MOSAIC DIAGNOSTICS

OAT ORGANIC ACIDS TEST

Requisition #:	1246823			*Practitioner:*	MICHELLE GAUCHER
Patient Name:	Geoffrey Mccormick			*Date of Collection:*	10/22/2023
Date of Birth:	08/07/1995	*Patient Age:*	28	*Time of Collection:*	Not Given
Patient Sex:	M			*Report Date:*	10/31/2023

Organic Acids Test - Nutritional and Metabolic Profile

Metabolic Markers in Urine	Reference Range (mmol/mol creatinine)	Patient Value	Reference Population - Males Age 13 and Over
Intestinal Microbial Overgrowth			
Yeast and Fungal Markers			
1 Citramalic	0.11 - 2.0	0.66	
2 5-Hydroxymethyl-2-furoic *(Aspergillus)*	≤ 18	14	
3 3-Oxoglutaric	≤ 0.11	0	
4 Furan-2,5-dicarboxylic *(Aspergillus)*	≤ 13	7.7	
5 Furancarbonylglycine *(Aspergillus)*	≤ 2.3	0	
6 Tartaric *(Aspergillus)*	≤ 5.3	0.20	
7 Arabinose	≤ 20	H 32	
8 Carboxycitric	≤ 20	0	
9 Tricarballylic *(Fusarium)*	≤ 0.58	0.13	
Bacterial Markers			
10 Hippuric	≤ 241	160	
11 2-Hydroxyphenylacetic	0.03 - 0.47	0.41	
12 4-Hydroxybenzoic	≤ 0.73	0.40	
13 4-Hydroxyhippuric	≤ 14	2.6	
14 DHPPA (Beneficial Bacteria)	≤ 0.23	0.06	
Clostridia Bacterial Markers			
15 4-Hydroxyphenylacetic *(C. difficile, C. stricklandii, C. lituseburense & others)*	≤ 18	7.2	
16 HPHPA *(C. sporogenes, C. caloritolerans, C. botulinum & others)*	≤ 102	9.8	
17 4-Cresol *(C. difficile)*	≤ 39	3.5	
18 3-Indoleacetic *(C. stricklandii, C. lituseburense, C. subterminale & others)*	≤ 6.8	0.55	

This test was developed, and its performance characteristics determined by Mosaic Diagnostics Laboratory. It has not been cleared or approved by the US Food and Drug Administration.

