Clinical, enzymic, and molecular characterisation of a Portuguese family with a chronic form of $G_{M2}$-gangliosidosis B1 variant

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Abstract

Mutations in the hexosaminidase A gene (HEXA) causing the B1 variant of $G_{M2}$-gangliosidosis result in the presence of a mutant enzyme protein with a catalytically defective $\alpha$ subunit. A rare and panethnically distributed mutation, transition G533A (Arg178His), is known to be a common allele among Portuguese patients with the subacute phenotype. We now report the presence of an Arg178His allele in three Portuguese sibs with a chronic form of the disease, who carry the transition G755A (Arg252His) on the second allele. This novel mutation is the first B1 allele to be associated with an adult phenotype.

Key words: $\beta$-hexosaminidase; HEXA mutations; Tay-Sachs disease.

B1 variant is a rare form of $G_{M2}$-gangliosidosis characterised by the presence of a mutant Hex A ($\alpha\beta$ heterodimer) with an altered substrate specificity owing to mutations in the catalytic site on the $\alpha$ subunit.1,2 This disease has been reported in patients with the subacute phenotype (with onset ranging from late infantile to juvenile),3,4 the majority of them carrying at least one Arg178His allele5,6 and having a Portuguese background.7 To date, the chronic form of the disease has only been reported in three sibs of Portuguese origin but their genotype, to our knowledge, is not known.8

The pedigree of a Portuguese family studied in the present report is depicted in fig 1. Table 1 summarises the clinical characteristics of the three affected sibs. The molecular defects were identified by PCR–SSCP analysis (fig 2) followed by direct sequencing (fig 3). The patients were found to be compound heterozygotes for the mutations G533A and G755A. The genotype of the other family members was identified by testing both mutations by PCR–SSCP analysis (fig 2). The mutation G755A was confirmed by RFLP analysis with restriction enzyme NlaIII (fig 4). The mobility shifts corresponding to novel mutation G755A were not seen on SSCP analysis of 100 normal $\alpha$ chain genes (data not shown). Table 2 summarises the clinical, molecular, and biochemical data and compares it with previously published data on Portuguese B1 patients.9 In leucocytes from patients homozygous for the Arg178His allele, the Hex A activity against 4MU-GlcNAc corresponded to about 50% of total hexosaminidase activity. In compound heterozygotes for this mutation, this activity seems to be dependent on the nature of the mutation present in the second allele. If the mutation produces no mature $\alpha$ subunit, such as in the classical infantile form of Tay-Sachs disease, the enzymic activity will be that generated by one Arg178His allele; therefore it must correspond to one half of the activity in
Table 1  Clinical summary of the affected sibs with B1 variant

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age at onset (y)</th>
<th>First symptom</th>
<th>Language retardation</th>
<th>Speech loss</th>
<th>Loss of ability to walk</th>
<th>Pyramidal signs</th>
<th>EEG</th>
<th>Present age (y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>II-2</td>
<td>11</td>
<td>Behavioural alterations</td>
<td>After 11 years</td>
<td>+</td>
<td>25 years</td>
<td>+</td>
<td></td>
<td>32</td>
</tr>
<tr>
<td>II-6</td>
<td>5</td>
<td>Behavioural alterations</td>
<td>5-6 years</td>
<td>13 years</td>
<td>Language disturbance</td>
<td>Not observed</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>II-9</td>
<td>7</td>
<td>Behavioural alterations</td>
<td>7-8 years</td>
<td>Not observed</td>
<td>Language disturbance</td>
<td>Not observed</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

Table 2  Clinical, biochemical, and molecular data on Portuguese B1 variant patients

