Child Neurology: Cognitive delay in a 7-year-old girl

Organic acidurias are an important group of inherited metabolic disorders that affect the intermediary metabolic pathways of carbohydrate, amino acid, and fatty acid oxidation, leading to the accumulation of organic acids. The 2-hydroxyglutaric acidurias are rare neurometabolic disorders characterized by developmental delay with or without other neurologic dysfunction. Three different subtypes have been described: D-2-hydroxyglutaric aciduria, L-2-hydroxyglutaric aciduria, and combined D,L-2-hydroxyglutaric aciduria. We describe the case of a child presenting with developmental delay who was found to have the classical biochemical, imaging, and genetic features of L-2-hydroxyglutaric aciduria.

Case report. A 7-year-old girl presented to the clinic for evaluation of cognitive delay. The patient, born at 41 weeks gestation, appeared to have met her early milestones on time. Her parents first became concerned about her development at approximately 4 years of age, when she was noted to have difficulty focusing and keeping up with her peers. Teachers described her as easily distracted and forgetful. Over the years, it was noted that she was increasingly lagging behind academically. Developmentally, when she was seen in clinic at age 7, she was able to ride a bike with training wheels, write her name and draw pictures, and dress herself. Her speech was difficult to understand.

She had a history of 3 convulsive febrile seizures at a younger age. Otherwise, she had not been noted to have any cognitive or neurologic decompensations with intercurrent illnesses. There was no family history of seizures or developmental delay. Her parents are originally from a small village in Eritrea and they denied any consanguinity.

On examination, her head circumference was 53.7 cm, at the 98th percentile. Weight and height were at the 50th percentile. She was able to state her name but was unable to recall the day of the week or month. She was able to follow a 2-step command, repeat 3 digits forward, and print her name legibly, but she had difficulty with right/left differentiation, subtracting, and reading. Her speech was suggestive of a lingual dysarthria, with about 25%-50% of her speech understandable to the examiner. She had mildly decreased tone throughout and had difficulty hopping or standing on each foot. Though her gait was normal, she was unable to tandem gait. The rest of her neurologic examination was normal for age.

What would her developmental age be based on the description given above? Would you consider brain imaging as part of the workup for developmental delay in a child?

Her developmental skills were approximately in the 4- to 5-year-old range. As part of the American Academy of Neurology (AAN)-recommended workup for children with developmental delay, an MRI of the brain was done (Level B; Class III evidence). This showed extensive relatively symmetrical white matter (WM) hyperintensity involving mostly the subcortical WM (figure). There was relative sparing of the periventricular and periolandic WM. Both the caudate and lentiform nuclei showed abnormal signal with sparing of the thalamus. The dentate nuclei showed similar increased signal intensity. There was sparing of the corpus callosum and brainstem.

What conditions can produce this MRI pattern of WM involvement or abnormal signal in the basal ganglia? What would be the next step in your workup?

The differential diagnosis for the imaging findings discussed above would include Canavan disease, Kearns-Sayre syndrome, 3-hydroxy-3-methylglutaryl-coenzyme A lyase deficiency, and succinic semialdehyde dehydrogenase deficiency.

Bloodwork performed included a normal thyroid-stimulating hormone level, plasma pyruvate, lactic acid, amino acid screen, total/free carnitine levels, and acylcarnitine profile. Urine was sent for analysis of organic acids and the results showed “massive excretion of 2-hydroxyglutaric acid” (>1,000 mmol/mol creatinine). At this point genetic testing was performed, showing a homozygous mutation in the 1-2-hydroxyglutarate dehydrogenase gene. The mutation consisted of a T>G transversion (c.903T>G) in exon 7, resulting in the substitution of tyrosine by a stop codon at position 301 (p.Tyr301X). Based on these findings, a diagnosis of L-2-hydroxyglutaric aciduria was made.

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The basal ganglia and dentate nucleus are affected early during the disease with abnormalities of the putamen and caudate nucleus starting at the outer rim and moving inwards. The basal ganglia and dentate nucleus are affected early during the disease with abnormalities of the putamen and caudate nucleus starting at the outer rim and moving inwards. The basal ganglia and dentate nucleus are affected early during the disease with abnormalities of the putamen and caudate nucleus starting at the outer rim and moving inwards. The basal ganglia and dentate nucleus are affected early during the disease with abnormalities of the putamen and caudate nucleus starting at the outer rim and moving inwards. The basal ganglia and dentate nucleus are affected early during the disease with abnormalities of the putamen and caudate nucleus starting at the outer rim and moving inwards. 

Organic acidurias can be divided into classical and cerebral groups based on their clinical features. Patients with classical organic acidurias usually present with acute metabolic decompensation after a short symptom-free period at birth. In contrast, cerebral organic acidurias such as 1,2-hydroxyglutaric aciduria typically present with neurologic symptoms in the absence of severe metabolic derangements. The pattern of presentation of the neurologic symptoms can
also help distinguish between the different cerebral organic acidurias. For example, in glutaric aciduria type I the symptoms occur acutely, while in 1-2-hydroxyglutaric aciduria there is more of an insidious onset with slow progression. However, the neurologic symptoms themselves usually overlap between different conditions and alone would be poor predictors of a specific cerebral organic aciduria. Clinically, most patients with 1-2-hydroxyglutaric aciduria present in childhood with developmental delay usually consisting of mild to moderate psychomotor retardation. Cerebellar ataxia and epilepsy occur in about two-thirds of patients while macrocephaly and extrapyramidal symptoms are present in half. Hypotonia is usually prevalent in the early stages of the disease with spasticity appearing later. Our patient demonstrates many of these characteristic features, including macrocephaly, dysarthria, ataxia, mild hypotonia, and cognitive delay. No epidemiologic studies are yet available to determine incidence, life expectancy, or whether incidence differs by ethnicity. However, disease progression is usually slow, with most patients reaching adulthood.

Only 2 case reports in the literature document specific therapies producing improvement of neurologic function with decrease in the urinary excretion of 1-2-hydroxyglutaric acid. Further studies are needed to identify therapeutic strategies that decrease cerebral formation of 1-2-hydroxyglutaric acid. The improvement in neurologic function following biochemical alteration is encouraging for the future outlook of this rare disease.

**AUTHOR CONTRIBUTIONS**

Dr. Cachia was responsible for drafting and revising the manuscript for content, including medical writing for content, study concept and design, acquisition and analysis of data, concept, and analysis of data. Dr. Stine was responsible for drafting and revising the manuscript for content, including medical writing for content, analysis and interpretation of data, and study supervision.

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