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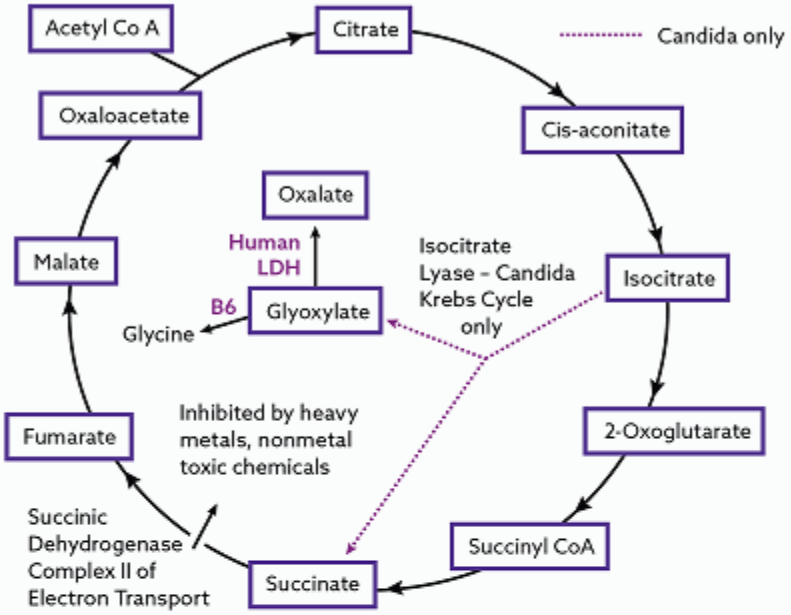
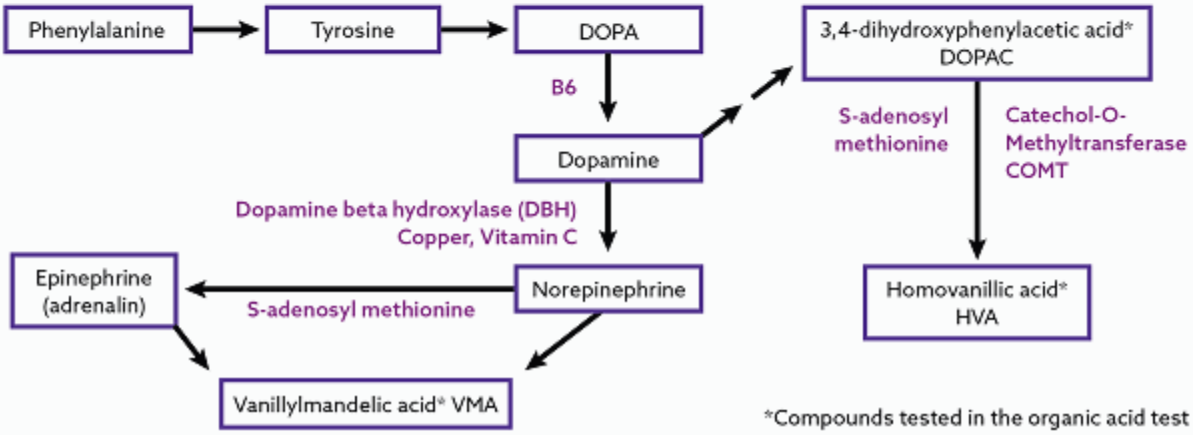
Human Krebs Cycle showing Candida Krebs Cycle variant that causes excess Oxalate via Glyoxylate



Major pathways in the synthesis and breakdown of **catecholamine neurotransmitters** in the absence of microbial inhibitors



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Metabolic Markers in Urine	Reference Range *(mmol/mol creatinine)*	Patient Value	Reference Population - Males Age 13 and Over
Oxalate Metabolites			
19 Glyceric	0.21 - 4.9	2.9	2.9
20 Glycolic	18 - 81	H 87	87
21 Oxalic	8.9 - 67	H 68	68
Glycolytic Cycle Metabolites			
22 Lactic	0.74 - 19	H 197	197
23 Pyruvic	0.28 - 6.7	2.1	2.1
Mitochondrial Markers - Krebs Cycle Metabolites			
24 Succinic	≤ 5.3	0.86	0.86
25 Fumaric	≤ 0.49	0.28	0.28
26 Malic	≤ 1.1	0	0.00
27 2-Oxoglutaric	≤ 18	8.0	8.0
28 Aconitic	4.1 - 23	12	12
29 Citric	2.2 - 260	68	68
Mitochondrial Markers - Amino Acid Metabolites			
30 3-Methylglutaric	0.02 - 0.38	0.36	0.36
31 3-Hydroxyglutaric	≤ 4.6	H 6.0	6.0
32 3-Methylglutaconic	0.38 - 2.0	1.5	1.5
Neurotransmitter Metabolites			
Phenylalanine and Tyrosine Metabolites			
33 Homovanillic (HVA) *(dopamine)*	0.39 - 2.2	1.3	1.3
34 Vanillylmandelic (VMA) *(norepinephrine, epinephrine)*	0.53 - 2.2	1.7	1.7
35 HVA / VMA Ratio	0.32 - 1.4	0.80	0.80
36 Dihydroxyphenylacetic (DOPAC) *(dopamine)*	0.27 - 1.9	1.2	1.2
37 HVA/ DOPAC Ratio	0.17 - 1.6	1.1	1.1
Tryptophan Metabolites			
38 5-Hydroxyindoleacetic (5-HIAA) *(serotonin)*	≤ 2.9	0.89	0.89
39 Quinolinic	0.52 - 2.4	1.4	1.4
40 Kynurenic	≤ 1.8	1.1	1.1

