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Haematological changes in malaria-infected children in North-West Nigeria

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Aim: Malaria is prevalent in the tropical and subtropical regions of the world and has been associated with some haematological changes. This study determined the effect of malaria infection on haematological values amongst children in north-western Nigeria.

Materials and methods: Fifty-eight malaria-infected children, aged 1–12 years, and 58 age-matched uninfected children were studied between September and December 2011 at Aminu Kano Teaching Hospital, Kano. Blood samples collected were analysed for full blood count using a Swelab Alfa 3-part analyser and malaria parasite test using the field staining technique.

Results: There were significantly lower values of haematocrit, haemoglobin concentration, and platelet count of 29.0 ± 4.7%, 10.0 ± 1.7 g/L, and 195.9 ± 111.9 × 109/L in malaria-infected children compared to 32.3 ± 2.8%, 11.1 ± 1.1 g/L, and (287.4 ± 92.6) × 109/L, respectively, in uninfected control subjects ($P < 0.05$), while the values of total white blood cell count, granulocyte count, lymphocyte count, and mid-cell count in malaria-infected and noninfected children showed no significant differences ($P > 0.05$). Parasite densities had no significant influences on haematocrit, haemoglobin, or white blood cell counts ($P > 0.05$), but showed influence on platelet count ($P < 0.05$).

Conclusion: Changes in haematological values in malaria-infected children are associated with anaemia and thrombocytopaenia irrespective of their sex. It is recommended that platelet count be determined as it could assist in the diagnosis of malaria infection.

Key words: Haematological changes, malaria-infected children, north-western Nigeria

1. Introduction

In spite of intensive worldwide efforts to reduce its transmission, malaria remains the most serious and widespread protozoal infection of humans. Over 40% of the world's population is at risk of contracting the disease, which is endemic in 91 countries, mostly developing ones (1).

Malaria is the most prevalent infectious disease in the tropical and subtropical regions of the world in addition to being the major cause of morbidity in the tropics (2–5). The World Health Organization reported that malaria is responsible for nearly 90% of deaths in Africa (6), while records have shown that about 50% of the Nigerian population suffers from at least 1 episode of malaria annually with over 45% of all out-patient visits being associated with malaria (7,8). Approximately 0.25 million deaths of Nigerian children under the age of 5 have been associated with malaria yearly (9).

Human malaria is caused by 4 species of *Plasmodium*, namely *P. falciparum*, *P. vivax*, *P. ovale*, and *P. malariae*, with the majority of malaria cases caused by *P. falciparum* (10).

Haematological changes are some of the most common complications in malaria as the changes involve the major cell lines such as red blood cells, leukocytes, and thrombocytes (11). Anaemia, thrombocytopaenia, and leukocytosis or leukopaenia in malaria have been reported, but the extent of these alterations varies with the level of malaria, endemicity, background haemoglobinopathy, nutritional status, demographic factors, and malaria immunity (12–14).

There is a paucity of information on haematological changes in malaria-infected Nigerian children and this has necessitated this study in Kano, north-western Nigeria, as the findings can further assist in the diagnosis of malaria.

2. Materials and methods

The study was conducted on 116 febrile children, aged 1–12 years, who attended the paediatric clinic of Aminu Kano Teaching Hospital, Kano after informed consent was received, short histories were taken, and clinical examinations were done. Out of the 116 patients studied

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between September and December 2011, 58 of them were infected with malaria, while the remaining uninfected 58 children were used as controls.

Blood samples were collected from every patient into EDTA containers for the thick blood film preparation to detect the presence or absence of malaria parasites and determine full blood counts (FBCs) involving haematocrit, haemoglobin concentration, white blood cell count, platelet count, granulocyte count, lymphocyte count, and mid-cell count (monocyte, eosinophil, and basophil count).

Thick blood films were stained by the field staining technique (15) while the parasite density was determined by the method of Greenwood and Armstrong (16). FBC was measured using a quality-controlled Swelab Alfa 3-part haematology analyser manufactured by Boule Medical AB, Sweden.

