



Genetic Fact Sheets for Parents

Fatty Acid Oxidation Disorders

Screening, Technology, and Research in Genetics is a multi-state project to improve information about the financial, ethical, legal, and social issues surrounding expanded newborn screening and genetic testing – [http:// www.newbornscreening.info](http://www.newbornscreening.info)

Disorder Name: Carnitine transporter deficiency

Acronym: CTD

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This fact sheet contains general information about CTD. Every child is different and some of this information may not apply to your child specifically. Not all is known about CTD. At present, there is no standard treatment plan. Certain treatments may be recommended for some children but not others. Children with CTD should be followed by a metabolic doctor in addition to their primary doctor.

What is CTD?

CTD stands for “carnitine transporter deficiency.” It is one type of [fatty acid oxidation disorder](#). People with CTD have problems using fat as energy for the body.

Fatty Acid Oxidation Disorders:

Fatty acid oxidation disorders (FAODs) are a group of rare inherited conditions. They are caused by enzymes that do not work properly.

A number of enzymes are needed to break down fats in the body (a process called fatty acid oxidation). Problems with any of these enzymes can cause a fatty acid oxidation disorder. People with FAODs cannot properly break down fat from either the food they eat or from fat stored in their bodies.

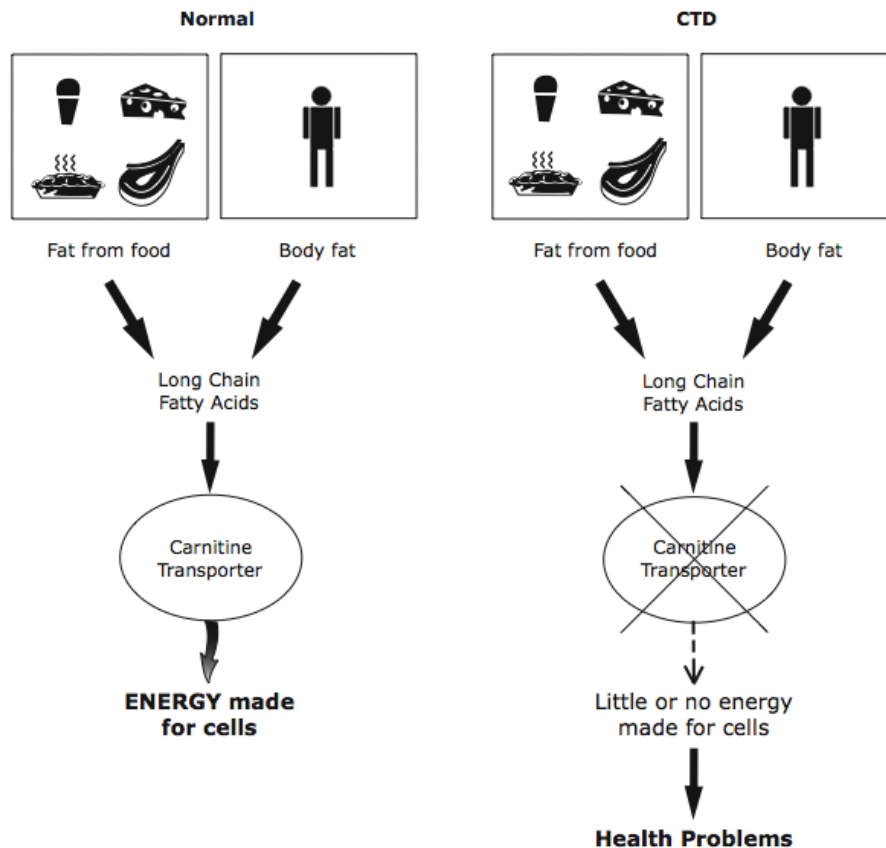
The symptoms and treatment vary between different FAODs. They can also vary from person to person with the same FAOD. See the fact sheets for each specific FAOD.

FAODs are inherited in an autosomal recessive manner and affect both males and females.

What causes CTD?

CTD is caused by problems with the enzyme “carnitine transporter” (CT). In people with CTD, the CT enzyme is either missing or not working properly. This enzyme’s job is to carry a substance called carnitine into our cells. Carnitine helps the body make energy from the fat in food. It also helps us use fat already stored in the body.

Carnitine Transporter Deficiency CTD



Energy from fat keeps us going whenever our bodies run low of their main source of energy, a type of sugar called glucose. Our bodies rely on fat when we don't eat for a stretch of time – like when we miss a meal or when we sleep.