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Metabolic Markers in Urine	Reference Range *(mmol/mol creatinine)*	Patient Value	Reference Population - Males Age 13 and Over
Pyrimidine Metabolites - Folate Metabolism			
41 Uracil	≤ 6.9	1.3	1.3
42 Thymine	≤ 0.36	0.10	0.10
Ketone and Fatty Acid Oxidation			
43 3-Hydroxybutyric	≤ 1.9	H 3.3	3.3
44 Acetoacetic	≤ 10	0.87	0.87
45 Ethylmalonic	0.13 - 2.7	1.6	1.6
46 Methylsuccinic	≤ 2.3	0.79	0.79
47 Adipic	≤ 2.9	0.52	0.52
48 Suberic	≤ 1.9	H 3.2	3.2
49 Sebacic	≤ 0.14	0.09	0.09
Nutritional Markers			
Vitamin B12			
50 Methylmalonic ✱	≤ 2.3	1.3	1.3
Vitamin B6			
51 Pyridoxic (B6)	≤ 26	0	0.00
Vitamin B5			
52 Pantothenic (B5)	≤ 5.4	3.0	3.0
Vitamin B2 (Riboflavin)			
53 Glutaric ✱	≤ 0.43	0.04	0.04
Vitamin C			
54 Ascorbic	10 - 200	H 330	330
Vitamin Q10 (CoQ10)			
55 3-Hydroxy-3-methylglutaric ✱	≤ 26	7.7	7.7
Glutathione Precursor and Chelating Agent			
56 N-Acetylcysteine (NAC)	≤ 0.13	0	0.00
Biotin (Vitamin H)			
57 Methylcitric ✱	0.15 - 1.7	0.66	0.66

✱ ***A high value for this marker may indicate a deficiency of this vitamin.***

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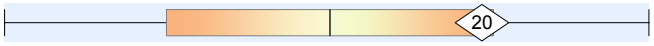
Metabolic Markers in Urine	Reference Range *(mmol/mol creatinine)*	Patient Value	Reference Population - Males Age 13 and Over

Indicators of Detoxification

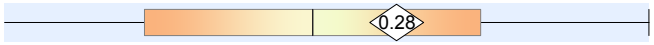
Glutathione

58	Pyroglutamic ✱	5.7 - 25		20	

Methylation, Toxic exposure

59	2-Hydroxybutyric ✱✱	≤ 1.2	H	2.2	

Ammonia Excess

60	Orotic	≤ 0.46		0.28	

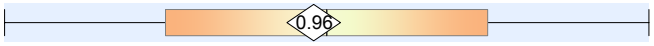
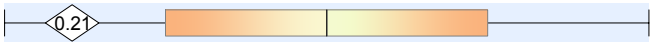
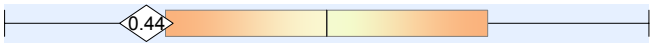
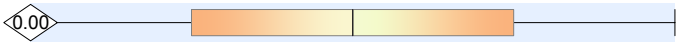
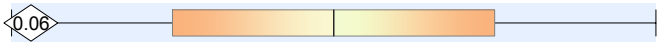
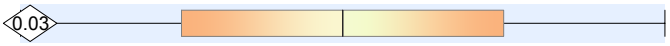
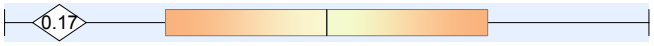
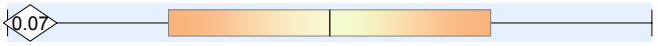
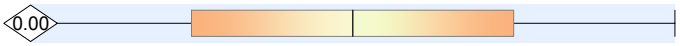
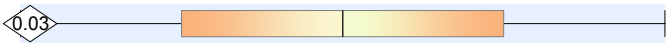
Aspartame, salicylates, or GI bacteria

