The haemoglobin pattern of sickle cell and haemoglobin C $\beta^+$-thalassaemia in Liberia

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Summary Haemoglobin components in 21 Liberians with Hb S $\beta^+$-thalassaemia and four with Hb C $\beta^+$-thalassaemia were measured to classify the forms of $\beta^+$-thalassaemia present in the population. In 20 Hb S and all Hb C $\beta^+$-thalassaemics the data were consistent with the interaction of these variants with the mild type 2 (Negro) form of $\beta^+$-thalassaemia. The data available were insufficient to classify the remaining case, a young child. It was concluded that the clinically more severe type of $\beta^+$-thalassaemia giving Hb A levels of 5 to 15% in compound heterozygotes is probably uncommon in Liberia.

Analysis of haemoglobin A levels in double heterozygotes for $\beta$-thalassaemia and $\beta$ chain structural haemoglobin variants is important in classifying the different forms of $\beta^+$-thalassaemia present in a population. Previous studies have shown there to be two main types of Hb S $\beta^+$-thalassaemia, those with haemoglobin A in the 5 to 15% range and those with levels of 20 to 30% haemoglobin A. The former is usually associated with a more severe clinical course, whereas the latter normally results from the interaction of haemoglobin S with the mild type 2 (Negro) form of $\beta$-thalassaemia.

Sickle cell $\beta^+$-thalassaemia is well documented in black populations. However, there are few published data relating to the quantification of haemoglobin A in Hb S $\beta^+$-thalassaemia in Negroes other than from the USA or Jamaica.

In Liberia there is a high frequency of both haemoglobin S and $\beta$-thalassaemia, and compound heterozygotes for $\beta$-thalassaemia and haemoglobin S are encountered not infrequently. In this report, data are given on the levels of haemoglobin A in double heterozygotes for $\beta^+$-thalassaemia and haemoglobins S or C from both clinical work and surveys.

Materials and methods

The subjects lived either in the Mount Nimba area of northern Liberia or in Buchanan on the coast of central Liberia. However, many originated from other parts of Liberia and several ethnic groups are represented. Date of birth data were not available in most instances and so ages were mainly estimated.

The diagnosis of sickle cell $\beta^+$-thalassaemia was arrived at by demonstrating haemoglobins S, A+F, and A$_2$ on electrophoresis. Standard methods of haemoglobin electrophoresis and identification of haemoglobin components were used. Haemolysates were prepared in most instances from venous blood; occasionally fingerprick blood was used. Screening haemoglobin electrophoresis was done on cellulose acetate using a Tris buffer system pH 8.5. A solubility test was used to confirm the identity of haemoglobin components migrating as Hb S. There was good separation of haemoglobins A+F, S, and A$_2$ or C. These were measured by elution following electrophoresis. Hb A concentrations were calculated by subtracting the Hb F values obtained by alkali denaturation from the Hb A+F fraction measured by elution. In this laboratory the normal range of Hb A$_2$ is 1.5 to 3.2%, $\beta$-thalassaemia trait carriers normally have a value over 3.7%. The intracellular distribution of Hb F was studied by an elution method using a citric acid buffer.

Results

Twenty-one sickle cell $\beta^+$-thalassaemia (table) and four Hb C $\beta^+$-thalassaemia compound heterozygotes were identified during investigations on over 10,000 people. Sickle cell $\beta^0$-thalassaemia was not observed. Nine sickle cell and three Hb C $\beta^+$-thalassaemias were incidental findings during population screening, health checks for employment,
The haemoglobin pattern of sickle cell and haemoglobin C \( \beta^- \)-thalassaemia in Liberia

