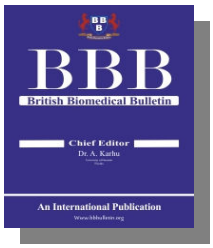
Journal Home Page www.bbbulletin.org

BRITISH BIOMEDICAL BULLETIN



Original

Fetal Hemoglobin Level in Sickle Cell Anaemic Individuals of Yavatmal District, Maharashtra, India

Akanksha R Mahajan, Varsha S. Zade*, Sandeep M. Chede and Kashinath M. Klukarni

Department of Zoology Government Vidarbha Institute of Science and Humanities, Amravati, Sant Gadge Baba Amravati University, Amravati.444601 Maharashtra, India

A R T I C L E I N F O

Received 10 June 2014
Received in revised form 17 June 2014
Accepted 19 June 2014

Keywords:
Sickle cell disease (SCD),
Fetal haemoglobin HbF,
Tribals,
Yavatmal district.

Corresponding author: *Department of Zoology Government Vidarbha Institute of Science and Humanities, Amravati, Sant Gadge Baba Amravati University, Amravati.444601 Maharashtra, India*
E-mail address: zvarsha27@gmail.com

A B S T R A C T

Sickle cell disease (SCD) is a major gene disorder among the tribal population of central India. Fetal Haemoglobin (HbF) is the best-known genetic modulator of sickle cell anaemia, which varies dramatically in concentration in the blood of these patients. The patients with SCA display a remarkable variability in the disease severity. Hence the objective of the present study was to determine the Fetal Haemoglobin (HbF) level in SCD patients (SS), carriers (AS) and normal individuals (AA). Studied population shows the highest HbF level in SS followed by AS individuals and a slightly higher HbF level in SS females than in their male counterparts. Among different age groups the highest HbF% was found in the age group of 11-20 years. And the mean HbF level appears to be declining as age advances

Introduction

Sickle-cell anemia is a hereditary disease produced by haemoglobin S in its homozygous form, (Hb^sHb^s)[1]. It causes a translocation of the amino acid in position 6 of a normal beta globin, transforming glutamic acid into valine, and thus diminishing protein solubility[2]. Haemoglobin is a tetrameric protein compound made up of a complex of four polypeptide chains and four heme groups[3]. It is the oxygen-carrying molecule of RBC, and it makes up approximately 95% of the RBC proteins[4]. In normal adults this protein is composed of 96-98% of HbAA ($\alpha_2\beta_2$), up to 3-5% of HbA_2 ($\alpha_2\delta_2$) and less than 1% of HbF ($\alpha_2\gamma_2$)[5]. In sickle cell disease (SCD) patients produce haemoglobin SS (HbSS) due to a mutation in the β-globin gene cluster[6]. This mutation results in the production of an abnormal version of the beta chain of haemoglobin (HbS), which has difficulty in carrying oxygen properly through the body. However, this disease has been associated with a great phenotypic

heterogeneity and clinical variability[7]. HbF is the most powerful modulator of the cilinical and haematological features of sickle cell anaemia[8]. To protect against various complications of disease, different concentrations of HbF were postulated to be required, although any increment in HbF had a beneficial effect on mortality[9,10].

SCA patients with high HbF levels not only have less severe clinical course, but also have mild clinical complications[11] because an increase in haemoglobin F inhibits polymerization of sickle haemoglobin[12]. Persistent production of variable levels of HbF into childhood and adult life is a characteristic finding in sickle cell anemia and more severe forms of β-thal. HbF levels are also useful for predicting the clinical severity of sickle cell disease (SCD)[13]. HbF and S are heterogeneously distributed within the RBC population of patients with HbSS disease, and their transfusion studies indicated that those RBCs with higher proportions of HbF had longer life spans[14] and distribute the HbF heterogeneously with some red cells (F cells) expressing more HbF than others[15]. The strong relationship existing between HbF level and disease severity in SCA suggests that baseline measurement of percentage HbF is paramount in predicting important aspects of clinical course. Due to the influence of genetic modifiers of SCA like co-existence of α –thalassemia determination of Hb A_2 also become necessary[16]. Hence, this study deals with the status of HbF, HbS , HbA and HbA_2, level in SCD patients (SS), sickle cell carriers (AS) and normals (AA) of tribal individuals belonging to Yavatmal district.