61	2-Hydroxyhippuric	≤ 0.86		0.58	

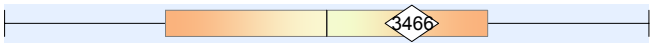
✱ ***A high value for this marker may indicate a Glutathione deficiency.***

✱✱ ***High values may indicate methylation defects and/or toxic exposures.***

Amino Acid Metabolites

62	2-Hydroxyisovaleric	≤ 2.0		0.96	
63	2-Oxoisovaleric	≤ 2.0		0.21	
64	3-Methyl-2-oxovaleric	≤ 2.0		0.44	
65	2-Hydroxyisocaproic	≤ 2.0		0	
66	2-Oxoisocaproic	≤ 2.0		0.06	
67	2-Oxo-4-methiolbutyric	≤ 2.0		0.03	
68	Mandelic	≤ 2.0		0.17	
69	Phenyllactic	≤ 2.0		0.07	
70	Phenylpyruvic	≤ 2.0		0	
71	Homogentisic	≤ 2.0		0.03	
72	4-Hydroxyphenyllactic	≤ 2.0		0.26	
73	N-Acetylaspartic	≤ 38		0.55	
74	Malonic	≤ 9.9		4.4	
75	4-Hydroxybutyric	≤ 4.3		2.4	

Mineral Metabolism

76	Phosphoric	1,000 - 4,900		3,466	

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Indicator of Fluid Intake

77	***Creatinine**	**177**	**mg/dL**	

*The creatinine test is performed to adjust metabolic marker results for differences in fluid intake. Urinary creatinine has limited diagnostic value due to variability as a result of recent fluid intake. Samples are rejected if creatinine is below 20 mg/dL unless the client requests results knowing of our rejection criteria.

Explanation of Report Format

The reference ranges for organic acids were established using samples collected from typical individuals of all ages with no known physiological or psychological disorders. The ranges were determined by calculating the mean and standard deviation (SD) and are defined as ± 2SD of the mean. Reference ranges are age and gender specific, consisting of Male Adult (≥13 years), Female Adult (≥13 years), Male Child (<13 years), and Female Child (<13 years).

There are two types of graphical representations of patient values found in the new report format of both the standard Organic Acids Test and the Microbial Organic Acids Test.

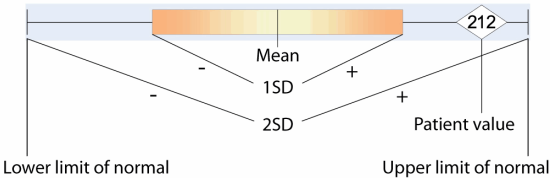
The first graph will occur when the value of the patient is within the reference (normal) range, defined as the mean plus or minus two standard deviations.

The second graph will occur when the value of the patient exceeds the upper limit of normal. In such cases, the graphical reference range is “shrunk” so that the degree of abnormality can be appreciated at a glance. In this case, the lower limits of normal are not shown, only the upper limit of normal is shown.

In both cases, the value of the patient is given to the left of the graph and is repeated on the graph inside a diamond. If the value is within the normal range, the diamond will be outlined in black. If the value is high or low, the diamond will be outlined in red.

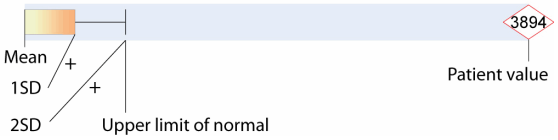
Example of Value Within Reference Range

Metabolic Markers in Urine	Reference Range *(mmol/mol creatinine)*		Patient Result	Reference Range - Males Age 13 and Under
Intestinal Microbial Overgrowth				
HPHPA (Clostridia marker)	<	219 .9	212	



Example of Elevated Value

Metabolic Markers in Urine	Reference Range *(mmol/mol creatinine)*		Patient Result	Reference Range - Males Age 13 and Under
Intestinal Microbial Overgrowth				
HPHPA (Clostridia marker)	<	219 .9	H 3894	