### TABLE

<table>
<thead>
<tr>
<th>Case No</th>
<th>Tribe</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Haemoglobin analysis (%)</th>
<th>Clinical findings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( H_b ) A ( S ) A2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Bassa*</td>
<td>1 F</td>
<td>25.7</td>
<td>5.3</td>
<td>Anaemia, splenomegaly</td>
</tr>
<tr>
<td>2</td>
<td>Mano*</td>
<td>1 F</td>
<td>31.3</td>
<td>(A+F)†</td>
<td>Anaemia, splenomegaly</td>
</tr>
<tr>
<td>3</td>
<td>Bassa</td>
<td>3 M</td>
<td>25.8</td>
<td>2.7</td>
<td>Anaemia, hepatosplenomegaly</td>
</tr>
<tr>
<td>4</td>
<td>Gissi</td>
<td>6 M</td>
<td>6.5</td>
<td>24.2</td>
<td>Anaemia, splenomegaly</td>
</tr>
<tr>
<td>5</td>
<td>Mano</td>
<td>8 M</td>
<td>25.6</td>
<td>5.7</td>
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</tr>
<tr>
<td>6</td>
<td>Bassa</td>
<td>10 F</td>
<td>22.8</td>
<td>5.1</td>
<td>Anaemia, splenomegaly</td>
</tr>
<tr>
<td>7</td>
<td>Bassa</td>
<td>10 F</td>
<td>24.5</td>
<td>3.4</td>
<td>Anaemia, splenomegaly</td>
</tr>
<tr>
<td>8</td>
<td>Mandingo*</td>
<td>15 F</td>
<td>17.0</td>
<td>16.7</td>
<td>Mild anaemia</td>
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<tr>
<td>9</td>
<td>Mano</td>
<td>15 F</td>
<td>18.8</td>
<td>9.2</td>
<td>Anaemia, pregnant</td>
</tr>
<tr>
<td>10</td>
<td>Bassa</td>
<td>15 M</td>
<td>30.0</td>
<td>5.4</td>
<td>Mild anaemia</td>
</tr>
<tr>
<td>11</td>
<td>Bassa</td>
<td>18 F</td>
<td>24.9</td>
<td>5.1</td>
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<tr>
<td>12</td>
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<td>18 M</td>
<td>15.5</td>
<td>18.2</td>
<td>Mild anaemia</td>
</tr>
<tr>
<td>13</td>
<td>Bassa</td>
<td>18 F</td>
<td>22.0</td>
<td>1.0</td>
<td>Anaemia, pregnant</td>
</tr>
<tr>
<td>14</td>
<td>Gio</td>
<td>18 F</td>
<td>24.3</td>
<td>5.9</td>
<td>Mild anaemia, leg ulcers</td>
</tr>
<tr>
<td>15</td>
<td>Kpelle</td>
<td>Adult M</td>
<td>27.0</td>
<td>&lt;1.0</td>
<td>Mild anaemia</td>
</tr>
<tr>
<td>16</td>
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<td>Adult F</td>
<td>16.2</td>
<td>10.0</td>
<td>Severe anaemia, pregnant</td>
</tr>
<tr>
<td>17</td>
<td>Bassa*</td>
<td>Adult F</td>
<td>24.1</td>
<td>20.1</td>
<td>Mild anaemia</td>
</tr>
<tr>
<td>18</td>
<td>Bassa</td>
<td>Adult F</td>
<td>30.0</td>
<td>&lt;1.0</td>
<td>Post-partum haemorrhage</td>
</tr>
<tr>
<td>19</td>
<td>Gissi</td>
<td>Adult M</td>
<td>31.0</td>
<td>9.0</td>
<td>Mild anaemia</td>
</tr>
<tr>
<td>20</td>
<td>Bassa</td>
<td>Adult M</td>
<td>29.4</td>
<td>2.4</td>
<td>Mild anaemia</td>
</tr>
<tr>
<td>21</td>
<td>Bassa</td>
<td>Adult M</td>
<td>25.3</td>
<td>1.4</td>
<td>Mild anaemia</td>
</tr>
</tbody>
</table>

*Diagnosis supported by family studies.
†No separate \( H_b \) F determination.

Blood donation, etc. Among the remainder, in only two instances was a haemoglobinopathy suspected as the primary diagnosis. In children with splenomegaly, the degree of enlargement was not greater than that seen in normal children from the same areas of holoendemic malaria.

In the 20 cases where full haemoglobin analysis was done (table), \( H_b \) S \( \beta^- \)-thalassaemics fell into two groups; 16 subjects had a haemoglobin A level (within experimental limits) in the 20 to 30% range (mean 25.7%, SEM ±0.81%). \( H_b \) A2 levels were raised (mean 4.6%, SEM ±0.2%). One woman (case 17) with an unusually high \( H_b \) F level (20%) has been described previously. She had one child with homozygous \( \beta^- \)-thalassaemia and another with sickle cell trait. The mean \( H_b \) F value of the other 15 subjects was 4.2% (SEM ±0.7%).

