Introduction

Warburg Micro syndrome (WARBM) is a rare autosomal recessive disease. In 1993 Warburg first described in an inbred Pakistani family three children suffering from microcephaly, microcornea, congenital cataract, retinal dystrophy, optic nerve atrophy, cognitive disability, hypothalamic hypogonitism and corpus calsums agenesia [1]. Onward, in addition to severe growth and psychomotor delay, more connotative features are reported in facies (low anterior hairline, narrow forehead, short nose with prominent root, blepharophimosis, large ears, short prominent philtrum, and micrognathia), in skeletal deformities (hallux valgus, overlapping toes, clinodactyly, camptodactyly, arachnodactyly) and in neurologic disorders (spastic paresis and progressive motor neuropathy) [2-5]. Polymericgia emerges as the most frequent cortical malformation, however other gyration abnormalities or various brain alterations such as ventriculomegalgy and cerebellar vermis hypoplasia are possible [5]. Electroencephalogram (EEG) abnormalities as well as tonic-clonic, partial and myoclonic seizures are described [3-7].

WARBM is caused by mutations of RAB3GAP1, RAB3GAP2 [8] or RAB18 genes [4] in about 50% of cases, RAB3GAP1 being the most common gene involved. Rarely the disease is linked to TBC1D20 gene, which is known to probably act through TBC1D20 gene.

We describe the clinical and instrumental findings of two children born to consanguineous parents and carriers of a novel RAB18 mutation. In association with typical WARBM dysmorphic and neurological signs, the firstborn had a peculiar epileptic phenotype including “myoclonic absences” and previously undescribed findings at brain magnetic resonance imaging (MRI).

Case Report

The first-born

A one-year-old child was brought to our attention for a severe motor and intellectual delay. He was initially the sole son of two healthy first cousins from Morocco. The family history was negative for neurological and genetic disorders. Pregnancy elapsed with intrauterine growth restriction which required a caesarean section at 34 gestational weeks. At birth, the newborn had a weight of 1370 grams and an Apgar score of 7/9. He had an apnoeic event at 2 days of life and a neonatal hyperbilirubinemia peak of 12 mg/dL on the fifth day.

At the time of our first assessment (12 months of age) he had neither postural control nor language; he showed poor orientation, worse to visual stimulations compared to sounds and touch. He had microcephaly, narrow face, sparse eyebrows, frontal hypertrichosis, palpebral pseudoptosis, ogival palate, bulbous nose, short philtrum, asymmetric large ears and tapering fingers. The child was also suffering from microphthahalyma, microcornea, small pupils, bilateral cataract, cryptorchidism and congenital talipes equinovarus. Abdomen and cardiac ultrasound were negative.

A brain MRI had been performed at three months of age (Figure 1). In addition to a widespread white matter hypointensity on T2-weighted images—likely related to a physiological hypomyelination-, it showed bilateral frontal polymicrogyria consisting of smoothed sulci and multiple cortical microgyria. The gyration abnormality extended posteriorly to the opercular regions and to the most cranial sections of both parietal lobes. The sylvian fissures were enlarged and the corpus calsums was hypoplastic. At subsequent MRI examinations, performed at 30 months and 8 years of age, pericerebral subarachnoidal spaces were increased and the frontal horns of the lateral ventricles were wider; supratentorial white matter was poorly represented and hyperintense on T2-weighted images, consistent with an incomplete or delayed myelination. Corpus calsum was hypotrophic. Last MRI performed at 8 years’ detected in the infra-tentorial district an enlargement of cisterna magna with a superior hypertrophy of vermis, a mild dilatation of the fourth ventricle and a hypotrophy of middle cerebellar peduncles. Peri-ventricular white matter marked hyperintensity on T2-weighted images persisted, suggesting a focal marked hypo-dysmyelination.

At three years of age he underwent lens aspiration and after a few years the surgical correction of a secondary corectopia was required. The optic correction of aphakia with glasses couldn't improve his vision due to the coexistence of exotropia, nystagmus, bilateral corneal haze, and a progressive bilateral optic atrophy.