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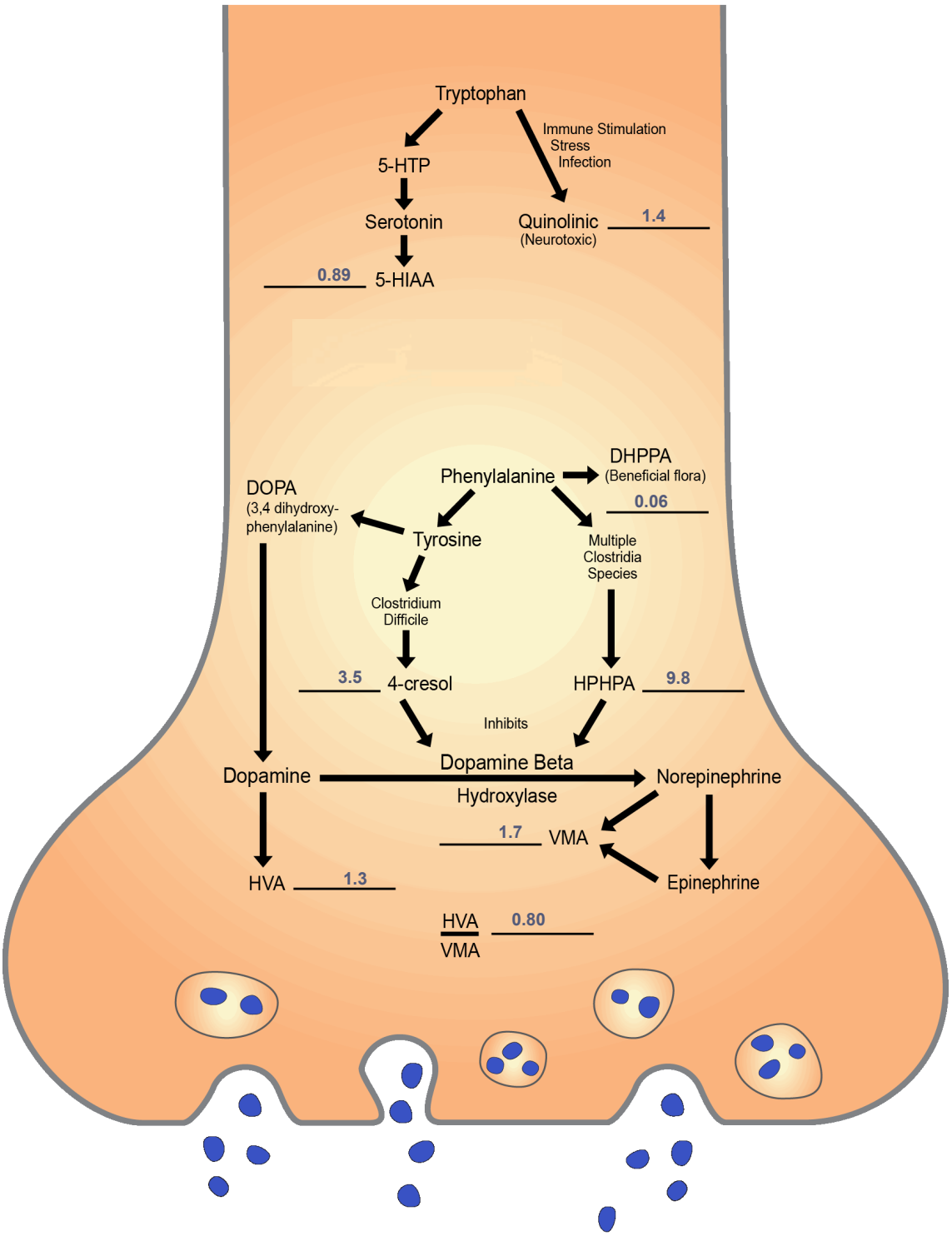
Neurotransmitter Metabolism Markers



The diagram contains the patient's test results for neurotransmitter metabolites and shows their relationship with key biochemical pathways within the axon terminal of nerve cells. The effect of microbial byproducts on the blockage of the conversion of dopamine to norepinephrine is also indicated.