When the normal CT enzyme is missing or not working well, the body cannot use fat for energy. Instead, it must rely solely on glucose. Although glucose is a good source of energy, there is a limited amount available. Once the glucose has been used up, the body tries to use fat without success. This leads to low blood sugar, called hypoglycemia, and to the build up of harmful substances in the blood

If CTD is not treated, what problems occur?

There are two main types of CTD: one begins in infancy, the other in childhood.

CTD in infants

Babies with CTD first show symptoms between birth and age three. CTD can cause bouts of illness called metabolic crises. Some of the first symptoms of a metabolic crisis are:

- extreme sleepiness
- behavior changes
- irritable mood
- poor appetite

Other symptoms then follow:

- fever
- nausea
- diarrhea
- vomiting
- hypoglycemia

If a metabolic crisis is not treated, a child with CTD can develop:

- breathing problems
- swelling of the brain
- seizures
- coma, sometimes leading to death

Babies who are not treated may have other effects:

- enlarged heart
- enlarged liver
- muscle weakness
- anemia

Repeated episodes of metabolic crisis can cause brain damage. This can result in learning problems or intellectual disabilities.

Symptoms of a metabolic crisis often happen after having nothing to eat for more than a few hours. Symptoms are also more likely when a child with CTD gets sick or has an infection.

CTD in children

Children with CTD appear perfectly normal until symptoms begin, usually between the ages of one and seven. Some of the effects of childhood CTD are:

- enlarged heart
- muscle weakness
- if left untreated, risk of heart failure and death

Children with this type of CTD do not have episodes of hypoglycemia or metabolic crises. Their intelligence is not affected.

Some children with CTD never have symptoms and are only found to be affected after a brother or sister is diagnosed. Many infants diagnosed with CTD, based on newborn screening results, never develop symptoms of CTD.

What is the treatment for CTD?

Your baby's primary doctor will work with a metabolic doctor to care for your child. Your doctor may also suggest that you meet with a dietician familiar with CTD.

Certain treatments may be advised for some children but not others. When necessary, treatment is usually needed throughout life. The following are treatments often recommended for children with CTD:

1. L-carnitine

The main treatment for CTD is lifelong use of L-carnitine. This is a safe and natural substance that helps body cells make energy. It also helps the body get rid of harmful wastes. L-carnitine can reverse the heart problems and muscle weakness that happen in children with CTD.

Your doctor will decide whether or not your child needs L-carnitine. Unless you are advised otherwise, use only L-carnitine prescribed by your doctor. Do not use L-carnitine without checking with your doctor.

2. Avoid going a long time without food

Infants and young children with CTD need to eat frequently to prevent a metabolic crisis. Your metabolic doctor will tell you how often your child needs to be fed. In general, it is often suggested that infants be fed every four to six hours. Some babies need to eat even more frequently than this. It is important that infants be fed during the night. They may need to be woken up to eat if they do not wake up on their own. Your metabolic doctor and dietician will give you an appropriate feeding plan for your infant. Your doctor will also give you a 'sick day' plan tailored to your child's needs for you to follow during illnesses or other times when your child will not eat.

Your metabolic doctor will continue to advise you on how often your child should eat as he or she gets older. When they are well, many teens and adults with CTD can go without food for up to 12 hours without problems. The other treatments usually need to be continued throughout life.

3. Diet

Sometimes, in addition to L-carnitine treatment, a diet low in fat and high in carbohydrates is recommended. Any diet changes should be made under the guidance of a dietician familiar with CTD. Ask your doctor whether your child needs to have any changes in his or her diet.

4. Tracking carnitine levels

Your child will have regular blood tests to measure their carnitine levels. The diet and medication may need to be adjusted based on blood test levels.

5. If your baby has CTD, call your doctor at the start of any illness

Always call your health care provider when your baby has any of the following:

- poor appetite
- low energy or excessive sleepiness
- vomiting
- diarrhea
- an infection
- a fever
- persistent muscle pain or weakness

Babies with CTD need to eat extra starchy food and drink more fluids during any illness – even if they may not feel hungry – or they could have a metabolic crisis. Children who are sick often don't want to eat. If they won't or can't eat, they may need to be treated in the hospital to prevent serious health problems.

Ask your metabolic doctor if you should carry a special travel letter with medical instructions for your child's care.

What happens when CTD is treated?

With prompt and careful treatment, children with CTD usually live healthy lives with typical growth and development. Treatment with L-carnitine can often reverse heart enlargement and muscle weakness.