2.1. Statistical analysis

The mean values and standard deviations of the parameters were determined and the differences between the values of malaria-infected and noninfected children (controls) were assessed using Student's t-test, while one-way analysis of variance was employed to compare the parasite densities against the haematological values. Prevalences of platelet counts in malaria-infected children and controls were assessed using chi-square tests, and $P \leq 0.05$ was considered significant.

3. Results

Haematological values in malaria-infected and control subjects are summarised in Table 1. There were significantly lower mean values of haematocrit, haemoglobin concentration, and platelet count of 29.0 ± 4.7%, 10.0 ± 1.7 g/L, and (195.9 ± 111.9) × 10^9/L in malaria-infected children compared to 32.3 ± 2.8%, 11.1 ± 1.1 g/L, and (287.4 ± 92.6) × 10^9/L, respectively, in the control subjects ($P < 0.05$). The values of white blood cell count, granulocyte count, lymphocyte count, and mid-cell count in malaria-infected and noninfected children showed no statistically significant differences ($P > 0.05$).

Table 2 shows haematological values in malaria-infected and control subjects in relation to sex. The mean

Table 1. Haematological values in malaria-infected and control subjects.

Parameter	Noninfected children (controls)	Malaria-infected children	P-value
Number of subjects	58	58	
Haematocrit (%)	32.3 ± 2.8	29.0 ± 4.7	<0.05
Haemoglobin (g/L)	11.1 ± 1.1	10.0 ± 1.7	<0.05
White blood cell count (×10^9/L)	6.7 ± 2.2	6.74 ± 2.7	>0.05
Platelet count (×10^9/L)	287.4 ± 92.6	195.9 ± 111.9	<0.05
Granulocyte count (%)	48.5 ± 14.5	51.4 ± 14.8	>0.05
Lymphocyte (%)	45.8 ± 14.1	42.4 ± 14.0	>0.05
Mid-cells (%)	5.7 ± 2.0	6.1 ± 2.7	>0.05

Table 2. Haematological values in malaria-infected and control subjects in relation to sex.

Parameter	Noninfected male children (control)	Infected male children	P-value	Noninfected female children (control)	Infected female children	P-value
Number of subjects	34	34		24	24	
Haematocrit (%)	32.1 ± 2.9	28.3 ± 4.2	<0.05	32.7 ± 2.6	29.9 ± 5.2	<0.05
Haemoglobin (g/L)	11.1 ± 1.1	9.8 ± 1.5	<0.05	11.2 ± 1.1	10.3 ± 1.9	>0.05
White blood cell count (×10^9/L)	6.77 ± 2.1	6.8 ± 2.8	>0.05	6.5 ± 2.4	6.7 ± 2.5	>0.05
Platelet count (×10^9/L)	297.1 ± 88.2	199.8 ± 118.0	<0.05	273.6 ± 98.6	190.4 ± 105.0	<0.05
Granulocyte (%)	50.1 ± 13.3	50.4 ± 13.7	>0.05	46.2 ± 16.0	52.7 ± 16.4	>0.05
Lymphocyte (%)	44.6 ± 12.8	43.1 ± 12.5	>0.05	47.5 ± 15.9	41.3 ± 16.0	>0.05
Mid-cells (%)	5.2 ± 1.88	6.1 ±3.1	>0.05	6.3 ± 2.0	6.0 ± 1.9	>0.05

values of haematocrit, haemoglobin, and platelet count of 28.3 ± 4.2%, 9.8 ± 1.5 g/L, and (199.8 ± 118.0) × 10^9/L in malaria-infected male children compared to 32.1 ± 2.9%, 11.1 ± 1.1 g/L, and (297.1 ± 88.2) × 10^9/L, respectively, in uninfected male children showed significant differences ($P < 0.05$), while the values of malaria-infected and control male subjects with regards to white blood cell count, granulocyte count, lymphocyte count, and mid-cell count showed no significant differences ($P > 0.05$). The values of haematocrit and platelet count of 29.9 ± 5.2% and (190.4 ± 105.0) × 10^9/L in malaria-infected female children compared to 32.7 ± 2.6% and (273.6 ± 98.6) × 10^9/L, respectively, in control subjects showed significant differences ($P < 0.05$), while haemoglobin, white cell count, granulocyte count, lymphocyte count, and mid-cell count in malaria-infected and control female subjects showed no significant differences ($P > 0.05$).

