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MALARIA: THE RELATIONSHIP OF DIFFERENT ABO BLOOD GROUPS WITH MALARIA

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Abstract:

Background: *Frequency of ABO blood groups had remained changed in different regions according to environmental factors and diseases. Blood group O is highly frequent in areas where malaria had been remained frequent. ABO and Rh blood groups had protective role in diseases as suggested in different studies.*

Objective: *Main objective of current study was concerned to find out the relationship of different ABO blood groups with malaria.*

Design: *This study was cross sectional.*

Setting: *This current research was conducted in the department of medicine, during the period from May 2017 to December 2017 at Peoples Medical College Hospital Nawabshah.*

Sample Size: *After achieving the selection criterion, 385 subjects from either gender with malaria were recruited in the study.*

Material and Methods: *Different variables such as sex, age, address, presence of malaria parasite and blood group of patient were obtained subsequent to brief consultation. Clinical examination of subjects was carried out for malarial diagnosis. Samples of blood for malaria parasite and blood grouping were collected.*

Results: *In385 diagnosed patients **of** malaria, 191 (49.6%) male and194 (50.4%) were females. Plasmodium falciparum were seen in 153 subjects, while plasmodium vivax was detected in 232 cases. Blood grouping was done in all subjects of study who were positive for malaria. Blood group O+ve was observed in 34.8% subjects.*

Conclusion: *The blood group O +ve were commonly associated with malaria.*

Key Words: *Malaria, Malaria Parasite, ABO blood group, Rh blood group.*

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INTRODUCTION:

More than a century had passed discussing association between the malaria and ABO blood types. Worldwide a large number of studies were conducted on this subject; various consequences of blood group (ABO & Rh) were observed on various forms of malarial parasite. The latest literature assessment from worldwide presents contradictions about these consequences among malaria and ABO blood groups[1][2].Vulnerability of life threatening malaria affected by ABO blood grouping still needs clarification. Initially it was advocated that blood group A may be harmful [3][4] and blood group O was considered as defensive[5]. However a decisive case–control study, further possibly confusing malarial risk aspects such as hemoglobin variations were deficient. Two recent studies had concluded that Blood group O is protective against severe malaria [6][7].

Because of the close relationship between parasites and erythrocytes, we can expect that any variation in the latter can change the penetration and establishment of merozoites. Genetic factors play an important role in erythrocyte composition. Studies had suggested the existence of receptors thatparticipateintheadherenceandinvasionoferythrocytesbyparasites. [8] [9] [10] Individuals with blood group O are relatively resistant to severe falciparum malaria [11].

However, reviewed findings from all studies suggested that individuals of blood group O are relatively resistant to severe disease caused by P. falciparum infection [11]**.** It is observed that the severity of the malaria disease even cerebral malaria depends depend upon the rosettes formation of the parasitized erythrocytes. It was observed that rosettes formation of parasitized RBCs were more readily in A,B or AB blood groups in comparison to subjects with blood group O [12]. This difference in rosetting capability were plasmodium falciparum strain dependent, specific predilection of rosetting for other than O blood groups, and not merely a phenomenon of laboratory-proliferated strains, but this rosetting property had similarly isolated in wild clinical isolates belonging from major malarial zones around the ecosphere [13][14][15].

Rationale

In Pakistan studies on relation of ABO blood groups and malaria are infrequent, and most of these were done retrospectively. This study will help in making public health policies. The incidence of ABO blood groups in subjects suffering from malaria will be concluded to isolate whether ABO blood groups have any protective role in the different forms and types of malaria. Further research on Association of ABO blood group with malaria is needed in Pakistan. This study estimates the risk of acquiring malaria in relation to different groups of blood in Pakistani populace.

OBJECTIVE:

Main objective of current study was concerned to find out the relationship of different ABO blood groups with malaria.

Operational Definitions:

Malaria:

Malaria an infectious disease of parasitic protozoans (a single celled micro-organism) related to Plasmodium causing diseases in human beings and also other animals. All the species of plasmodium causes diseases. P. falciparum causes severe diseases, whereas P. vivax, P. ovale and P. malariae usually cause milder forms of disease. P. knowlasi may rarely cause disease in mankind.Thick and thin film microscopy by geimsa staining and/or antigen based rapid diagnostic tests are used for the diagnosis of malaria [16][17].

