Wilson's disease is a hereditary disorder of autosomal recessive inheritance that can cause irreversible, potentially lethal lesions to liver and brain. Its molecular cause is the appearance of mutations in the atp7b gene. A total of 379 different disease-producing mutations are currently known, turning the molecular diagnosis of this disorder into a formidable challenge. The present study used single-strand conformational polymorphism for the detection of conformational changes in exon 8 of this gene. Two shifts distinct from the normal allele, denominated b and c, were detected and mapped to mutations L708P and 2304DupC in heterozygosis. Allelic frequencies for these mutations in 72 Cuban Wilson’s disease patients were 2 and 0.7%, respectively.

**Keywords**: Wilson’s disease, mutation L708P, SSCP
The molecular diagnosis of Wilson’s disease is a formidable task. Not only are there 21 exons in the $atp7b$ gene, but the number of high frequency mutations is low; varying in number and incidence with the ethnic background and geographical location of every population. Exon 8 is polymorphic; more than 50 disease-causing mutations have been mapped there [3]. Mutation L708P affects copper transport and has a frequency of 60% in the Canaries, 16.7% in Brazil, and less than 1% in the United States [11-13]; mutation 2304DupC, on the other hand, produces a frameshift and has a frequency of 2.6% in North America, [13]. Both have been mapped to exon 8 of the $atp7b$ gene.

Despite its complexities, the molecular diagnosis of this disorder would not only help in the identification of its genetic cause, but serve as confirmation to clinical diagnosis. In addition, it could be used to screen carriers and aid in the identification of anticipatory symptoms, in order to provide early treatment and improve the quality of life of the patient.

The determination of the mutational spectrum of $atp7b$ gene requires an adequate screening technology [4, 14]. The detection of single-strand conformational polymorphisms (SSCP) is a technique well-suited for this purpose.

Taking into account that Wilson’s disease has never been molecularly diagnosed in Cuba, the present work is aimed at the search for conformational and mutational changes in exon 8 (polymorphic exon) of the $atp7b$ gene in Cuban patients with this clinical diagnosis.

Materials and methods

The present was a descriptive study, recruiting 72 non-related patients clinically diagnosed with Wilson’s disease. The evaluation was performed by a multidisciplinary team (one geneticist, four gastroenterologists, two neurologists and a biochemist), following inclusion criteria for the diagnosis. Written informed consent by means of a consent form was obtained from each volunteer before inclusion in the study, following the ethical guidelines of the Helsinki declaration. Consent from underage patients, as well as authorization for the selection of this sample, was obtained through their legal tutors. The study posed no significant risk for the patients, as screening was performed by single-stranded DNA electrophoresis under non-denaturing conditions. Fragment size, for SSCP to be effective, must be 150 to 300 bp. The power of SSCP resides on the intricate relationship between electrophoretic migration and conformational structure exhibited by single-stranded DNA.

In order to characterize the samples by SSCP, the success of PCR amplification was first verified and then 3.5 μL of a bromophenol blue stop solution (0.05% BPB, 10 mM NaOH, 95% formamide, 20 mM EDTA) were mixed with 1 μL of the amplified product in a final volume of 7 μL, heating the mixture for 5 min at 96 °C and quickly quenching it on ice. The sample was analyzed in a commercially available ready-made acrylamide gel (GeneGel Excel 12.5/24 Kit), run in a GenePhor unit at 500 V, 15 W, 15 °C for 3 h, visualizing the results by electrophoresis in 2% agarose gels at constant voltage (250 V).

Detection of mutation L708P

Once the conformational changes of exon 8 were detected, we proceeded to verify the presence of mutation L708P in the patients whose electrophoretic motilities matched that of the L708P positive control. Fifteen microliters of the PCR product were digested with 15 U of Alu I restriction enzyme at 37 °C for 3 h, visualizing the results by electrophoresis in 2% agarose gels at constant voltage (250 V).

Detection of mutation 2304DupC

The presence of the 2304DupC mutation was verified by fluorescent DNA sequencing in an ALF-Express II unit from Amersham Pharmacia Biotech. PCR products were purified with the QiAquick Kit (Qiagen) following instructions from the manufacturer; and the resulting electrophoreograms were analyzed with the ALFwin Sequence Analyser 2.11 and Blast (sequence alignment) software applications.