Materials and Methods

Authors had Collaboration with Anthropological Survey of India, Ministry of Culture, Department of culture, Government of India. Hence, ethical committee approval was procured by Anthropological survey of India, Nagpur Central Regional Centre, Nagpur. Prior consent was taken from each individual under study. A total of 100 individuals belonging to 7 different tribal castes were screened for SCD in some tribal villages from Yavatmal district from February 2013 to June 2013. Blood samples were collected from SCD patients, carriers and controls into Ethylene Diamene Tetraacetic Acid (EDTA) anticoagulant by organizing screening camps in co-ordination with the officials from Primary Health Centers as well as Sub-district and Rural Hospitals. Sebia Capillary Electrophoresis (CE) is the approved method offers quantitation and detection of normal and abnormal haemoglobins, as an aid in the diagnosis of hemoglobinopathies. CE also provide very enhanced resolution and foculisation in the separation of HbA_2, HbF, HbA and S especially useful in Sickle Cell anaemia diagnosis[17-19]. Sebia Capillarys Electrophoresis was used for detecting the levels of HbA, HbA_2, HbS and HbF of all the individuals at the laboratory of Anthropological survey of India, Nagpur Central Regional Centre, Nagpur.

Results

In our study, level of HbF was found to be highest in SS individuals (22.15±1.162), negligible in AS (1.01±0.32) and not found in AA individuals. Similarly, the highest level of Hb S was seen in SS individuals (74.81±0.97), moderate in AS (34.78±0.98) and not seen in AA individuals However, the level of Hb A was found to be highest in AA individuals (97.14±0.13), moderate in AS (61.18±1.20) and negligible in SS individuals (1.94±0.65). Whereas, Hb A_2 was observed in minute quantity in SS (2.48±0.26), AS (2.84±0.06) and AA (2.74±0.13) individuals (Table I.).

When the level of Hb F was compared between SS male and female individuals, it

was found that, Hb F was higher in female (22.85±1.62) than their male counterparts (20.76±1.24). However, the level of Hb S was more in male (76±1.16) than their female counterparts (74.21±1.33) (Table II.).

In different age groups differing level of Hb F was observed. In the age group <10 YRS level of Hb F was found to be (21.55±1.80), slightly higher in 11-20 YRS (23.6±3.39). In the 21-30 YRS of age group it was (22.63±3.75) and slightly lower in >31 YRS (21.6±1.79). It was also observed that the mean HbF level appears to be declining as age advances. Similarly, the level of Hb S varies according to level of Hb F (Table III and Fig I.).

Discussion

The level of Hb F was found to be highest in SS individuals (22.15±1.162) followed by AS individuals (1.01±0.32). In three different studies conducted at Nigeria a mean fetal haemoglobin level of (5.16±4.04)[16], (6.4±4.0)[20] and (7.4±3.6)[13] was reported in SS individuals. A similar study performed in Calabar, Nigeria, reported that the mean HbF value in HbSS subjects was higher (3.05±1.61%) than in HbA (0.20±0.25%) and HbAS (1.07±0.98%) subjects[21]. The variations in the HbF levels in HbSS patients and others from different localities could be due to common single-nucleotide polymorphisms (SNPs) at the BCL11A and HBS1L-MYB loci, which have been implicated previously in HbF level variation in non-anemic European populations[22]. An association between a BCL11A SNP and HbF levels in a SCD cohort study in the USA has also recently been demonstrated. A report on human HbF expression also supports this claim, suggesting that the BCL 11A gene is a potential regulator of HbF expression[23].

The HbF level in SS females (22.85±1.62) was recorded higher as compared to SS males (20.76±1.24) and the difference was statistically significant ($p<0.001$). However, another study showed statistically higher value of HbF in males than in females[13]. The mean HbF level was higher in females than in males, with female HbSS and HbSC subjects having the highest mean HbF level. This is in agreement with a study showing that, after the age of 10, HbF levels were consistently higher in females than in males, and this was statistically significant[24]. The difference between males and females was suspected to be due to the hormonal effects of puberty. In a study estimating HbF levels in SCD, male sickle cell patients were found to have significantly lower levels of HbF than their female counterparts[25].