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Interpretation

High yeast/fungal metabolites (1-8) Elevations of one or more metabolites indicate a yeast/fungal overgrowth of the gastrointestinal (GI) tract. Prescription or natural (botanical) anti-fungals, along with supplementation of high potency multi-strain probiotics, may reduce yeast/fungal levels.

High glycolic (20): in the absence of oxalic is most likely a result of GI yeast overgrowth (Aspergillus, Penicillium, Candida) or due to dietary sources containing glycerol/glycerine. Glycolic acid had also been found to be a metabolite in Acetobacter, Acidithiobacillus, Alcanligenes, Corynebacterium, Cryptococcus, Escherichia, Gluconobacter, Kluyveromyces, Leptospirillum, Pichia, Rhodococcus, Rhodotorula and Saccharomyces (PMID: 11758919; PMID: 26360870; PMID: 14390024).

High oxalic (21) with or without elevated glyceric (19) or glycolic acids (20) may be associated with the genetic hyperoxalurias, autism, women with vulvar pain, fibromyalgia, and may also be due to high vitamin C intake. However, kidney stone formation from oxalic acid was not correlated with vitamin C intake in a very large study. Besides being present in varying concentrations in most vegetables and fruits, oxalates, the mineral conjugate base forms of oxalic acid, are also byproducts of molds such as *Aspergillus* and *Penicillium* and probably *Candida*. If yeast or fungal markers are elevated, antifungal therapy may reduce excess oxalates. High oxalates may cause anemia that is difficult to treat, skin ulcers, muscles pains, and heart abnormalities. Elevated oxalic acid is also the result of anti-freeze (ethylene glycol) poisoning. Oxalic acid is a toxic metabolite of trichloroacetic acid and other environmental pollutants. In addition, decomposing vitamin C may form oxalates during transport or storage.

Elevated oxalate values with a concomitant increase in glycolic acid may indicate genetic hyperoxaluria (type I), whereas increased glyceric acid may indicate a genetic hyperoxaluria (type II). Elevated oxalic acid with normal levels of glyceric or glycolic metabolites rules out a genetic cause for high oxalate. However, elevated oxalates may be due to a new genetic disorder, hyperoxaluria type III.

Regardless of its source, high oxalic acid may contribute to kidney stones and may also reduce ionized calcium. Oxalic acid absorption from the GI tract may be reduced by calcium citrate supplementation before meals. Vitamin B6, arginine, vitamin E, chondroitin sulfate, taurine, selenium, omega-3 fatty acids and/or N-acetyl glucosamine supplements may also reduce oxalates and/or their toxicity. Excessive fats in the diet may cause elevated oxalate if fatty acids are poorly absorbed because of bile salt deficiency. Unabsorbed free fatty acids bind calcium to form insoluble soaps, reducing calcium's ability to bind oxalate and increase its absorption. If taurine is low in a plasma amino acid profile, supplementation with taurine (1000 mg/day) may help stimulate bile salt production (taurocholic acid), leading to better fatty acid absorption and diminished oxalate absorption.