Blood Group

Blood grouping or typing is the classification of blood that is based on the presence or absence of either antibodies as well as antigenic substances on the surface of erythrocytes. Universal blood grouping system is the ABO system which is the most important system for blood transfusion in humans. Concomitant antibodies to anti-A and anti-B are frequently immunoglobulin M, abbreviated IgM.The blood is grouped as; A, B, AB and O, with +, - or Null denoting RhD status. Isolation of someone's blood group of depends upon the ABO and the RhD antigen [18][19].

DESIGN: This study was cross sectional.

SETTING: This current research was conducted in the department of medicine, during the period from May 2017 to December 2017 at Peoples Medical College Hospital Nawabshah.

SAMPLE SIZE: After achieving the selection criterion, 385 subjects from either gender with malaria were recruited in the study.

Inclusion and exclusion criterion

All patients of either gender with clinical history of malaria and positive malaria parasite antigen (MP/ ICT Antigen) were included and patients not willing for taking part in study, known cases of blood disorders, HBsAg, sickle cell disease were excluded from study.

Ethical consideration

Approval of study was sought from the hospital ethics committee PMCH Nawabshah. Permission for data collection was taken from the head of department of the Medicine. Subjects were thoroughly informed about the objectives and

methods of the study. Written informed consent obtained from adult subjects while ensuring that the data will be kept confidential.

MATERIAL AND METHODS:

Different variables such as sex, age, address, presence of malaria parasite and blood group of patient were obtained subsequent to brief consultation. Clinical examination of subjects was carried out for malarial diagnosis. Samples of blood for malaria parasite and blood grouping were collected. Data was collected through interview based questionnaire. After all aseptic measures blood sample were collected from a vein in all subjects of malaria. Sample size with 95% confidence level and 5% margin of error from total population of about 1.6 million with distribution response rate of 50% were calculated by using Rao Software. Sample size included **385** participants. Blood grouping was done in all subjects with positive antigen for malaria parasite to analyze the frequency of ABO blood groups and malaria parasite.

RESULTS:

A total of 890 patients with fever were tested for malaria and 770 cases were selected for malaria testing out of them 385 were positive for malarial antigen testing while rest were negative. Positive subjects were classified according to ABO blood group. Of these, 385 cases were included after confirmation of parasitaemia with MP and ICT Antigen testing. The distribution of blood groups in this group was significantly different from that of 385 control subjects from the same area.

A total of 385 subjects from either sex were included in current study. There were 191 (49.61%) males and 194 (50.38%) female, the female ratio was slightly higher than male in current study.

The mean age of subjects was 39.06 with standard deviation of 16.35 years; the age ranged between 20 years as minimum while 93 years was maximum age of study subjects.

The frequency and percentage of cases of malaria in blood group A-ve was 4(1.0%), in A+ve 96(24.9%), AB +ve 33(8.6%), AB-ve 0(0.0%), B+ve 110(28.6%), B-ve 0(0.0%), O+ve 134(34.8%) and O-ve 8(2.1%) respectively.

Dominant residence ratio was from rural set up as compared to urban setup. There were 228 (59.22%) subjects who belonged to rural areas while 157 (40.77%) subjects were residents of urban areas. There was dominancy of plasmodium vivax in present study, 232 (60.25%) patients had suffered from malaria due plasmodium vivax, while 153 (39.75%) patients had suffered from plasmodium falciparum.

Different blood groups of patients and control subjects were checked out. The blood group O was dominant group seen in subjects suffering from malaria, a total of 142 (36.88%) subjects of malaria were with blood group O, out of them blood group O+ve was seen in 134 (34.8%) subjects and blood group O-ve was seen in 08 (02.1%). Blood group B was isolated in 110 (28.6%) subjects; all of them were Rh +ve. Blood group A was seen in 100 (25.97%) subjects with malaria, from which blood group A+ve in 96 (24.93%) and A-ve was seen in 04(01.03%) and only 33(08.57%) subjects had blood group AB, which were all Rh +ve.($P<0.05$)

In control subjects blood group O was also dominant and seen in 118 (30.64%), from them Rh +ve blood group was seen in 110 (28.57%) and Rh -ve in 18 (04.67%) subjects, blood group B was detected in 113 (29.42%) out of them 95 (24.7%) were Rh +ve and 18 (04.7%) were Rh –ve. Blood group A was noted in 97 (25.19%) Rh+ve in 85 (22.1%) and Rh-vein 12(03.1%) whereas, AB blood group was isolated 47 (12.20%) from them Rh +ve were 45(11.7%) and Rh –ve 02 (0.5%) of controls. ($P<0.05$)

P. Falciparum was detected in 153 (39.74%) cases in which blood group A-ve 0 (0.0%), A+ve 39(25.5%), AB +ve 12(07.8%), AB-ve 0(0.0%), B+ve 45(29.4%), B-ve 0(0.0%), O+ve 57(37.3%) and O-ve 0(0.0%).