When the level of HbF was compared among different age groups, highest value was observed in the age group of 11-20 year (23.6±3.39) followed by 21-30 year (22.63±3.75) and then >30 years(21.6±1.79). When age is considered, the 1-10-year age group had the lowest mean HbF level (21.55±1.80) among all hemoglobin genotypes and the relationship was statistically significant ($P<0.05$). The mean HbF level appears to be declining as age advances[16]. This increased HbF level is a compensatory mechanism for sickling in SS subjects because HbF reduces the tendency of HbS to polymerize within the red cell[26]. This highlights the need to determine HbF along with HbA_2 in assisting to differentiate HbSS, HbS-beta-thalassemia and HbS-HPFH and hence determination of HbA_2 and HbF should graduate from research activity to routine tool in order to project the management of SCA to a level where the clinical course among others could be easily predicted at diagnosis.

Genetic studies have established that increased HbF level may result from rare deletions within the betaglobin gene cluster or from point mutations in the promoters of the fetal gamma-globin genes (hereditary persistence of fetal haemoglobin, HPFH), however, additional loci are known to

increase HbF levels in adult life, which has been identified using combination of genome-wide analysis within a large kindred[27].

Conclusion

Within the study population, the HbF level was found to be highest in HbSS and very low in HbAS and HbAA. In SS subjects the HbF level is higher compared to other hemoglobin variants. When the HbF status was compared between SS males and females, it was found that the level of HbF was higher in HbSS females than their male counterparts. However, the highest level was recorded for the age group 11-20 years when compared with different age groups. It is highly imperative to always estimate not only the levels of HbF, but also of HbA_2 so as to be able to clearly define the clinical course of every sickle cell disease patient.

Acknowledgment

Authors are grateful to Anthropological survey of India, Nagpur Central Regional Centre for providing the laboratory facilities and their guidance wherever needed.

Author's Contribution

AR Mahajan and SM Chede collected the blood samples and performed the Capillary Electrophoresis and participated in its design, coordination and acquisition of data and drafted the manuscript. VS Zade and KM Kulkarni conceived of the study and made substantial contributions to conception and design, analysis and interpretation of data and had given final approval for publishing.

References

1. Rastogi RB. Modern Biology, In Chapter: 22, Heredity and Variation, Pritambar Publishing Co. Pvt. LTD, New Dellhi. 1997;IV-29.
2. Mehanna AS. Sickle cell anemia and antisickling agents then and now. *Curr Med Chem*, 2001;8(2):79-88.
3. Adachi K, Kim J, Asakura T, Schwartz E. Characterization of two types of fetal hemoglobin: alpha2 G gamma2 and alpha2 Agamma2. Blood; 1990;75(10):2070-2075.
4. Harmening DM, Lasky L, Latchaw P. Blood preservation: historical perspectives, review of metabolism and current trends; in Modern blood banking and transfusion practices; 4th (ed) DM Harmening Philadelphia, PA: F.A. Davis co.;1999.
5. Cheesbrough M. Part District laboratory practice in Tropical Countries, Cambridge; 1. 2nd ed UK: Cambridge University press; 2006;268–285.
6. Reid HJ, Photiades DP, Ukponmwan VO and Osamo O. Concurrent diabetes mellitus and the haemoglobinopathies: A Nigerian Study, IRCS Med. Sci.;1984;12:853.
7. Steinberg MH. Predicting clinical severity in sickle cell anemia. *Br J Haematol*. 2005;129:465-81.
8. Sebastiani P, Wang L, Naloan VG, Melista E, Ma Q, Baldwin CT, Steinberg MH. Fetal Hemoglobin in sickle cell anemia: Bayesian modelling of genetic associations. *Am J Hematol*. 2008;83:189-195.
9. Powars D, Weiss JN, Chan LS, Schroeder WA. Is there a threshold level of fetal hemoglobin that ameliorates morbidity in sickle cell anemia? Blood. 1984;63(4):921-926.
10. Platt OS, Brambilla DJ, Rosse WF, Milner PF, Castro O, Steinberg MH, Klug PP. Mortality in sickle cell disease: life expectancy and risk factors for early death. *N Engl J Med*. 1994;330:1639-1644.
11. Higgs DR, Aldridge BE, Lamb J, Clegg JB, Weatherall DJ, Hayes RJ, Lowrie J. et al. The interaction of thalassemia and homozygous sicklecell disease. *N Engl J Med*. 1982;306: 1441–1446.
12. Akinsheye1 I, Alsultan A, Solovieff N, Ngo D, Baldwin CT, Sebastiani P, Chui DHK, and Steinberg MH. Fetal hemoglobin in sickle cell anemia Blood: 2011; 118(1).
13. Kotila TR, Fawole OI, Shokunbi WA. Haemoglobin F and clinical severity of