<table>
<thead>
<tr>
<th>Case</th>
<th>Clinical phenotype</th>
<th>Genotype</th>
<th>Hexosaminidase activity in leucocytes*</th>
<th>4MU-GlcNAc</th>
<th>4MU-GlcNAcS6</th>
</tr>
</thead>
<tbody>
<tr>
<td>II-2</td>
<td>Chronic</td>
<td>Arg178His/Arg252His</td>
<td>873</td>
<td>56-0</td>
<td>7-60</td>
</tr>
<tr>
<td>II-6</td>
<td>Chronic</td>
<td>Arg178His/Arg252His</td>
<td>785</td>
<td>53-0</td>
<td>5-60</td>
</tr>
<tr>
<td>II-9</td>
<td>Subacute (juvenile onset)</td>
<td>Arg178His/Arg178His</td>
<td>1086</td>
<td>57-0</td>
<td>8-50</td>
</tr>
<tr>
<td>n=10</td>
<td>Subacute (late infantile onset)</td>
<td>Arg178His/Arg252His</td>
<td>1045 (610-1934)</td>
<td>61-0 (43-0-66-0)</td>
<td>2-60 (0-59-7-00)</td>
</tr>
<tr>
<td>n=1</td>
<td>Normal</td>
<td>Arg178His</td>
<td>1300</td>
<td>24-0</td>
<td>4-00</td>
</tr>
<tr>
<td>I-2</td>
<td>Arg252His heterozygous</td>
<td>Arg178His/Arg252His</td>
<td>2133 (1598-2985)</td>
<td>59-64 (3-63-3)</td>
<td>145 (118-166)</td>
</tr>
</tbody>
</table>

*The hexosaminidase activity was determined as previously described. **Total Hex, hexosaminidase activity (nmol/h/mg protein) determined against the neutral synthetic substrate; % Hex A, activity of the main peak eluted during NaCl gradient expressed as % of total 4MU-GlcNAc recovered activity after ion-exchange chromatography on DEAE-cellulose; Hex A, hexosaminidase A activity (nmol/h/mg protein) determined against the sulphated synthetic substrate which was further purified as previously described. †Enzymatic data published in a previous report.

homozygous patients. However, if the mutation is compatible with the synthesis of a mature protein with the enzymological characteristics of B1 variant, with residual activity against the synthetic unsulphated substrate, the Hex A activity is expected to be correspondingly higher. The Arg252His substitution, resulting from the mutation G755A, occurs at conserved amino acids in human β chain, with the α and β chain from mouse, and the hexosaminidase polyepptide from Dictyostelium discoideum.

The clinical phenotype of patients with the substitution Arg178His and Arg252His in respective alleles is less severe than that observed for Arg178His homozygotes. Assuming that the clinical phenotype depends on enzymatic residual activity against ganglioside GM3, in vivo, it can be predicted that the Hex A generated by the Arg252His allele shows a higher intralysosomal residual activity than that generated by the Arg178His allele. Therefore it is likely that patients who have at least one Arg252His allele would have a chronic phenotype, irrespective of the nature of the mutation present in the other allele.

The majority of B1 mutations described in published reports occurred at codon 178, in which arginine is replaced by histidine, cysteine, or leucine. The identification of another mutation also in one arginine codon points to the role of this positively charged amino acid in the catalytic domain of the α subunit. On the other hand, Arg252 is a4 amino acids from Arg178 in the coding sequence. Although the nature of the replaced amino acid is similar they might have different effects on the disruption of the tertiary structure of the catalytic domain of the protein.

Figure 3  Sequence analysis of PCR samples. The segment of genomic DNA with an altered SSCP pattern was subjected to asymmetrical amplification, using the temperature profile of symmetrical PCR. The asymmetrical product was further purified and directly sequenced. The relevant portion of the sequence is shown. E5, exon 5 (antisense strand); E7, exon 7 (sense strand); G, control; P, patient.
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12 Beccari I, Emiliani C, Hosseini R, Orlandin A, Stirling JL. Intermediate forms of human β-N-acetyhexosaminidase lack activity towards 4-methylumbelliferyl-β-N-acetyl-