Table 3 summarises the haematological values of malaria-infected children in relation to sex. There were no significant differences in the values of male and female infected children with regards to haematocrit, haemoglobin, white blood cell count, platelet count, granulocyte count, lymphocyte count, and mid-cell count ($P > 0.05$).

Table 4 shows the influence of malaria parasite densities on haematological parameters. The values of haematocrit, haemoglobin, white blood cell count, granulocyte count, lymphocyte count, and mid-cell count with regard to malaria parasite (mp) densities (1–1000 mp/μL, 1001–10,000 mp/μL, and >10,001 mp/μL) showed no significant differences ($P > 0.05$), while there were significant differences in platelet counts ((236.2 ± 116.1) × 10^9/L, (184.4 ± 89.8) × 10^9/L, and (99.0 ± 58.0) × 10^9/L) with regards to malaria parasite densities of 1–1000 mp/μL, 1001–10,000 mp/μL, and >10,001 mp/μL, respectively ($P < 0.05$).

Table 5 shows the distribution and prevalence of platelet counts in malaria-infected and control subjects. The prevalence of platelet count distributions of <150.0 × 10^9/L and >301.0 × 10^9/L were 37.9% and 15.5% in malaria-infected children compared to 8.6% and 46.6%, respectively, in control subjects. These differences were statistically significant ($P < 0.05$) while the prevalence in platelet count distributions of 150–300.0 × 10^9/L

Table 3. Haematological values of malaria-infected children in relation to sex.

Parameter	Malaria-infected male children	Malaria-infected female children	P-value
Number of subjects	34	24	
Haematocrit (%)	28.3 ± 4.2	29.9 ± 5.2	>0.05
Haemoglobin (g/L)	9.8 ± 1.5	10.3 ± 1.9	>0.05
White blood cell count (×10^9/L)	6.8 ± 2.8	6.7 ± 2.5	>0.05
Platelet count (×10^9/L)	199.8 ± 118.0	190.4 ± 105.0	>0.05
Granulocyte count (%)	50.4 ± 13.7	52.7 ± 16.4	>0.05
Lymphocyte (%)	43.1 ± 12.5	41.3 ± 16.0	>0.05
Mid-cells (%)	6.1 ± 3.1	6.0 ± 1.9	>0.05

Table 4. Influence of malaria parasite density on haematological parameters.

Parameter	1–1000 malaria parasites/mL	1001–10,000 mp/μL	>10,001 mp/μL	P-value
Number of subjects	31	16	11	
Haematocrit (%)	30.2 ± 3.9	27.0 ± 5.4	28.4 ± 5.0	>0.05
Haemoglobin (g/L)	10.4 ± 1.4	9.3 ± 1.9	9.8 ± 1.8	>0.05
White blood cell count (×10^9/L)	7.1 ± 2.9	6.7 ± 2.1	5.8 ± 2.9	>0.05
Platelet count (×10^9/L)	236.2 ± 116.1	184.4 ± 89.8	99.0 ± 58.0	<0.05
Granulocyte count (%)	48.6 ± 11.6	53.8 ± 19.2	55.6 ± 15.2	>0.05
Lymphocyte (%)	44.6 ± 11.2	40.6 ± 18.3	38.8 ± 14.2	>0.05
Mid-cells (%)	6.9 ± 2.2	5.63 ± 1.6	5.61 ± 1.9	>0.05

Table 5. Distribution and prevalence of platelet counts in malaria-infected and control subjects.

