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Original Research Article

Haemoglobin variants seen in a secondary care hospital of Nagaland, India

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ABSTRACT

Background: Haemoglobinopathies is one of the commonest Globin gene disorders in the world, especially in South east Asia and in India the Northeastern regions in particular. These conditions represent a major health burden with significant morbidity and mortality and cause considerable social and financial burdens. However, there is a scarcity of data on haemoglobinopathies or haemoglobin (Hb)variants among the population of Nagaland a Northeastern states of India. This retrospective study was conducted with an aim to fill the data gap on various Hb Variants in the region.
Methods: The present study is a retrospective study, conducted in secondary hospital in Nagaland. A total of 646 Hb high-performance liquid chromatography (HPLC) and complete blood count (CBC) data were collected from patients whose sample were sent to laboratory for Hb variants screening.
Results: In a total of 646 patient data analysed, 44.27% had a normal Hb HPLC pattern, while 55.73% shows abnormal Hb variants. HbE homozygous was observed in 23.84%, heterozygous HbE 16.56%, heterozygous β-thalassemia 9.44%, heterozygous sickle cell 2.17%, homozygous sickle cell/sickle cell β-thalassemia1.86%, Compound form of HbE homozygous with β-thalassemia 0.93%. Among the Hb variants detected, HbE variants is the commonest variants.
Conclusions: The study analysed 646 samples using HPLC, finding over half 55.73% with abnormal haemoglobin patterns, mainly HbE variants. As Scarcity of data is seen in the region, this study provides an important baseline for future research highlighting the need for screening, genetic counselling, and molecular studies.

Keywords: Haemoglobinopathies, Haemoglobin Variants, HbE, Northeast India, Nagaland

INTRODUCTION

Hemoglobinopathies or haemoglobin (Hb) variants are common genetic disorder of haemoglobin molecule. Worldwide, hemoglobinopathies accounts for about 7% of the population, this is one of the world's major health concern.[1] In India, 4.52% of the screened population have been identified as considerable carriers of beta-thalassemia trait and about 11% affected by some form of hemoglobinopathy.[2] Hemoglobinopathies are highly prevalent in North-East India, mostly studied in Assam with the prevalence of 50-60%.[3,4] Therefore, screening for haemoglobinopathies or Hb variants are important in this part of the world when a patient is presented with anemia and also if there is a family history of hemoglobinopathies.[1,5]

The mutation in hemoglobinopathies or Hb variants can be divided into two main groups. The thalassaemic syndrome and structural Hb variants. Both are caused due to mutation in either α or β globin genes giving rise to abnormal hemoglobin variants.[6,7]

α-thalassemia are caused due to mutation in α-globin gene and β-thalassemia are caused due to mutation in β- globin gene. β-thalassemia are most commonly seen in South-East Asia. Major complications are risk of iron overload or multi organ failure, and are long term transfusion

dependent.[3,8] Apart from thalassemia, structural Hb variants such as HbE, HbS, and HbC can also be seen. HbE is predominantly seen in the North east region of India.[3,9,11]

HbE when synthesized at a reduced rate, it behaves like β-thalassemia.[12] This leads to thalassaemic phenotype. HbE can be seen as heterozygous, homozygous or compound HbE β-thalassemia form. Heterozygous HbE usually are clinically asymptomatic, homozygous HbE can show mild to severe anemia. While compound HbE β-thalassemia form can result in moderate to severe anemia leading to transfusion dependent anemia.[12-15]

High performance liquid chromatography (HPLC) has become a widely used tool for the assessment of hemoglobinopathies or Hb variants. HPLC gives accurate separation and quantification of HbA, HbA2, HbF and other Hb variants. Elevated HbA2 is characterized by β-thalassemia trait, where the other peaks identify HbE, HbS and other structural variants.[16,17] Along with the HPLC, complete blood count (CBC) is also done for screening of Hb variants.

In North East India, HbE is the most prevalence Hb variants. However, the spectrum of hemoglobinopathies or Hb variants in North East India especially in State like Nagaland remains insufficiently characterized or understudied. This can be due to less data available or lack of comprehensive population studies.[18-21]

Many haemoglobinopathies or Hb variants shows variable in their clinical presentation, some shows mild to moderate anemia not needing major medical intervention to some showing severe anemia leading to transfusion dependent. So, early detection of haemoglobinopathies or Hb variants is key to reduce the disease burden in population.[17,22-24]

Haemoglobinopathies or Hb variants continue to possess a major health challenge in north east India particularly in the state of Nagaland because of the scarcity of data. Thus, this study aims and hope to fill the data gap by looking at the Spectrum of Hb variants in the patient coming to Secondary hospital in Nagaland which in turn will help understand the possible disease burden in the population and also opens door for further research.

