Organic Acids In Central Energy Pathways

Marker elevations may suggest nutrient deficiencies in the metabolic pathway

Food Source Proteins → Amino Acids → Keto Acids

Food Source Carbohydrates → Glucose → Pyruvate

Lactate ↔ Pyruvate (B3)

Pyruvate → Acetyl-CoA

Food Source Fats → Fatty Acids → Fatty Acyl-CoA

Fatty Acyl-CoA → * Beta-Oxidation (B2, B3, Carnitine)

Acetyl-CoA ↔ Acetoacetate (B6) ↔ Beta-Hydroxybutyrate (B3)

Fatty Acids (Carnitine) → Hydroxymethylglutarate → Cholesterol (CoQ10)

Hydroxymethylglutarate (Biotin) → Beta-Hydroxyisovalerate (B1, B2, B3, B5 Lipoic Acid, Mg ++)

Leucine (amino acid conversion to keto acids) (B6) → Alpha-Ketoisocaproate → Beta-Hydroxyisovalerate

B1, B2, B3, B5 Lipoic Acid

ASN (amino acid) ↔ Aspartate (Mn++, Mg++ Biotin; B6)

Aspartate ↔ Oxaloacetate

Acetyl-CoA + Oxaloacetate → Citrate

CITRIC ACID CYCLE

Oxaloacetate (B3) → Malate → Fumarate (B2, Fe++) → Succinate → Succinyl-CoA

Citrate → cis-Aconitate → Isocitrate (B3, Mg++, Mn++) → Alpha-Ketoglutarate

Cysteine, Fe++, Glutathione

GLN ↔ GLU (B3; B6)

Proline, Histidine, Arginine — Amino Acids

Alpha-Ketoglutarate → Succinyl-CoA (B1, B2, B3, B5, Lipoic Acid)

UREA CYCLE

NH3 + CO2 (B5, Mg++, K+) → Carbamoyl - P → Orotate → Citrulline → Arginosuccinate → Arginine → Urea → Ornithine → Citrulline

Tyrosine (B6) ← Phenylalanine

Tyrosine → L-Dopa (B3) → Dopamine (Cu++, Ascorbate) → Norepinephrine (Mg++) → Epinephrine

Dopamine (B2) → Homovanillate

Norepinephrine (B2, Mg++, Fe++) → Vanilmandelate

NEUROTRANSMITTER METABOLISM

Kynurenate (B6; B2, B3, B5) ← Kynurenine → 3-Hydroxykynurenine (B6) → Quinolinate (Mg++) → NAD

Kynurenine (B1; B3)

Tryptophan (amino acid) (B3, Fe++) → 5-HTP (B6) → Serotonin (B2, B6) → 5-Hydroxyindoleacetate

Isoleucine (B6) → Alpha-Keto-Beta-Methylvalerate

Food Source Proteins (amino acid conversion to keto acids) → Isoleucine

Valine (B6) ↔ Alpha-Ketoisovalerate

Alpha-Keto-Beta-Methylvalerate + Valine + Alpha-Ketoisovalerate (B1, B2, B3, B5 Lipoic Acid, Mg ++) → Propionyl-CoA (B3, B5)

Propionyl-CoA ← Odd chain fatty acids; Cholesterol side chains

Propionyl-CoA → Methylmalonyl-CoA (Biotin) (Methylmalonate)

Methylmalonyl-CoA (Methylmalonate) → Succinyl-CoA (B12)

Methionine → Cysteine (B6) → GSH → Pyroglutamate

**Alpha-Ketobutyrate ↔ Alpha-Hydroxybutyrate

Threonine → **Alpha-Ketobutyrate

Alpha-Hydroxybutyrate → Beta-Hydroxybutyrate

NADH, FADH2 → Mitochondrial electron transport system → CoQ10 → O2, H2O → Cellular Energy → ATP → Biosynthetic Reactions

* Interference with mitochondrial beta-oxidation yields products of incomplete alternate oxidative pathways; adipate, suberate, ethylmalonate and methylsuccinate

** Interferance with alpha-ketobutylate oxidation yeilds subsequent elevation of urinary alpha-hydroxybutyrate

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