S. Plos One 2015;45-56.
12. Ullah I, Ali MU, Saeed A, Rafiq A, Sattar Z, Hussain S. Hematological Profile of Patients Having Malaria-positive Peripheral Blood Smears: A Cross-sectional Study at a Diagnostic Research Center in Khyber Pakhtunkhwa, Pakistan. Cureus. 2018;10:9.

13. Maina R, Walsh D, Gaddy C, Hongo G, Waitumbi J, Otieno L et al. Impact of *Plasmodium falciparum* infection on haematological parameters in children living in Western Kenya. Malaria J. 2010;9:03–04.

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