METHODS

Study design and place

The present study is a retrospective study, where data of the patient who has undergone testing for Hb variants by Hb HPLC testing in Bio-Rad D10 instrument and complete blood count (CBC) in Sysmex XS-800i and XN-550 cell analyser in laboratory department of a secondary hospital in Nagaland. The study hospital in Nagaland is located in the border with Assam, caters to patients from Nagaland, Assam, Manipur, Mizoram, Meghalaya, Tripura and Arunachal Pradesh. Maximum being from Nagaland and Assam.

Study period

The data was collected from November 2017 to April 2024.

Subject recruitment

Patient who has undergone testing for Hb variants by Hb HPLC testing in laboratory department of a secondary hospital in Nagaland.

Inclusion criteria

Patient sample send to Department of Laboratory Sciences for testing of Hb variants by Hb HPLC were included.

Exclusion criteria

Incomplete data were excluded from the study.

Sample size

A total of 646 patient data on Hb HPLC and CBC were collected for analysis.

Statistical analysis

Data analysis was done by using Microsoft Excel 2021 version. Descriptive statistics, including frequencies, percentages, mean and Standard deviation were calculated.

RESULTS

A total of 646 patient samples data for Hb HPLC and CBC from November. 2017 to April 2024 were included in the study. The spectrum of Hb variants showed that 286 cases (44.27%) had a normal HPLC pattern, while 360 cases (55.73%) demonstrated Hb variants. Figure 1 shows the distribution of normal and Hb variants pattern.

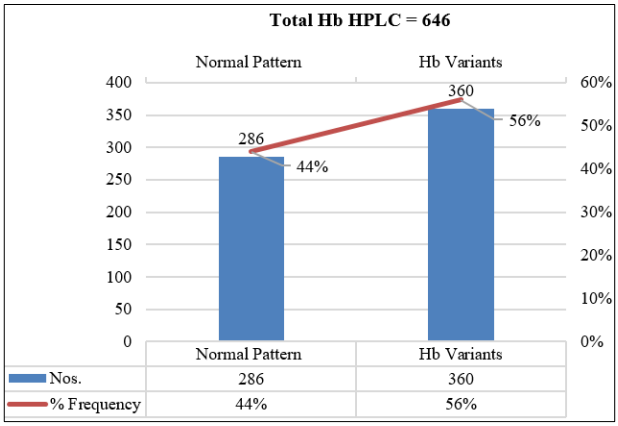

Figure 1: Histogram for normal pattern and Hb variants.

Table 1 shows The Hb variants detected and their frequency, HbE homozygous was observed in 154 cases

(23.84%), heterozygous HbE in 107cases (16.56%), heterozygous β-thalassemia in 61 cases (9.44%), heterozygous sickle cell in 14 cases (2.17%), homozygous sickle cell/sickle cell beta thalassemia in 12 cases (1.86%), compound form of HbE homozygous with β-thalassemia in 6 cases (0.93%), homozygous β-thalassemia in 4 cases (0.62%), HbD Punjab trait in 1 case (0.15%), and Hb Lepore in 1 case (0.15%). Among the Hb variants detected, HbE variants is the commonest variants.

Table 1: Total Hb variants seen.

Hb variants seen	N	Frequency (%)
HbD (Punjab) trait	1	0.15
Hb Lepore	1	0.15
HbE homozygous	154	23.84
HbE homozygous/HbE with beta thalassemia	6	0.93
Heterozygous beta thalassemia	61	9.44
Heterozygous HbE	107	16.56
Heterozygous sickle cell	14	2.17
Homozygous beta thalassemia	4	0.62
Homozygous sickle cell/sickle cell beta thalassemia	12	1.86
Normal pattern	286	44.27
Grand total	646	

Gender wise distribution of Hb variants is shown in Table 2. The present study has more female participants than male. As Hb variants (haemoglobinopathies or thalassemia) are autosomal recessive gene inherited disorder, both the gender can be equally effected.

Table 3 present the state-wise distribution of Hb variants. In the study the majority of Hb variants cases were seen from Assam (344 cases) and followed by Nagaland (291 cases), with a small proportion from other Northeastern states (11 cases). In Assam, HbE homozygous was the predominant variant, showing 123 cases (35.76%), followed by heterozygous HbE (17.15%) and heterozygous β-thalassemia (8.43%). In Nagaland, heterozygous HbE shows 43 cases (14.78%), HbE homozygous shows 31 cases (10.65%), and heterozygous β-thalassemia 31 cases (10.65%) were observed.