Plasmodium vivax was detected in 232 (60.26%) cases, blood group A-ve04 (01.7%), A+ve 57(24.6%), AB +ve 21 (09.1%), AB-Ve 0(0.0%), B+ve 65(28.0%), B-ve 0(0.0%), O+ve 77(33.2%) and O-vein 08(03.4%) subjects. Chi square values collected and shown pearson chi –square value 8.603, df 5 and Asymp.Sig (2-sided) 0.126, with likely hood ratio of 12.843, df 5 and Asymp.Sig (2-sided) 0.025.

The cross-tabulation of blood groups among controls and patients was statistically significant. In control group; blood type O+ve was seen in 110 (28.6%), blood group O-ve in 18 (04.7%), B+ve 95 (24.7%), B-ve 18 (04.7%), A+ve 85 (22.1%), A-ve 12(03.10%), AB +ve 45(11.7%) and AB –ve 2(0.5%) cases. While in subjects with malaria; blood group A-ve 04(1.0%), A+ve96(24.9%), AB +ve 33(8.6%), AB-ve 0(0.0%), B+ve 110(28.6%), B-ve 0(0.0%), O+ve 134(34.8%) and O-ve in 8(2.1%) respectively.

Chi square values collected and shown pearson chi –square value 1264.838, df 35 and Asymp.Sig (2-sided) 0.000, with likely hood ratio of 948.795, df 35 and Asymp.Sig (2-sided) 0.000.

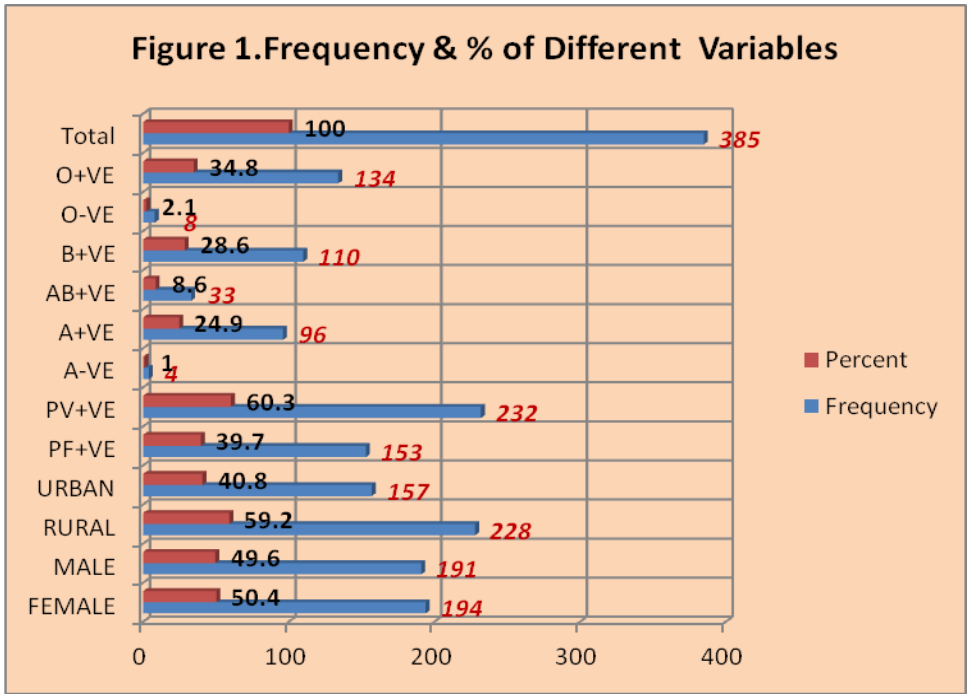

Table 1. Descriptive Statistics. n=385

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
age in years	385	73.00	20.00	93.00	39.0649	.83354	16.35522	267.493