In cases 8, 12, and 16, the comparatively low \( H_b \) A value (15.5 to 17.2%) was associated with a fetal haemoglobin of 10% or greater. Case 12 had a \( H_b \) A2 level in the normal range. A further case with a high \( H_b \) F level, a young child (case 4), had 6.5% \( H_b \) A and \( H_b \) A2 in the normal range. His mother was not available for investigation but the alleged father had a normal haemoglobin pattern. In all \( H_b \) S \( \beta^- \)-thalassaemics fetal haemoglobin showed a heterocellular distribution.

\( H_b \) A levels in the four \( H_b \) C \( \beta^- \)-thalassaemics were 20.1, 23.4, 26.4, and 28.0%. The highest level of \( H_b \) F was 5.2% and the distribution of \( H_b \) F was heterocellular. One of the \( H_b \) C \( \beta^- \)-thalassaemics, an adult male, was anaemic with mild hepatosplenomegaly. The other three, two of them pregnant women, were mildly anaemic.

**Discussion**

The results indicate that although there was some heterogeneity, most cases of sickle cell and \( H_b \) C \( \beta^- \)-thalassaemia described here resulted from the interaction of these variants with the type 2 (Negro) form of \( \beta^- \)-thalassaemia. In the three older subjects in whom high \( H_b \) F levels were associated with a slightly low \( H_b \) A value, a heterocellular HPFH gene may have been segregating, as suggested for the 18-year-old Negro boy with \( H_b \) S \( \beta^- \)-thalassaemia described by Weatherall. However, in these three patients, genetic evidence is lacking and it cannot be excluded that the high levels of \( H_b \) F caused some artefactual difficulty in estimating the level of \( H_b \) A.

An associated HPFH gene could also explain the findings in the Gissi boy with a very low \( H_b \) A value. However, here the high \( H_b \) F level can be explained on the basis of age and he could have had the low \( H_b \) A type of \( H_b \) S \( \beta^- \)-thalassaemia, but again without genetic evidence no firm conclusions can be reached.

The normal \( H_b \) A2 values seen here in cases 4 and 12 are unusual in \( H_b \) S \( \beta^- \)-thalassaemia in black populations, although this has been reported in association with high \( H_b \) F levels in other racial
groups.\(^1\) However, in the Jamaican series of Serjeant \textit{et al},\(^4\) two persons with the Negro type of Hb S \(\beta^+\)-thalassaemia had Hb A\(_2\) values in the normal range.

In earlier reports of Hb S \(\beta^+\)-thalassaemia in black populations from the USA\(^2\) and Jamaica,\(^4\) subjects with haemoglobin A in both the 5 to 15\% and 20 to 30\% ranges were described. However, the \(\beta\)-thalassaemia gene in the former cases usually came from a non-black source. By contrast, a previous study of \(\beta\)-thalassaemia homozygotes in Liberia\(^1\) suggested, as here, that the type of \(\beta^+\)-thalassaemia giving Hb A levels of 5 to 15\% in compound heterozygotes is uncommon in Liberia.

How frequent is sickle cell \(\beta^+\)-thalassaemia in Liberia? Although the syndrome was found in about two per 1000 persons, this was a biased sample, being partly based on a hospital population. However, the Bassa tribe from which most of the subjects in this study came has been shown to have a high frequency of both haemoglobin S and \(\beta\)-thalassaemia.\(^5\)\(^6\)\(^12\) Based on gene frequencies of 0.041 for Hb S and 0.067 for \(\beta\)-thalassaemia,\(^13\) the estimated frequency of double heterozygotes in the Bassa comes out at more than five per 1000. It is unlikely to be as high as this, however, as the two genes do not appear to be evenly distributed among the Bassa.\(^5\)\(^14\)

Nevertheless, sickle cell \(\beta^+\)-thalassaemia is clearly not uncommon in Liberia and although usually mild clinically may present more severe manifestations during pregnancy. Unfortunately, as with other thalassaemia syndromes, detailed haemoglobin studies are needed to characterise the condition. As these are often not available in countries like Liberia, sickle cell \(\beta\)-thalassaemia will usually go undetected.

**References**


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