Babies with CTD who have repeated episodes of metabolic crisis may have permanent brain damage. This can cause learning problems or intellectual disabilities.

What causes the CT enzyme to be absent or not working correctly?

Genes tell the body how to make enzymes. The SLC22A5 gene instructs the body to make the CT enzyme. Everyone has two copies of the SLC22A5 gene. People with CTD have changes, also called variants in both copies of their SLC22A5 genes that cause them to not work correctly. Because of the variants in the SLC22A5 genes, the CT enzyme either does not work properly or is not made at all.

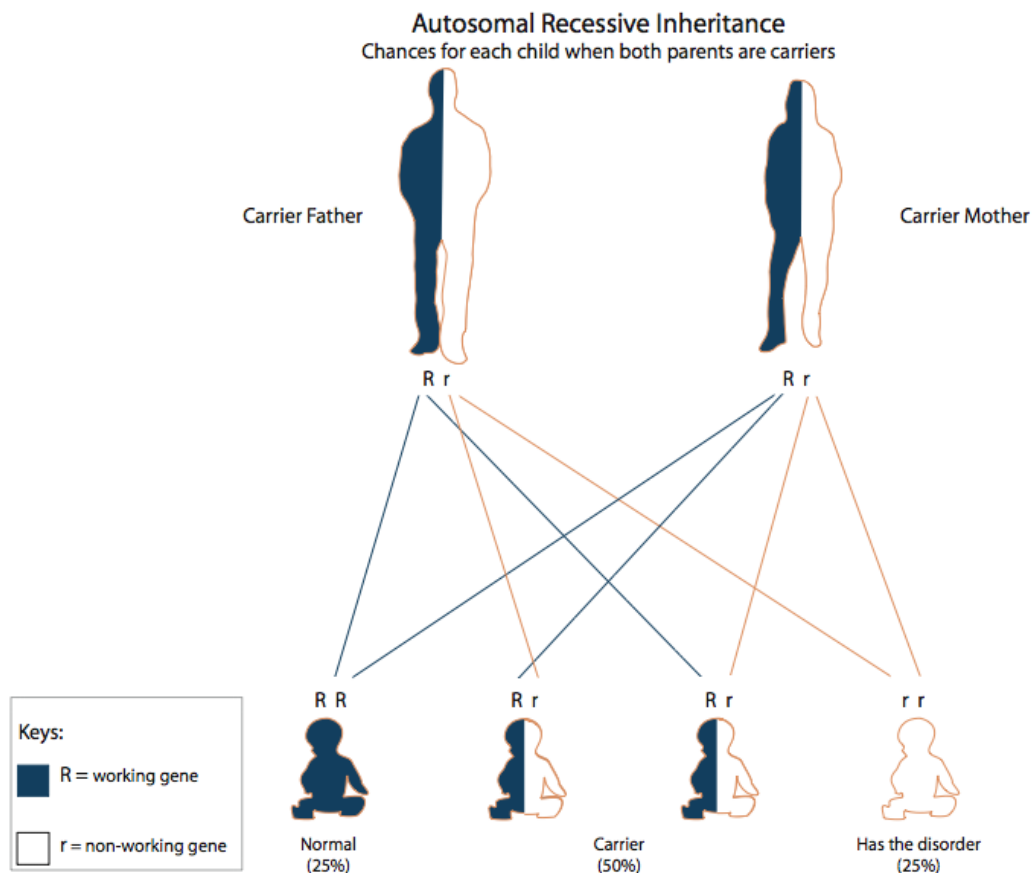
How is CTD inherited?

CTD is inherited in an autosomal recessive manner. It affects both boys and girls equally.

Everyone has two copies of the SLC22A5 gene that make the CT enzyme. In children with CTD, neither of these genes works correctly. These children inherit one non-working SLC22A5 gene from each parent.

Parents of children with CTD are rarely affected with the disorder. Instead, each parent has a single non-working SLC22A5 gene for CTD. They are called carriers. Carriers do not have CTD because their other SLC22A5 gene is working correctly.

When both parents are carriers, there is a 25% chance in each pregnancy for the child to have CTD. There is a 50% chance for the child to be a carrier, just like the parents. And, there is a 25% chance for the child to have two working genes.



Genetic counseling is available to families who have children with CTD. Genetic counselors can answer your questions about how CTD is inherited, choices during future pregnancies, and how to test other family members. Ask your doctor about a referral to a genetic counselor.

Is genetic testing available?

