Vitamin B1 (Thiamine)

Thiamine, also called vitamin B1, is a water-soluble vitamin that is involved in many cellular processes. In biochemistry, thiamine is most commonly seen in the phosphate derivative form of thiamine pyrophosphate (TPP). This coenzyme is necessary for the proper functioning of essential enzymes in the catabolism of sugars and amino acids including branched-chain amino acid dehydrogenase, pyruvate dehydrogenase, alpha-ketoglutarate dehydrogenase, and transketolase. Because these enzymes are used to make ATP for cellular energy, thiamine depletion can cause severe ATP depletion. Symptoms of thiamine deficiency have a broad range including Wernicke-Korsakoff syndrome and beriberi. In general, aerobic tissues that require high levels of ATP for proper functioning like the brain and heart are affected first. Because thiamine is necessary for glucose metabolism, infusion of glucose can precipitate or worsen thiamine deficiency. Therefore, thiamine is always given with IV glucose in patients susceptible to a thiamine deficiency.

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Mechanism

Branched-chain Ketoacid Dehydrogenase
Branched-chains on Key-acidic-lemon Dehydrator
This enzyme complex has an analogous structure to pyruvate dehydrogenase and alpha-ketoglutarate dehydrogenase and requires thiamine pyrophosphate as a cofactor. This enzyme complex is responsible for the degradation of branched-chain amino acids like leucine, isoleucine, and valine.

Pyruvate Dehydrogenase
Pie-root Dehydrator
This enzyme complex consists of three enzymes that transform pyruvate to acetyl CoA via pyruvate decarboxylation and requires thiamine pyrophosphate as a cofactor.

Alpha-ketoglutarate Dehydrogenase
Afro Key-glutorade Dehydrator
This is an enzyme complex in the citric acid cycle. This enzyme catalyzes the reaction from alpha-ketoglutarate plus NAD and CoA to succinyl CoA plus CO2 and NADH. This enzyme complex requires thiamine pyrophosphate as a cofactor.

Transketolase
Train-key
Transketolase is an enzyme involved in the pentose phosphate pathway and uses the cofactor thiamine pyrophosphate to transfer a two-carbon fragment. In mammals, this enzyme connects the pentose phosphate pathway to glycolysis, allowing excess sugar phosphates to be utilized in the main carbohydrate metabolic pathways. Its presence is also necessary for the production of NADPH in the pentose phosphate pathway.

DEFICIENCY EFFECTS

Wernicke-Korsakoff Syndrome
Worm-Mickey Corset-cop
Thiamine deficiency is known to cause Wernicke-Korsakoff syndrome which is a combination of two conditions: Wernicke encephalopathy and Korsakoff syndrome. Wernicke encephalopathy is an acute condition characterized by the triad of encephalopathy, oculomotor dysfunction, and ataxia. Korsakoff syndrome is a chronic condition that may develop as a result of Wernicke encephalopathy and is characterized by selective amnesia (retrograde and antegrade).

Beriberi
Beriberi
Thiamine deficiency is known to cause beriberi which has two forms: wet and dry. Wet beriberi is characterized by cardiovascular complications and dry beriberi by neurological complications.

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ATP Depletion

ATP-battery low

Because the enzymes that require thiamine are used to make ATP for cellular energy, thiamine depletion can cause severe ATP depletion.

Aerobic Tissues Like Brain and Heart Affected First

Brain and Heart in Aerobic-outfit

In general, aerobic tissues that require high levels of ATP for proper functioning like the brain and heart are affected first by thiamine deficiency.

Considerations

Deficiency Can Worsen with Glucose Infusion

Glue-bottle IV

Because thiamine is necessary for glucose metabolism, infusion of glucose can precipitate or worsen thiamine deficiency. Therefore, thiamine is always given with IV glucose in patients susceptible to a thiamine deficiency.

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