First wakefulness EEG (12 months of age) revealed low-amplitude fast rhythms prevailing frontally and a central-parietal focus of high voltage 4-6 Hz waves. During sleep, bisynchronous discharges of irregular high amplitude spike-waves or polyspike-waves were detectable on the frontal-central-temporal regions. Visual evoked potentials (VEPs) were progressively abolished whereas electroretinogram (ERG) was normal; brainstem auditory evoked responses (BAERs) showed delayed responses.

Since he was 2 years old he suffered from recurrent focal
showed an intensification of the frontal-central-parietal focus of 3-4 Hz regular high amplitude 3 Hz spike-waves (Figure 2). Interictal EEG They were related to an EEG paroxysmal discharge of generalized and lasting 10-12 seconds. Clinically the seizures were characterized by
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vocals, social smile and motor stereotypies of arms. A demyelinating hypotonia and limbs dystonic movement disorder. He had dysphagia and severe intellectual disability. The visual acuity was motu manu in the right eye and light perception in left eye. He could produce sporadic
The patient was born full term through an urgent caesarean section required by IUGR and fetal distress. Neonatal weight was 1900 grams and the extra uterine life adaptation was adequate. Postnatal sucking was ineffective. At our first evaluation, the child was one-year-old and he had no developmental, postural or praxic skill appropriate for age. He had microphthalmia, bilateral cataract, microcornea, a central corneal opacity, small pupils and iris dysgenesis. Clinical features also included microcephaly, frontal hypertrichosis, sparse and up-slanted eyebrows, hypotelorism, short palpebral fissures, bulbous nose, arched palate, micrognathia, and a sacral Mongolic patch. He had axial hypotonia, limbs spasticity and a dyskinetic movement disturbance of face and
epileptic status mainly related to fever. Simultaneously EEG disclosed asynchronous parietal-occipital low voltage spikes or spike-waves moderately increased by sleep. Carbamazepine treatment was introduced with a temporary effect.

The clinical picture evolved to a spastic tetraparesis with axial hypotonia and limbs dystonic movement disorder. He had dysphagia and severe intellectual disability. The visual acuity was motu manu in the right eye and light perception in left eye. He could produce sporadic vocals, social smile and motor stereotypes of arms. A demyelinating limbs neuropathy arose, with a predominantly motor involvement.

At 6 years’ tonic seizures supervened in wellness. Carbamazepine was thus replaced with Levetiracetam leading to a good response. Starting from the age of 8 years, the child had repeated daily MA lasting 10-12 seconds. Clinically the seizures were characterized by loss of consciousness, right head deviation and generalized rhythmic myoclonias superimposed on progressive tonic limbs abduction. They were related to an EEG paroxysmal discharge of generalized and regular high amplitude 3 Hz spike-waves (Figure 2). Interictal EEG showed an intensification of the frontal-central-parietal focus of 3-4 Hz high amplitude activity, at times intermingled with synchronous or asynchronous spike-waves discharges. Clonazepam and Valproate were added to treatment and afterwards no further epileptic events occurred nor epileptiform activities were observed. Karyotype, array-CGH and Sanger sequencing of tubulin and GPR56 genes detected no alterations. Over the years, the patient had two brothers: a healthy child and an affected one reported below.

The younger brother
The patient was born full term through an urgent caesarean section required by IUGR and fetal distress. Neonatal weight was 1900 grams and the extra uterine life adaptation was adequate. Postnatal sucking was ineffective. At our first evaluation, the child was one-year-old and he had no developmental, postural or praxic skill appropriate for age. He had microphthalmia, bilateral cataract, microcornea, a central corneal opacity, small pupils and iris dysgenesis. Clinical features also included microcephaly, frontal hypertrichosis, sparse and up-slanted eyebrows, hypotelorism, short palpebral fissures, bulbous nose, arched palate, hypogenitalism and a sacral Mongolic patch. He had axial hypotonia, limbs spasticity and a dyskinetic movement disturbance of face and
In both affected brothers a homozygous nonsense variation c.421C>T (p.Arg141) was detected by Sanger sequencing (Figure 3). Parents and the healthy brother were heterozygous. This variation was never reported as known mutation (HGMD professional) or detected in healthy databases (db SNP, 1000 Genomes Project, NHLBI GO Exome Sequencing Project, Exome Aggregation Consortium, MLPA). Nevertheless, this mutation introduces a premature stop codon after 141 amino acids, it is predicted to be deleterious by all consulted bioinformatic webtools (MutationTaster, PolyPhen-2, LRT, SIFT, Mutation Assessor, CADD) and its evidence of pathogenicity is very strong according to the criteria of the American College of Medical Genetics and Genomics [10].