Platelet count	Noninfected children (control) (%)	Malaria-infected children (%)	P-value
Number of Subjects	58	58	
$<150.0 \times 10^9$/L	22 (37.9)	5 (8.6)	<0.05
$150.0–300.0 \times 10^9$/L	27 (46.6)	26 (44.8)	>0.05
$>301.0 \times 10^9$/L	9 (15.5)	27 (46.6)	<0.05

in malaria-infected and control subjects showed no significant difference (P > 0.05).

4. Discussion

Haematological changes have been associated with malaria infection and these have been found to involve red blood cells, leukocytes, and thrombocytes (11). However, scanty information on these changes is available in Nigeria, which therefore necessitated this study in Kano, north-western Nigeria, as the findings can further assist in the diagnosis of malaria in infected subjects.

In this study, significantly lower values of haematocrit and haemoglobin concentration have been observed in malaria-infected children compared to the controls, and these findings are in agreement with previous reports (6,11,17). Anaemia in malaria, however, is associated with a combination of haemolysis of parasitised red blood cells, accelerated removal of both parasitised and innocently unparasitised red blood cells, depressed and ineffective erythropoiesis due to tumour necrosis factor alpha, anaemia of chronic disease, and splenic phagocytosis or pooling (18–21).

Divergent views have been expressed on total white blood cell count in malaria-infected subjects as leukopaenia has been reported by some authors (14,17,22) and leukocytosis has also been documented by other authors (23,24). This study has shown, however, that there was no significant difference in total white blood cell count in malaria-infected children compared to control subjects, which agrees with the finding of Maina et al. (11). The different values may be associated with environmental factors, socioeconomic status, or malaria immunity, among other factors (12–14). The study has further revealed that there were no statistically significant differences in granulocyte and lymphocyte counts between malaria-infected and noninfected children, and these findings are in agreement with many earlier reports (11–25) but disagree with the findings of George and Ewelike-Ezeani (17). In some cases of acute malaria, however, lymphopenia has been reported, but this has been associated with redistribution of lymphocytes with sequestration in the spleen (26,27).

Mid-cell (monocytes, eosinophils, and basophils) counts in this study showed no significant difference in malaria-infected children compared to the control subjects. Significantly higher values of monocyte count, however, have been reported by previous authors (11,17).

Thrombocytopaenia has been observed in malaria-infected children in this study, which is consistent with earlier reports (11,17,20). However, thrombocytopaenia in malaria infection has also been associated with sequestration and pooling of the platelets in the spleen, immune-mediated destruction of circulating platelets, and platelets mediating the clumping of *P. falciparum*-infected erythrocytes, leading to pseudo-thrombocytopenia (11,17,28).

There were no significant differences associated with the values of haematocrit, total white blood cell count, platelet count, granulocyte count, lymphocyte count, and mid-cell count in relation to sex in both malaria-infected and control subjects. These findings are consistent with previous reports on haematological values that showed no significant gender variation (29,30).

This study has shown that there was no influence of malaria parasite density on the values of haematocrit, haemoglobin concentration, white blood cell count, granulocyte count, lymphocyte count, and mid-cell count; however, a significantly decreasing platelet count with increasing malaria parasite density was observed. These findings are in line with previous reports (11,14,17).

This study has further revealed that thrombocytopaenia is significantly more prevalent in malaria-infected children than in noninfected subjects. This finding may likely give a clue in the diagnosis of malaria, especially in an endemic area. The high prevalence of thrombocytopenia in this study has been confirmed by earlier reports (11,17,25).

In conclusion, changes in some haematological values in malaria-infected children in this study are associated with anaemia and thrombocytopaenia, irrespective of sex. It is also evident that platelet count determination, among other tests, may possibly be useful in monitoring the response of the patient to therapy, more so as the platelet count decreases when malaria parasite density increases. However, the mild to severe changes associated with the haematological values in malaria-infected children in

this study could be attributed to environmental factors, endemicity, and malaria immunity, among other factors. It is therefore recommended that the determination of platelet count be carried out in febrile or patients with pyrexia of unknown origin as the value could give a clue or further assistance in the diagnosis of malaria infection.

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