sickle cell anaemia among Nigerian adults. *Afr J Med Sci*. 2000;29(3-4):229-31.
14. Singer K, Fisher B. Studies on abnormal hemoglobins. V. The distribution of type S (sickle cell) hemoglobin and type F (alkali resistant) haemoglobin within the red cell population in sickle cell anemia. Blood. 1952;7:1216-1226.
15. Murphy VK, and Haywood LJ. Comparative survival curve analysis in sickle cell disease. Applied Mathematics and computation. 1981;9(2):143-152.
16. Olaniyi JA, Arinola OG, Odetunde AB. Foetal haemoglobin (hbf) status in adult sickle cell anaemia patients in ibadan, Nigeria. *Annals of Ibadan Postgraduate Medicine*. 2010;8: 30-33.
17. Chen FT, Liu CM, Hsieh YZ, Sternberg JC. Capillary electrophoresis—a new clinical tool. Clin Chem. 1991;37:14–19.
18. Gulbis B, Fontaine B, Vertongen F, Cotton F. The place of capillary electrophoresis techniques in screening for haemoglobinopathies. *Ann Clin Biochem*. 2003;40:659–662.
19. Ishioka N, Iyori N, Noji J, Kurioka S. Detection of abnormal haemoglobin by capillary electrophoresis and structural identification. Biomed Chromatogr. 1992;6:224–226.
20. 20 Enosolease ME, Ejele OA, Awodu OA. The influence of foetal haemoglobin on the frequency of vaso-occlusive crisis in sickle cell anaemia patients. Niger Postgrd Med J. 2005;12(2):102-105.
21. Uko EK, Useh MF, Gwanmesia FN. Frequency of foetal haemoglobin and haemoglobin values in various haemoglobin genotypes in Calabar, Nigeria. *East Afr Med J*. 1997;74:809–811
22. Uda M, Galanello R, Sanna S, Lettre G, Sankaran VG, Chen W, Usala G, Busonero F et al. 2008 Genome-wide association study shows BCL11A associated with persistent fetal hemoglobin and amelioration of the phenotype of beta-thalassemia. *Proc Natl Acad Sci USA*105:1620–1625.
23. Sankaran VG, Menne TF, Xu J, Akie TE, Lettre G, Van Handel B, Mikkola HK, Hirschhorn JN, Cantor AB, Orkin SH. Human fetal hemoglobin expression is regulated by the developmental stage-specific repressor BCL11A. Science. 2008;322:1839–1842.
24. Maude GH, Hayes RJ and Serjeant G. The haematology of steady state homozygous sickle cell disease: interrelationships between haematological indices. *Br J Haematol*. 1987;66:549–558.
25. Mason KP, Grandison Y, Hayes RJ, Serjeant BE, Serjeant GR, Vaidya S, Wood WG. Post-natal decline of fetal haemoglobin in homozygous sickle cell disease: relationship to parenteral Hb F levels. *Br J Haematol*. 1982;52:455–463.
26. Wood WG. Increased HbF in adult life. Baillieres Clin Haematol. 1993;6:177-213.
27. Thein SL, Sampietro M, Rohde K, Rochette J, Weatherall DJ, Lathrop GM, Demenais F. Detection of major gene for hetrocellular hereditary persistence of foetal haemoglobin after accounting for genetic modifiers. *American Journal of Human Genetics*. 1994;54:241-228.