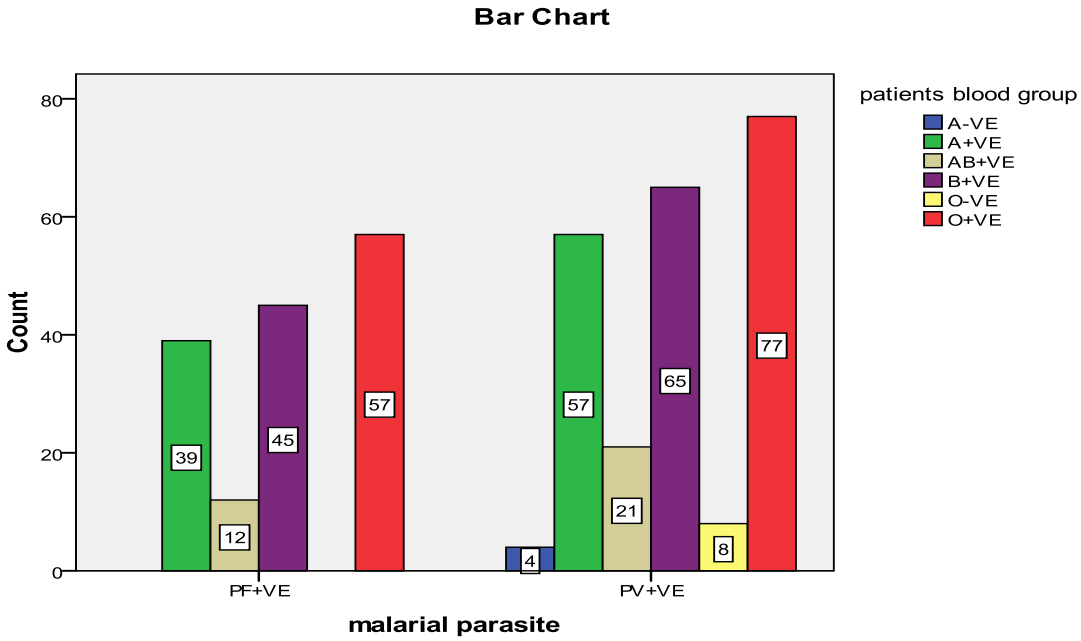

Table 2. Malaria Parasite * Patient's Blood Group Cross Tabulation									
			Patient's Blood Group						
			A-VE	A+VE	AB+VE	B+VE	O-VE	O+VE	Total
Malaria Parasite	PF+VE	Count	0	39	12	45	0	57	153
		% within malaria parasite	.0%	25.5%	7.8%	29.4%	.0%	37.3%	100.0%
	PV+VE	Count	4	57	21	65	8	77	232
		% within malaria parasite	1.7%	24.6%	9.1%	28.0%	3.4%	33.2%	100.0%
Total		Count	4	96	33	110	8	134	385
		% within malaria parasite	1.0%	24.9%	8.6%	28.6%	2.1%	34.8%	100.0%
Chi-Square Tests		Value	df	Asymp. Sig. (2-sided)					
Pearson Chi-Square		8.603	5	.126					
Likelihood Ratio		12.843	5	.025					

Table 3. Control Blood Group * Patient's Blood Group Cross Tabulation									
			Patient's Blood Group						
			A-VE	A+VE	AB+VE	B+VE	O-VE	O+VE	Total
Control Blood Group	A-VE	Count	4	8	0	0	0	0	12
		% within control blood group	33.3%	66.7%	.0%	.0%	.0%	.0%	100.0%
	A+VE	Count	0	85	0	0	0	0	85
		% within control blood group	.0%	100.0%	.0%	.0%	.0%	.0%	100.0%
	AB-VE	Count	0	0	2	0	0	0	2
		% within control blood group	.0%	.0%	100.0%	.0%	.0%	.0%	100.0%
	AB+VE	Count	0	3	31	0	0	11	45
		% within control blood group	.0%	6.7%	68.9%	.0%	.0%	24.4%	100.0%
	B-VE	Count	0	0	0	18	0	0	18
		% within control blood group	.0%	.0%	.0%	100.0%	.0%	.0%	100.0%
	B+VE	Count	0	0	0	92	0	3	95
		% within control blood group	.0%	.0%	.0%	96.8%	.0%	3.2%	100.0%
	O-VE	Count	0	0	0	0	8	10	18
		% within control blood group	.0%	.0%	.0%	.0%	44.4%	55.6%	100.0%
	O+VE	Count	0	0	0	0	0	110	110
		% within control blood group	.0%	.0%	.0%	.0%	.0%	100.0%	100.0%
Total		Count	4	96	33	110	8	134	385
		% within control blood group	1.0%	24.9%	8.6%	28.6%	2.1%	34.8%	100.0%
Chi-Square Tests			Value	df	Asymp. Sig. (2-sided)				
Pearson Chi-Square			1264.838	35	.000				
Likelihood Ratio			948.795	35	.000				