High levels of oxalates are common in autism. Malabsorption of fat and intestinal *Candida* overgrowth are probably the major causes for elevated oxalates in this disorder. Even individuals with elevated glyceric or glycolic acids may not have a genetic disease. To rule out genetic diseases in those people with abnormally high markers characteristic of the genetic diseases, do the following steps: (1) Follow the nutritional steps indicated in this interpretation for one month; (2) If *Candida* is present, treat *Candida* for at least one month; (3) Repeat the organic acid test after abstaining from vitamin C supplements for 48 hours; (4) If the biochemical markers characteristic of genetic oxalate disorders are still elevated in the repeat test, consider DNA tests for the most common mutations of oxalate metabolism. DNA testing for type I hyperoxaluria is available from the Mayo Clinic, Rochester, MN as test #89915 "*AGXT* Gene, Full Gene Analysis" and, for the p.Gly170Arg mutation only, as # 83643 "Alanine:Glyoxylate Aminotransferase [*AGXT*] Mutation Analysis [G170R], Blood"). Another option to confirm the genetic disease is a plasma oxalate test, also available from the Mayo Clinic (Phone 507.266.5700). Plasma oxalate values greater than 50 micromol/L are consistent with genetic oxalate diseases and may serve as an alternate confirmation test.

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Bone tends to be the major repository of excess oxalate in patients with primary hyperoxaluria. Bone oxalate levels are negligible in healthy subjects. Oxalate deposition in the skeleton tends to increase bone resorption and decrease osteoblast activity.

Oxalates may also be deposited in the kidneys, joints, eyes, muscles, blood vessels, brain, and heart and may contribute to muscle pain in fibromyalgia. Oxalate crystal formation in the eyes may be a source of severe eye pain in individuals with autism who may exhibit eye-poking behaviors. High oxalates in the GI tract also may significantly reduce absorption of essential minerals such as calcium, magnesium, zinc, and others. In addition, oxalate deposits in the breast have been associated with breast cancer.

A low oxalate diet may also be particularly useful in the reduction of body oxalates even if dysbiosis of GI flora is the major source of oxalates. Foods especially high in oxalates include spinach, beets, chocolate, soy, peanuts, wheat bran, tea, cashews, pecans, almonds, berries, and many others.

People with abnormally high markers characteristic of the genetic diseases should do the following:
1. Avoid spinach, soy, nuts, and berries for one month.
2. If *Candida* is present, treat *Candida* for at least one month.
3. Repeat the organic acid test having abstained from vitamin C supplements for 48 hours.
4. If the biochemical markers characteristic of genetic oxalate disorders are still elevated in the repeat test, consider DNA tests for the most common mutations of oxalate metabolism.

High lactic acid and/or high pyruvic acid (22,23) may be caused by many nonspecific factors, such as vigorous exercise, bacterial overgrowth of the GI tract, shock, poor perfusion, anemia, mitochondrial dysfunction or damage, and many other causes. Conversion of pyruvic acid to acetyl-CoA requires the cofactors coenzyme A (derived from pantothenic acid), lipoic acid, FAD derived from riboflavin, and thiamine. However, the possibility of an inborn error of metabolism increases as the value exceeds 300 mmol/mol creatinine. Values greater than 1000 mmol/mol creatinine indicate a much higher likelihood of an inborn error of metabolism. There are many inborn errors of metabolism that present elevated lactic acid, including disorders of sugar metabolism and pyruvate dehydrogenase deficiency.

Low or low normal citric acid (29) may be due to impaired function of the Krebs cycle, low dietary intake of citrate-containing foods such as citrus fruits and juices, potassium deficiency, acidosis (especially renal tubular acidosis), chronic kidney failure, diabetes, hypoparathyroidism, or excessive muscle activity. Low values may indicate increased risk of oxalate kidney stone formation, especially if oxalic acid is elevated also. Supplement with calcium or magnesium citrate if oxalic acid is elevated.