Table 1. Show the values of Mean±SE of different Hemoglobin variants in SS, AS and AA individuals

Parameters	Sickle cell patient (SS) n=40		Sickle cell gene carrier (AS) n=30		Normal (AA) n=30	
	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range
Hb A	1.94±0.65	0.3-3.5	61.18±1.20	26-71.1	97.14±0.13	94.6-97.9
Hb F	22.15±1.162	10.7-37.4	1.01±0.32	0.3-1.9	0	0
Hb S	74.81±0.97	61.1-85.8	34.78±0.98	26.7-40.8	0	0
Hb A_2	2.48±0.26	0.3-5.8	2.84±0.06	1.8-3.5	2.74±0.13	1.9-5.4

Table 2. Showing comparison of Mean±SE of different Hemoglobin variants of SCD males and females compared with that of normal males and females.

Parameter	Sickle cell patient (SS)				Normal (AA)			
	Males n=20		Females n=20		Males n=15		Females n=15	
	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range
Hb A	0.47±0.47	0.3.3	1.47±0.66	0-3.5	97.03±0.23	94.5-97.7	97.21±0.16	94.6-97.9
Hb F	20.76±1.24	16-27.3	22.85±1.62	11.4-37.4	0	0	0	0
Hb S	76±1.16	70.5-81.2	74.21±1.33	61.1-85.8	0	0	0	0
Hb A_2	2.87±0.42	1.5-5.5	2.29±0.34	0.7-5.5	2.85±0.25	1.9-5.5	2.67±0.15	2.1-5.4

Table 3. Show the comparison of Mean±SE of different Hemoglobin variants of SCD patients belonging to different age groups. (n=10)

Parameter	<10 YRS		11-20 YRS		21-30 YRS		>31 YRS	
	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range
Hb A	0.97±0.62	0-3.5	0	0	0	0	0.97±0.59	0-3.3
Hb F	21.55±1.80	14.2-30.5	23.6±3.39	11.4-37.4	22.63±3.75	16-29	21.6±1.79	10.7-28.7
Hb S	75.1±1.45	68-77.6	74.14±3.15	61.1-85.8	75.03±3.37	69.9-81.2	74.92±1.25	69.6-80.3
Hb A_2	2.67±0.47	1.4-2.8	2.21±0.33	1.2-3.4	1.63±0.61	0.7-2.8	2.74±0.60	0.3-5.5

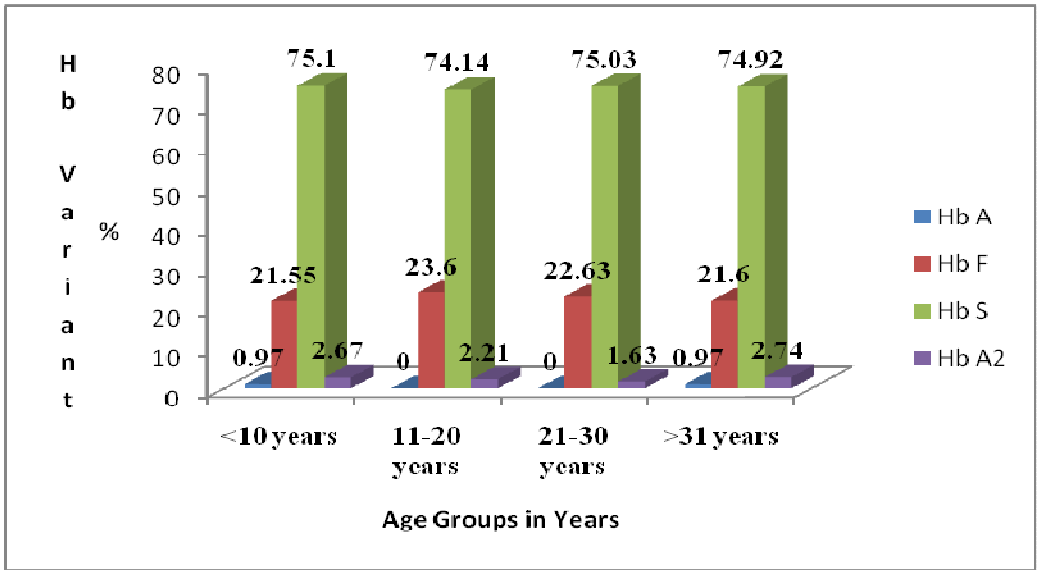


Figure 1. Showing the HbA%, HbF%, HbS% and HbA2% in SS patients of different age groups