Table 4. frequency & % of different blood groups in patients and controls					
	Control Blood Group			Patients Blood Group	
	Blood Group	Frequency	Percent	Frequency	Percent
Valid	A-VE	12	3.1	4	1.0
	A+VE	85	22.1	96	24.9
	AB-VE	2	.5	0	0.0
	AB+VE	45	11.7	33	8.6
	B-VE	18	4.7	0	0.0
	B+VE	95	24.7	110	28.6
	O-VE	18	4.7	8	2.1
	O+VE	110	28.6	134	34.8
	Total	385	100.0	385	100.0
p-value	0.000			0.000	

DISCUSSION:

A strong correlation of certain diseases had been observed throughout the world with the blood group of the subjects and Malaria was also one of that type disease groups. Studies were carried out all over the globe but yet no such study was conducted in our local set up. Blood groups and its association with type of malaria varies regionally, our aim was to evaluate and check the relationship of blood groups and malaria and to compare results of current study with reports from different regions of globe.

Malaria is widespread throughout Pakistan. Out of all diagnosed cases of malaria it is reported that Plasmodium vivax is dominant and responsible for up to 64%of cases, whereas 36% of malaria cases are attributed to P. falciparum respectively [20].In current study P. vivax was seen in 60.25% (232/385) of subjects whereas P. falciparum was seen in 39.74% (153/385) of malaria cases, results of current study were very similar to above study results. A retrospective cross sectional research conducted during 2009 to 2011 at Agha Khan Hospital Karachi reported that 83.0% cases of malaria had P. vivax, while 17.0% had P. falciparum and they also observed that P. vivax was responsible for severe malaria in 79.9% subjects [21].

Plasmodium is likely to infect any ABO blood group and may cause from mild uncomplicated disease to severe malaria in subjects. Conversely subjects with O blood type had mild uncomplicated malaria infection while subjects with blood group A and B exhibit severe malaria infection. Reports highlighted that incidence of substantial concentrations of P. *falciparum* infection and increased occurrence of severe malaria documented in blood type A and B subjects were more associated to young aged subjects.ABO blood groups harbor mild intensity for P. falciparum infection, but in blood group A there are increased intensities for P. falciparum infection. [22]

Incidence of malaria infection was high in young subjects with blood group A. Incidence of P. falciparum infection was not significantly dissimilar between blood groups of subjects. ($p > 0.05$). In current study blood group A was noted in 96 (24.9%) whereas blood group B was seen in 110 (28.6%) of subjects with malaria.

In subjects with malaria; blood group O+ve was more frequent in comparison to of control subjects, whereas the condition was reversed for blood group A+ve. The distribution of subjects according to ABO blood grouping of this study were nearly parallel to the generally recognized distribution in African people and alsofrom different places with a majority of blood group O predominant in malaria subjects patients, as also observed in current study. [23][24] Blood group O (Rh +ve& -ve) was dominant in current study with 36.88% of subjects.

Different clinical types of malaria were seen in all ABO blood groups however severe malaria like symptoms were revealed more commonly among blood group A and B subjects. Mostly asymptomatic and uncomplicated malaria was observed in subjects with O blood group. [25]

Different studies from various regions show controversy between the association of malaria and various ABO groups. Subjects with O blood type were comparatively protected from severe malaria as compared with other blood groups [6][26][27]. Regardless of the controversy, it was observed in

most studies that blood groups other than O were at significant high risk for severe malaria (life threatening) due to the increased rosette formation [26].

Study from Ethiopia had reported that subjects with blood type O had low incidence for developing severe malaria in comparison to subjects with other blood types [28]. Studies (cross sectional and case control) conducted in different countries as Brazil [29], Gabon [30] and India [31] had shown a significant relationship among ABO groups and malaria disease due to plasmodium falciparum. However reports from different countries around world specially Nigeria, Sudan, India and Colombia did not revealed any relationship among ABO blood types and malaria infection in subjects. It is reported that blood groups A and B had been established as plasmodium co receptor during the process of rosetting and therefore increasing the incidence of severe type of malaria. [32-36].