Table 2: Gender wise distribution of Hb variants.

Hb variants seen	Gender	
	Female	Male
HbD (Punjab) trait	1	0
Hb Lepore	1	0
HbE homozygous	87	67
HbE homozygous/HbE with beta thalassemia	4	2
Heterozygous beta thalassemia	36	25
Heterozygous HbE	61	46
Heterozygous sickle cell	6	8
Homozygous beta thalassemia	2	2
Homozygous sickle cell/sickle cell beta thalassemia	6	6
Normal pattern	178	108
Grand total	382	264

Along with HPLC, the study also collected CBC report for all the Hb variants. From that mean and standard deviation of haemoglobin fractions and red cell indices (MCV, MCH, and RDW) were calculated. Table 4 shows the detail mean and SD for Hb variants and red cell indices observed.

Overall, HbE variants (heterozygous or homozygous and compound HbE/beta thalassemia) was the most prevalent cases seen in the study. Particularly among patients from Assam and Nagaland. The red cell indices across different variants demonstrated characteristic microcytic hypochromic changes with variable degrees of anaemia.

Table 3: State wise distribution of Hb variants as per the study.

State wise distribution of Hb variants as per the study	N	Frequency (%)
Assam		
HbD (Punjab) trait	1	0.29
Hb lepore	1	0.29
HbE homozygous	123	35.76
HbE homozygous/HbE with beta thalassemia	4	1.16
Heterozygous beta thalassemia	29	8.43
Heterozygous HbE	59	17.15
Heterozygous sickle cell	8	2.33
Homozygous beta thalassemia	2	0.58
Homozygous sickle cell/sickle cell beta thalassemia	10	2.91
Normal pattern	107	31.10
Total	344	
Nagaland		
HbE homozygous	31	10.65
HbE homozygous/HbE with beta thalassemia	2	0.69

Continued.

State wise distribution of Hb variants as per the study	N	Frequency (%)
Heterozygous beta thalassemia	31	10.65
Heterozygous HbE	43	14.78
Heterozygous sickle cell	6	2.06
Homozygous beta thalassemia	2	0.69
Homozygous sickle cell/sickle cell beta thalassemia	2	0.69
Normal pattern	174	59.79
Total	291	
Other Northeastern states (Arunachal, Meghalaya, Mizoram and Tripura)		
Heterozygous beta thalassemia	1	9.09
Heterozygous HbE	5	45.45
Normal pattern	5	45.45
Total	11	
Grand Total	646	

Table 4: Mean and standard deviation for Hb variants and red cell indices.

Hb Variants	HbF%	HbA2%	Hb S%	HbO%	Hb g/dl	MCV Fl	MCH Pg	RDW CV	RBC mill/ul
HbE homozygous	4.7±3.2	83.0±9.2	0	9.9±6.7	8.6±2.2	61.0±6.8	20.4±3.4	18.3±2.7	4.4±1.1
HbE homozygous/HbE with beta thalassemia	35.0±12.0	55.3±10.1	0	7.7±1.5	4.7±2.3	63.2±4.7	20.6±4.7	32.9±5.3	2.5±1.3
Heterozygous beta thalassemia	2.1±3.7	5.3±1.2	0	78.1±11.3	8.9±2.8	71.8±13.3	22.6±5.1	18.4±4.2	4.2±1.4
HbE heterozygous	1.7±2.4	26.4±4.4	0	60.3±13.6	10.0±2.7	74.6±8.8	23.7±3.7	16.1±4.6	4.2±1.0
Heterozygous sickle cell	2.1±2.7	5.5±7.4	25.1±4.5	60.6±7.2	9.2±3.3	70.5±10.9	23.3±6.1	18.9±7.8	4.0±1.3
Homozygous beta thalassemia	61.4±13.0	15.0±18.6	0	7.7±2.6	2.7±1.4	62.9±2.7	19.4±2.0	33.4±3.3	1.4±0.8
Homozygous sickle cell/sickle cell beta thalassemia	18.7±5.3	3.3±1.5	67.8±5.4	5.8±3.0	6.6±2.4	77.9±11.4	25.9±4.7	18.3±4.4	2.8±1.0

