Primary carnitine deficiency

Primary carnitine deficiency is a condition that prevents the body from using certain fats for energy, particularly during periods without food (fasting). Carnitine, a natural substance acquired mostly through the diet, is used by cells to process fats and produce energy.

Signs and symptoms of primary carnitine deficiency typically appear during infancy or early childhood and can include severe brain dysfunction (encephalopathy), a weakened and enlarged heart (cardiomyopathy), confusion, vomiting, muscle weakness, and low blood sugar (hypoglycemia). The severity of this condition varies among affected individuals. Some people with primary carnitine deficiency are asymptomatic, which means they do not have any signs or symptoms of the condition. All individuals with this disorder are at risk for heart failure, liver problems, coma, and sudden death.

Problems related to primary carnitine deficiency can be triggered by periods of fasting or by illnesses such as viral infections. This disorder is sometimes mistaken for Reye syndrome, a severe disorder that may develop in children while they appear to be recovering from viral infections such as chicken pox or flu. Most cases of Reye syndrome are associated with the use of aspirin during these viral infections.

Frequency

The incidence of primary carnitine deficiency in the general population is approximately 1 in 100,000 newborns. In Japan, this disorder affects 1 in every 40,000 newborns.

Causes

Mutations in the SLC22A5 gene cause primary carnitine deficiency. This gene provides instructions for making a protein called OCTN2 that transports carnitine into cells. Cells need carnitine to bring certain types of fats (fatty acids) into mitochondria, which are the energy-producing centers within cells. Fatty acids are a major source of energy for the heart and muscles. During periods of fasting, fatty acids are also an important energy source for the liver and other tissues.

Mutations in the SLC22A5 gene result in an absent or dysfunctional OCTN2 protein. As a result, there is a shortage (deficiency) of carnitine within cells. Without carnitine, fatty acids cannot enter mitochondria and be used to make energy. Reduced energy production can lead to some of the features of primary carnitine deficiency, such as muscle weakness and hypoglycemia. Fatty acids may also build up in cells and damage the liver, heart, and muscles. This abnormal buildup causes the other signs and symptoms of the disorder.
Inheritance Pattern

Primary carnitine deficiency is inherited in an autosomal recessive pattern, which means both copies of the gene in each cell have mutations. Most often, the parents of an individual with an autosomal recessive disorder are carriers, which means they each carry one copy of the mutated gene. Carriers of SLC22A5 gene mutations may have some signs and symptoms related to the condition.

Other Names for This Condition

• carnitine transporter deficiency
• carnitine uptake defect
• carnitine uptake deficiency
• CUD
• renal carnitine transport defect
• systemic carnitine deficiency

Diagnosis & Management

Formal Diagnostic Criteria

• ACT Sheet: Decreased C0 and other acylcarnitines
  https://www.ncbi.nlm.nih.gov/books/NBK55827/bin/C0.pdf

Genetic Testing Information

• What is genetic testing?
  /primer/testing/genetictesting
• Genetic Testing Registry: Renal carnitine transport defect

Research Studies from ClinicalTrials.gov

• ClinicalTrials.gov
  https://clinicaltrials.gov/ct2/results?cond=%22primary+carnitine+deficiency%22

Other Diagnosis and Management Resources

• Baby’s First Test
  https://www.babysfirsttest.org/newborn-screening/conditions/carnitine-uptake-defect
• GeneReview: Systemic Primary Carnitine Deficiency
  https://www.ncbi.nlm.nih.gov/books/NBK84551
• The Linus Pauling Institute: L-Carnitine
  https://lpi.oregonstate.edu/mic/dietary-factors/L-carnitine
Additional Information & Resources

Health Information from MedlinePlus

- Health Topic: Cardiomyopathy
  https://medlineplus.gov/cardiomyopathy.html
- Health Topic: Lipid Metabolism Disorders
  https://medlineplus.gov/lipidmetabolismdisorders.html
- Health Topic: Newborn Screening
  https://medlineplus.gov/newbornscreening.html

Genetic and Rare Diseases Information Center

- Primary carnitine deficiency
  https://rarediseases.info.nih.gov/diseases/5104/primary-carnitine-deficiency

Additional NIH Resources

- NIH Office of Dietary Supplements: Carnitine
  https://ods.od.nih.gov/factsheets/Carnitine-HealthProfessional/

Educational Resources

- Orphanet: Systemic primary carnitine deficiency
  https://www.orpha.net/consor/cgi-bin/OC_Exp.php?Lng=EN&Expert=158
- Screening, Technology, and Research in Genetics
  http://www.newbornscreening.info/Parents/fattyaciddisorders/Carnitine.html
- The Linus Pauling Institute: L-Carnitine
  https://lpi.oregonstate.edu/mic/dietary-factors/L-carnitine
- Virginia Department of Health

Patient Support and Advocacy Resources

- FOD (Fatty Oxidation Disorders) Family Support Group
  https://fodsupport.org/
- Metabolic Support UK
  https://www.metabolicsupportuk.org/
- Muscular Dystrophy Association
  https://www.mda.org/disease/metabolic-myopathies/types/carnitine-deficiency
- National Organization for Rare Disorders (NORD)
  https://rarediseases.org/rare-diseases/systemic-primary-carnitine-deficiency/
- United Mitochondrial Disease Foundation
  https://www.umdf.org/
Clinical Information from GeneReviews

• Systemic Primary Carnitine Deficiency
  https://www.ncbi.nlm.nih.gov/books/NBK84551

Scientific Articles on PubMed

• PubMed
  https://www.ncbi.nlm.nih.gov/pubmed?term=%28%28carnitine+uptake+defect%29%5BTIAB%5D%29+OR+%28carnitine+transporter+deficiency%5BTIAB%5D%29+OR+%28primary+carnitine+deficiency%5BTIAB%5D%29+OR+%28systemic+carnitine+deficiency%5BTIAB%5D%29+AND+english%5Bla%5D+AND+human%5Bmh%5D+AND+%22last+3600+days%22%5Bdp%5D

Catalog of Genes and Diseases from OMIM

• CARNITINE DEFICIENCY, SYSTEMIC PRIMARY
  http://omim.org/entry/212140

Sources for This Summary

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/16652335

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/20027113

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/11509010

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/12210323

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/20574985

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/16602102 
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2557099/
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/22989098
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3495906/

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/17126586

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/23379544

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/15591002

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/12889657

  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/11715001

Reprinted from Genetics Home Reference: 

Reviewed: September 2014
Published: January 7, 2020

Lister Hill National Center for Biomedical Communications
U.S. National Library of Medicine
National Institutes of Health
Department of Health & Human Services