CONCLUSION:

All the ABO blood groups were infected with plasmodium. Disease caused by plasmodium varied from asymptomatic, mild uncomplicated to very severe malaria disease. Mild malaria infection usually (asymptomatic or mild disease) is usually seen in subjects with having blood group O, whereas blood groups A and B usually causes disease in young subjects and usually have severe type of malaria infection.

Current study highlighted, those young subjects with blood group A and B had high intensities as well as increased frequency occurrence of severe malaria infected with P. falciparum.

Conflict of Interests

The authors declare no conflict of interest for this study.

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Contribution of Authors

AAJ, GMJ and YT planned the current study, also had contribution in all aspects for research as data gathering, scrutiny, explanation and in writing of the document AAJ, BMT, MAS, NMJ took part in the data gathering. The study was supervised by AAJ. The manuscript was read and approved by all writers.

REFERENCES:

1. Uneke CJ. Plasmodium falciparum malaria and ABO blood group: is there any relationship? Parasitol Res. 2007;100:759–765. [PubMed]
2. Cserti CM, Dzik WH. The ABO blood group system and Plasmodium falciparum malaria. Blood. 2007;110:2250–2258. [PubMed]
3. Fischer PR, Boone P. Short report: severe malaria associated with blood group. Am J Trop Med Hyg. 1998;58:122–123. [PubMed]
4. LellB, May J, Schmidt-Ott RJ, et al. The role of red blood cell polymorphisms in resistance and susceptibility to malaria. Clin Infect Dis. 1999;28:794–799. [PubMed]
5. Pathirana SL, Alles HK, Bandara S, et al. ABO-blood-group types and protection against severe, Plasmodium falciparum malaria. Ann Trop Med Parasitol. 2005;99:119–124. [PubMed]
6. Rowe JA, Handel IG, Thera MA, et al. Blood group O protects against severe Plasmodium falciparum malaria through the mechanism of reduced rosetting. Proc Natl AcadSci U S A. 2007;104:17471–17476. [PMC free article] [PubMed]
7. Fry AE, Griffiths MJ, Auburn S, et al. Common variation in the ABO glycosyl-transferase is associated with susceptibility to severe Plasmodium falciparum malaria. Hum Mol Genet. 2008;17:567–576. [PMC free article] [PubMed]
8. Alkawa, M." Miller, L.H Johnson, J and Rabbage, J, Erythrocyte entry by malarial parasite. A moving junction between erythrocyte and parasite. J.Cell Bio, 1978, 77: 72-82,
9. Miller L.H' Mason, S.J, CLYDE, D.F. and McGINNISS, M.H, The resistance factor to P. vivax in blacks. The duffy blood group genotype ,Fy, Fy. New Engl.J.Med. 1976, 295: 302-304,
10. WERTHEMER, S.P AND J.W. plasmodium vivax interaction with the human Duffy blood group glycoprotein: identification of a parasite receptor-like protein. Exp.Parasit. 1989, 69: 340-350.
11. Facer CA, Brown J. ABO blood groups and falciparum malaria. Trans R Soc Trop Med Hyg .1979, 73:599–600PubMedCrossRefGoogle Scholar
12. Barragan A, Kremsner PG, Wahlgren M, Carlson J. Blood group A antigen is a coreceptor in Plasmodium falciparum rosetting. Infect Immun .2000, 68:2971–2975PubMedCrossRefGoogle Scholar
13. Rowe A, Obeiro J, Newbold CI, Marsh K