DISCUSSION

The present study shows a significant prevalence of haemoglobinopathies in Northeast India, particularly among populations from Nagaland and Assam. Of the 646 samples screened by HPLC, 55.73% showed haemoglobin variants, which is higher than the national Indian average of 11%, indicating a high burden of haemoglobinopathies in the study population.[2] A total of nine Hb variants and their compound forms were identified, which include HbE homozygous, HbE heterozygous, compound HbE β-thalassemia, β-thalassemia heterozygous and homozygous, heterozygous sickle cell, homozygous sickle cell/compound sickle cell β-thalassemia, HbD Punjab, and Hb Lepore. These findings are consistent with previous studies.[3,4,18]

HbE variants were the most commonly detected Hb variants in the present study, with HbE homozygous accounting for 23.84%, HbE heterozygous for 16.56%, and compound HbE homozygous with β-thalassemia for 0.93%. These findings are consistent with the high prevalence of HbE reported in Northeastern India by Baruah et al, where HbE homozygous and heterozygous cases were 21.02% and 25.48%, respectively.[18] In comparison, studies from West Bengal by Mondal et al reported lower frequencies, with HbE heterozygous at 3.02% and HbE homozygous at 0.34%.[25] Similarly, the ICMR multicentric study by Mohanty et al conducted across six Indian cities reported HbE prevalence ranging from 0–66.6%, with the highest burden observed in Northeast India.[26] These findings highlight the higher prevalence of HbE variants in Northeast India and indicate that, despite the smaller sample size, the present study

contributes valuable data toward bridging the existing epidemiological gaps in Nagaland.

β-thalassemias and their association with HbE and HbS represent a major public health concern in India, contributing substantially to high morbidity and mortality rate.[26] The present study detected heterozygous β-thalassemia 9.44% homozygous β-thalassemia 0.62% and compound HbE β-thalassemia 0.93%. ICMR multicentric study shows the prevalence of β-thalassemia varied from 0 to 10.5 %.[26] However, study from West Bengal shows slightly higher percentage in homozygous β-thalassemia with detection percentage at 1.66%.[25]

The present study also detected heterozygous sickle cell of 2.17%, homozygous sickle cell/sickle cell beta thalassemia of 1.86%, HbD Punjab trait 0.15%, and Hb Lepore 0.15% which is lesser in comparasion to HbE and beta thalassemias variants.

In the study, state-wise distribution showed a higher frequency of Hb variants in Assam, where HbE homozygous was most common with 35.76% and HbE heterozygous shows 17.15%, while in Nagaland HbE heterozygous is relatively higher with 14.78 and HbE homozygous shows 10.65%. In the study HbE detected in Nagaland is lower than that of Assam state but it is higher than national average of 11% as whole for Hb variants detected.[2] This reflects regional variation in haemoglobinopathy patterns.

Along with the HPLC data, complete blood count data was collected and analysed. CBC parameters demonstrated characteristic microcytic hypochromic changes with low MCV and MCH values across most Hb variants, along with varying degrees of anemia and raised RDW(CV). Severe anemia and markedly elevated HbF were observed in homozygous β-thalassemia and HbE/β-thalassemia cases. These hematological patterns may help differentiate haemoglobinopathies from nutritional anemia and support early screening using routine CBC findings (Table 5).

Table 5: Comparison of complete blood count findings (red cell indices) in various Hb variants among different studies.