**Figure 2**: EEG documentation of “myoclonic absences” in the firstborn. High amplitude generalized 3 Hz sharp-waves are related to limbs myoclonias and post-myoclonic silences superimposed on a progressive tonic contraction (see electromyography).

**Figure 3**: An affected child carries a homozygous nonsense variant in RAB18. Electropherogram from affected child (lower trace) shows a homozygous c.421C>T; p.Arg141* variant confirmed by direct sequencing. Nucleotide numbering reflects cDNA numbering with +1 corresponding to the A of the ATG translation initiation codon in the reference sequence NM_021252. Peptide residue numbering reflects protein primary structure with p.Met1 corresponding to the first methionine in the reference sequence NP_067075.

**Genetics**

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**Discussion**

Micro Warburg syndrome is a rare autosomal recessive disease caused by loss-of-function mutations of TBC1D20, RAB3GAP1, RAB3GAP2 or RAB18. Recent evidences suggest the absence of a clear gene-specificity: TBC1D20 and RAB3GAP1/2 transcripts may affect through different pathways the same target, i.e. the intracellular localization and functioning of RAB18 [8]. To date, only five RAB18
mutations have been described [3,7], therefore this report could further expand WARBM phenotype and particularly in relation to this gene.

First, in both brothers NCV detected a limb demyelinating neuropathy, with a mainly motor impairment as only sporadically reported in other WARBM patients with RAB gene mutations [3,6,7].

Secondly, in the younger child an optic hypoplasia was observed, unlike most of WARBM subjects usually suffering from a progressive optic atrophy. Moreover, both of our patients had a central opacity of cornea, never evidently reported before and possibly specific for RAB18-related microphthalmia.

Thirdly, in the firstborn brain MRI showed over the time the appearance of a marked peri-ventricular white matter hyperintensity on T2-weighted images, suggestive of a focal hypo-dysmyelination. This finding seems consistent with a white matter disorder rather than a myelination delay as previously reported in the literature. In the younger brother only one brain-MRI was performed at three months of life and no data are available on neuroradiological evolution.

Lastly, the first-born child had an epileptic phenotype characterized at onset by focal seizures, then by generalized tonic seizures and finally by MA. No seizure had occurred in the second-born up to the last follow up at 3 years of age, when EEG showed in sleep high voltage and asynchronous frontal-temporal paroxysms.

Seizures with “myoclonic” components were previously described in other patients with pathogenic RAB18 mutations [3,6,7]. In particular, 6 out of 13 patients had epilepsy, 3 with generalized tonic clonic seizures and the other 3 with myoclonic seizures. In two siblings reported by [2], the age at onset of myoclonic seizures was respectively 5 and 3 years. They were very frequent (20-25 episodes per day) and refractory to multiple anticonvulsants. In the female described by Handley [5] myoclonic seizures were described since two years of age. In all of patients ictal and interictal EEG disclosed diffuse spike and asynchronous frontal-temporal paroxysms.

MA are generalized seizures first described by Tassinari et al, with an average age of onset of 7 years. MA can represent the prevailing ictal expression of certain idiopathic epilepsies and can also occur, more often along other seizures types, in association with structural brain lesions or genetic syndromes [10-12].

Conclusion

It is documented for the first time MA in WARBM and we wonder whether the seizures with “myoclonic” features previously reported could actually be MA. In that case, MA may be considered as a significant component of WARBM epileptic phenotype, particularly in relation with RAB18 and considering its involvement in neurotransmitters release.

References