. Plasmodium falciparum rosetting is associated with malaria severity in Kenya. Infect Immun 199563:2323–2326PubMedGoogle Scholar
14. Treutiger CJ, Hedlund I, Helmby H, Carlson J, Jepson A, Twumasi P, Kwiatkowski D, Greenwood BM, Wahlgren M. Rosette formation in Plasmodium falciparum isolates and anti-rosette activity of sera from Gambians with cerebral or uncomplicated malaria. Am J Trop Med Hyg 1992, 46:503–510PubMedGoogle Scholar
15. Udomsangpetch R, Wählin B, Carlson J, Berzins K, Torii M, Aikawa M, Perlmann P, Wahlgren M. Plasmodium falciparum-infected erythrocytes form spontaneous erythrocyte rosettes. J Exp Med 1989,169:1835–1840PubMedCrossRefGoogle Scholar
16. Caraballo H. "Emergency department management of mosquito-borne illness: Malaria, dengue, and west nile virus". Emergency Medicine Practice. 2014,**16** (5). Archived from the original on 2016-08-01.
17. "Malaria Fact sheet N°94". WHO. March 2014. Archived from the original on 3 September 2014. Retrieved 28 August 2014.
18. Maton, Anthea; Jean Hopkins; Charles William McLaughlin; Susan Johnson; MaryannaQuon Warner; David LaHart; Jill D. Wright. Human Biology and Health. Englewood Cliffs NJ: Prentice Hall. 1993, ISBN 0-13-981176-1.
19. Schmid, P, Okroi M, "Also sprach Landsteiner – Blood Group 'O' or Blood Group 'NULL'", InfusTherTransfus Med, 2001, **28** (4): 206–8, doi:10.1159/000050239
20. World Health Organization. World malaria report: 2011. Geneva: The Organization; 2011.
21. Zubairi ABS , Nizami S , Raza A , Mehraj V, et al. Anita Fazal Rasheed Severe Plasmodium vivax Malaria in Pakistan. Emerg Infect Dis. 2013 Nov; 19(11): 1851–1854. doi: 10.3201/eid1911.130495. PMCID: PMC3837647. PMID: 24188313
22. Price RN, Douglas NM, Anstey NM. New developments in Plasmodium vivax malaria: severe disease and the rise of chloroquine resistance.CurrOpin Infect Dis. 2009;22:430–5 10.1097/QCO.0b013e32832f14c1 [PubMed][Cross Ref]
23. Reid RE, Lomas-Francis C. The blood group antigen (2nd edn). 2004. Elsevier Academic Press.
24. Geoff DS Human blood Groups (3rd edn). 2013. Wiley-Black.
25. Kuete T, Ngaba GP, Kue EK, Mpah EHM, Ekobo AS . Influence of ABO Blood Groups on PlasmodiumfalciparumParasitaemia and Malaria Clinical Types in Outpatients in a Government Hospital of Douala, Cameroon. J Infect Dis Med 2016,1:104. DOI: 10.4172/2576-1420.1000104
26. Rowe JA, Opi DH, Williams TN. Blood groups and malaria: fresh insights into pathogenesis and identification of targets for intervention. CurrOpin Hematol2009,16: 480-487.
27. Bedu-Addo G, Gai PP, Meese S, Eggelte TA et al. Reduced prevalence of placental malaria in primiparae with blood group O. Malaria Journal 2014, 13: 289.
28. Tekeste Z, Petros B. The ABO blood group and Plasmodium falciparum malaria in Awash, Metehara and Ziway areas, Ethiopia. Malaria Journal 2010, 9: 280.
29. Beiguelman B, Alves FP, Moura MM, Engracia V, Nunes AC, et al. The association of genetic markers and malaria infection in the Brazilian Western Amazonian region. Mem Inst Oswaldo Cruz 2003 ,98: 455-460.
30. Migot-Nabias F, Mombo LE, Luty AJ, Dubois B, Nabias R, et al. Human genetic factors related to susceptibility to mild malaria in Gabon. Genes Immun 2000,1: 435-441.
31. Pant CS, Gupta DK, Sharma RC, Gautam AS, Bhatti RM. Frequency of ABO blood groups, sickle cell haemoglobin, G-6-PD deficiency and their relation with malaria in scheduled castes and scheduled tribes of Kheda District, Gujarat. Indian J Malariol 1992, 29: 235-239.
32. Martin SK, Miller LH, Hicks CU, David-West A, Ugbode C, et al. Frequency of blood group antigens in Nigerian children with falciparum malaria. Trans R Soc Trop Med Hyg 1979,73: 216-218.
33. Kassim OO, Ejezie GC. ABO blood groups in malaria and schistosomiasis haematobium. Acta Trop1982,39: 179-184.
34. Bayoumi RA, Bashir AH, Abdulhadi NH. Resistance to falciparum malaria among adults in central Sudan. Am J Trop Med Hyg 1986, 35: 45-55
35. Thakur A, Verma IC. Malaria and ABO blood groups. Indian J Malariol 1992,29: 241-244.
36. Montoya F, Restrepo M, Montoya AE, Rojas W. Blood groups and malaria. Rev Inst Med Trop Sao Paulo 1994,36: 33-38.