Results and discussion

Studies in Cuba for the detection of mutations of the $atp7b$ gene in local Wilson’s disease patients started in 2008, making an inventory of conformational variants before moving on to the examination of their molecular basis.

The present work detected 3 conformational variants in exon 8 of $atp7b$ through the examination of

10 pmole/μL each of the oligonucleotides reported by Loudianos et al.: E8 1: 5’ CTA CTT CTT GGC AGC CTT CAC TG 3’, E8 2: 5’ GGA GCA GCT CTT TTC TGA ACC TG 3’ [16], dNTPs at 1 mM (Boehringer), PCR buffer 10X, MgCl2 15 mM, 1 μ Taq polymerase (Invitrogen); all in a

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72 Cuban patients clinically diagnosed with Wilson’s disease. The identified variants were denominated as a, b and c.

Figure 1 depicts the results of the analysis by 12.5% polyacrylamide gel electrophoresis of exon 8 from 23 out of the 72 patients, together with a positive control. Conformational shifts a, corresponding to the wild type, and conformational shift b, corresponding to mutation L708P in heterozygosis from a control sample, can be observed in the figure. Conformer b was detected in 3 out of the 72 clinically diagnosed, non-related patients. SSCP is based on the detection of changes, caused by the appearance of a mutation, on the tridimensional conformation adopted by a single-stranded molecule of DNA, which are reflected in its electrophoretic mobility. Mutation L708P in exon 8 produces, therefore, a conformational change in the DNA strand detectable by electrophoresis, as shown in figure 1.

In the samples with conformational change b, the presence of the L708P mutation was confirmed by digestion with the Alu I restriction endonuclease, as the mutation eliminates a recognition site for this enzyme. Patients homozygotic for this mutation produce a single 230 bp band upon digestion, whereas heterozygotes yield 230, 180 and 50 bp bands. Figure 2 demonstrates the presence of L708P in three heterozygotic patients.

This mutation arises from a thymine to cytosine substitution in position 2123 of the atp7b gene, resulting in a substitution of leucine by proline at residue number 708 in the ATP7B polypeptide. It has been detected in 60% of the cases in the Canaries, making it the most frequent mutation in 24 studied patients [11]. However, L708P has not been detected during studies targeting other Spanish populations [4, 17]. In Brazil it appears in 16.7% of the cases, being the second most frequent variant in a sample of 60 patients [12]; and appearing in less than 1% of 109 patients from 13 states of the USA and Puerto Rico [13]. The frequency of this mutation among the 72 analyzed Cuban patients was 2%.

In order to completely characterize the molecular basis of the disorder in the three patients heterozygotic for the L708P mutation, however, it would be necessary to find and catalog the other mutation that, together with the first, produces the symptomatology. Studies are therefore underway to analyze the remaining exons of atp7b gene.

Our work, in any case, provides the country with a fast technology for the molecular diagnosis and determination of mutation L708P in clinically diagnosed patients.

One of the 72 studied samples exhibited conformer C, with the same relative electrophoretic migration as the positive control for mutation 2304DupC in heterozygosis Figure 3. This mutation results from the insertion of a cytosine at position 2304 of atp7b gene, resulting in a frameshift. The presence of this mutation produces a conformational change detectable by SSCP (Figure 3), confirmed by DNA sequencing (Figure 4). This variant was detected at a frequency of 3.3% in the Brazilian sample of 60 patients mentioned above [12] and at 2.6% in the US [13]. The frequency in our sample of 72 patients was 0.7%.

The present is the first study reporting the allelic frequencies for Cuban patients of two mutations in atp7b gene, the most frequent mutation in 24 studied patients.


p7b gene, obtained from the analysis of 72 cases clinically diagnosed with Wilson’s disease. A total of three conformational changes were identified. Sixty-seven of the patients had the normal variant; three had conformation b, corresponding a mutation L708P in heterozygosis, and one had conformational c, corresponding to mutation 2304 DupC.

As mentioned above, the conclusion of the molecular diagnosis of the patients will require identifying mutations and polymorphisms in the remaining exons of atp7b gene, especially those most frequently identified during studies on other populations.

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