Variant	Parameter	Present study	Khera et al[17] (2015)	Buruah et al[18] (2014)	Mondal et al[25] (2016)
HbE homozygous	Hb (g/dl)	8.6±2.2	5.2	8.9±2.0	8.1±1.5
	MCV (fl)	61±6.8	58.6	62.7±7.1	66.9±3.4
	MCH (pg)	20.4±3.4	15.6	20.2±4.8	20.8±2.8
	RDW (cv)	18.3±2.7	18.3	16.7±2.5	
	RBC (mill/ul)	4.4±1.1	2.65	4.5±1.9	3.5±0.8
Heterozygous HbE	Hb (g/dl)	10.0±2.7	9.5±3.5	9.6±2.7	10.3±3.5
	MCV (fl)	74.6±8.8	70.3±9.2	74.3±8.5	82.0±3.6
	MCH (pg)	23.7±3.7	22.3±2.7	24.1±3.7	25.8±2.0
	RDW (cv)	16.1±4.6	18.8±7.0	15.6±2.8	
	RBC (mill/ul)	4.2±1.0	4.47±1.5	4.0±1.4	3.7±2.0
HbE homozygous/HbE beta thalassemia	Hb (g/dl)	4.7±2.3	4.9±1.9	5.8±2.6	7.9±0.8
	MCV (fl)	63.2±4.7	71.7±5.8	67.0±9.9	66.3±6.5
	MCH (pg)	20.6±4.7	19.6±1.8	20.7±3.9	18.7±3.0
	RDW (cv)	32.9±5.3	31.9±5.3	23.6±4.6	
	RBC (mill/ul)	2.5±1.3	2.5±0.7	2.9±1.3	3.3±0.7
Heterozygous beta thalassemia	Hb (g/dl)	8.9±2.8	9.3±2.7	7.9±3.4	9.5±1.7
	MCV (fl)	71.8±13.3	62.7±7.7	71.1±11.1	70.1±5.8
	MCH (pg)	22.6±5.1	19.5±2.5	22.4±4.3	21.0±3.2
	RDW (cv)	18.4±4.2	19.5±4.4	18.2±4.9	
	RBC (mill/ul)	4.2±1.4	5.18±2.7	3.6±1.5	4.1±1.3
Homozygous beta thalassemia	Hb (g/dl)	2.7 ±1.4	5.0±1.9	3.8±2.1	5.6±1.9
	MCV (fl)	62.9±2.7	64.9±7.9	66.3±8.5	72.0±6.9
	MCH (pg)	19.4±2.0	20.0±1.9	20.3±3.4	22.9±3.4
	RDW (cv)	33.4±3.3	26.5±6.7	26.8±3.6	
	RBC (mill/ul)	1.4±0.8	2.27±1.2	1.9±1.1	2.3±0.7
Heterozygous sickle cell	Hb (g/dl)	9.2±3.3	9.9	6.4±3.4	10.5±1.3
	MCV (fl)	70.5±10.9	73.2	78.2±17.0	86.3±4.2
	MCH (pg)	23.3±6.1	23.3	25.1±6.5	27.4±3.2
	RDW (cv)	18.9±7.8	16.1	20.2±5.1	
	RBC (mill/ul)	4.0±1.3	4.25	2.9±2.5	3.7±0.7

Continued.

Variant	Parameter	Present study	Khera et al[17] (2015)	Buruah et al[18] (2014)	Mondal et al[25] (2016)
Homozygous sickle cell/sickle cell beta thalassemia	Hb (g/dl)	6.6±2.4	6.4	6.2±2.1	7.5±1.8
	MCV (fl)	77.9±11.4	64.2	83.2±12.4	90.6±11.0
	MCH (pg)	25.9±4.7	17.4	26.3±4.0	30.2±3.8
	RDW (cv)	18.3±4.4	22.7	21.1±4.4	
	RBC (mill/ul)	2.8±1.0	4.32	2.6±2.7	2.5±0.6

The present study showed CBC findings comparable with studies by Khera et al, Buruah et al, and Mondal et al.[17,18] Most hemoglobin variants showed microcytic hypochromic anemia with low MCV and MCH values. HbE heterozygous cases had milder anemia, whereas HbE beta-thalassemia and homozygous beta-thalassemia showed severe anemia, high RDW, and low RBC counts. Sickle cell disorders also demonstrated moderate to severe anemia with variable red cell indices.

Overall, the findings were consistent with previous studies, supporting the utility of CBC with HPLC for screening and differential diagnosis of haemoglobinopathies and other anaemias. However, HPLC has its own limitation hence molecular studies remain essential for confirmation and identification of specific globin gene mutations.[5,25] Molecular characterization also helps understand the interaction and distribution of Hb variants within tribal populations beyond HPLC findings.

While this study provides essential baseline data, it also highlights the need for more comprehensive population-based research to fully characterize the spectrum of haemoglobin variants across all of Nagaland. Future studies should expand their geographic and demographic scope to include diverse tribal populations throughout the state to ensure a more representative prevalence rate.

Limitations

Due to the retrospective and hospital-based nature of the study, precise stratification of Hb variants among the different tribes of Nagaland could not be presented.

CONCLUSION

This study shows a high prevalence of haemoglobin variants among patients at a secondary care hospital in Nagaland, with HbE being the most common variant detected. The study demonstrated that combining HPLC analysis with CBC is an effective strategy for the accurate screening and differential diagnosis of these disorders.

Because of the retrospective nature of the study, it cannot precisely present the prevalence of haemoglobinopathies of the state of Nagaland. But never the less, by filling the data gap for the state of Nagaland, this research provides a foundation for future research about the disorders which will help reducing the disease burden of haemoglobinopathies in North East India.

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