High 3-hydroxyglutaric (31) is a metabolite associated with the genetic disease glutaric aciduria type I, which is due to a deficiency of glutaryl CoA dehydrogenase, an enzyme involved in the breakdown of lysine, hydroxylysine, and tryptophan. Other organic acids elevated include glutaric and glutaconic. This disease has been associated with clinical symptoms ranging from near normal to encephalopathy, cerebral palsy, and other neurological abnormalities. Some individuals with glutaric acidemia have developed bleeding in the brain or eyes that may be mistaken for the effects of child abuse . This abnormality should be confirmed by additional testing of enzyme deficiencies and/or DNA at a major pediatric medical genetics center (Morton et al. Glutaric aciduria type I: a common cause of encephalopathy and spastic paralysis in the Amish of Lancaster County, Pennsylvania. American J. Med. Genetics 41: 89-95, 1991). Elevated values may also be found in hepatic carnitine palmitoyltransferase I deficiency, short-chain acyl dehydrogenase deficiency (SCAD), and ketosis. Mitochondrial dysfunction induced by glutaric acid metabolites causes astrocytes to adopt a proliferative phenotype, which may underlie neuronal loss, white matter abnormalities and macrocephalia. Values in glutaric aciduria type I range from 60-3000 mmol/mol creatinine. Values higher than normal but less than 60 mmol/mol creatinine may be due to mild glutaric acidemia type I or to the other causes indicated above. Treatment of this disorder includes special diets low in lysine and supplementation with carnitine or acetyl-L-carnitine.

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5-hydroxyindoleacetic acid (5HIAA) (38) levels below the mean may indicate lower production and/or decreased metabolism of the neurotransmitter serotonin. 5-hydroxy-indoleacetic acid is a metabolite of serotonin. Low values have been correlated with symptoms of depression. Low production of 5 HIAA can be due to decreased intake or absorption of serotonin's precursor amino acid tryptophan, decreased quantities of cofactors needed for biosynthesis of serotonin such as tetrahydrobiopterin and vitamin B6 coenzyme. In addition, a number of genetic variations such as single nucleotide polymorphisms (SNPs) or mutations can cause reduced production of 5HIAA. Such SNPs are available on **The Great Plains DNA methylation pathway test** which can be performed on a cheek swab. Values may be decreased in patients on monoamine oxidase (MAO) inhibitors that are drugs or foods that contain tyramine such such as Chianti wine and vermouth, fermented foods such as cheeses, fish, bean curd, sausage, bologna, pepperoni, sauerkraut, and salami.

High 3-hydroxybutyric acids (43) and/or acetoacetic acids (44) indicate increased metabolic utilization of fatty acids. These ketones are associated with diabetes mellitus, fasting, dieting (ketogenic or SCD diet), or illness such as nausea or flu, among many other causes.

Slight elevation in suberic acid (48) is consistent with overnight fasting or increased fat in the diet. Regardless of cause, supplementation with L-carnitine or acetyl-L-carnitine may be beneficial.

Pyridoxic acid (B6) levels below the mean (51) may be associated with less than optimum health conditions (low intake, malabsorption, or dysbiosis). Supplementation with B6 or a multivitamin may be beneficial.

High ascorbic acid (vitamin C) (54) may be the result of supplementation. An elevated value of ascorbic acid does not mean that this amount of vitamin C is not beneficial.

High 2-hydroxybutyric acid (59) This organic acid is elevated when there is increased production of sulfur amino acids derived from homocysteine. The reasons for an increase can be due to the following reasons (which are not mutually exclusive):

1. There is increased need for glutathione to detoxify a host of toxic chemicals, resulting in increased shunting of homocysteine into the production of cysteine for glutathione. This is the most common reason.
2. There are genetic variants of the DNA such that methylation of homocysteine by betaine homocysteine methyl transferase or methionine synthase is impaired. . SNPs of genes in the methylation cycle are available on **The Great Plains DNA methylation pathway test** which can be performed on a cheek swab.
3. There are nutritional deficiencies of betaine, methylcobalamin, or methyltetrahydrofolate that reduce the enzyme activities of the enzymes in #2 above.
4. There is a genetic variant in cystathionine beta synthase (CBS) enzyme such that there is excessive shunting of homocysteine into cysteine production that results in excessive 2-hydroxybutyric acid formation.
5. Onset of diabetes mellitus or excessive alcohol use.
6. Presence of certain genetic diseases such as lactic acidosis, glutaric aciduria type II, dihydrolipoyl dehydrogenase (E3) deficiency, and propionic aciduria.

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