Genetic testing for CTD can be done on a blood sample. Genetic testing, also called DNA testing, looks for changes (variants) in the SLC22A5 genes that cause CTD. In some affected children, both gene changes can be found. However, in other children, neither or only one of the two gene changes can be found, even though we know they are present.

DNA testing is not necessary to diagnose your child. When available, it can be helpful for carrier testing or prenatal diagnosis, discussed below. Talk with your metabolic doctor or genetic counselor if you have questions about genetic testing for CTD.

What other testing is available?

CTD can be confirmed by a carnitine uptake test on a skin sample. Talk to your doctor or genetic counselor if you have questions about genetic testing for CTD.

Can you test during a future pregnancy?

If both gene changes have been found in the child with CTD, DNA testing can be done during future pregnancies. The sample needed for this test is obtained by either CVS or amniocentesis.

If DNA testing would not be helpful, testing during pregnancy can be attempted by performing special tests on fetal cells. Again, the sample needed for these tests is obtained by either CVS or amniocentesis.

Parents may either choose to have testing during pregnancy or wait until birth to have the baby tested. Parents may also choose to use assisted reproductive techniques to decrease the chance that their future children would have CTD. A genetic counselor can talk to you about your choices and answer other questions you may have about prenatal testing or testing your baby after birth.

Can other members of the family have CTD or be carriers?

Having CTD

The brothers and sisters of a baby with CTD have a small chance of being affected, even if they haven't had symptoms. Finding out whether any other children in the family have CTD is important because early treatment may prevent serious health problems. Talk to your doctor or genetic counselor about testing your other children for CTD.

Occasionally, a mother is diagnosed with CTD when her infant has a positive newborn screening test for CTD. The baby's low carnitine level at birth is because

of the mother's low carnitine levels. This is a condition called secondary carnitine deficiency. Infants with secondary carnitine deficiency are treated with L-carnitine until their carnitine levels are normal. They do not need lifelong treatment.

Mothers diagnosed with CTD because their infant had a positive newborn screen for CTD often have no symptoms of CTD. However, it is important that they talk to their doctor about treatment to prevent serious health problems.

CTD carriers

Brothers and sisters who do not have CTD still have a chance to be carriers like their parents. Except in special cases, carrier testing should only be done in people over 18 years of age.

If you are a parent of a child with CTD, your brothers and sisters have a 50% chance to be a CTD carrier. It is important for other family members to be told that they could be carriers. There is a very small chance they are also at risk to have children with CTD.

All states offer newborn screening for CTD. However, when both parents are carriers, newborn screening results are not sufficient to rule out CTD in a newborn baby. In this case, special diagnostic testing should be done in addition to newborn screening. It is very important that this testing be done immediately – ideally at 24 hours of age.

During pregnancy, women carrying fetuses with CTD may be at increased risk to develop serious medical problems. Some women carrying fetuses with Fatty Acid Oxidation Disorders have developed:

- excessive vomiting
- abdominal pain
- high blood pressure
- jaundice
- abnormal fat storage in the liver
- severe bleeding

All women with a family history of CTD should share this information with their obstetricians and other health care providers before and during any future pregnancies. Knowing about these risks allows better medical care and early treatment if needed.

Can other family members be tested?

Diagnostic testing for CTD

Brothers and sisters of a baby with CTD can be tested using a special test done on a skin sample or by DNA testing using a blood sample to determine if they also have CTD.

Mothers suspected of having CTD will have blood and urine tests to measure their carnitine levels. Some may also have a special test done on a skin sample or by DNA testing using a blood sample.

CTD carrier testing

If both gene changes have been found in the child with CTD, other family members can have DNA testing to see if they are carriers.

If DNA testing would not be helpful, other methods of carrier testing may be available. Your metabolic doctor or genetic counselor can answer your questions about carrier testing.

How many people have CTD?

About one in every 50,000 babies in the United States is born with CTD.

Does CTD happen more often in a certain ethnic group?

CTD occurs in all ethnic groups. It is more common in people from the Faroe Islands in the United Kingdom. About 1 in 300 babies born in the Faroe Island has CTD.

Does CTD go by any other names?

CTD is also called:

- Systemic primary carnitine deficiency (SPCD)
- Systemic carnitine deficiency (SCD)
- Primary carnitine deficiency
- Carnitine uptake defect (CUD)

Where can I find more information?

Fatty Oxidation Disorders (FOD) Family Support Group
<http://www.fodsupport.org>

Organic Acidemia Association
<http://www.oaanews.org>

United Mitochondrial Disease Foundation
<http://www.umdf.org>

Metabolic Support UK
<http://www.metabolicsupportuk.org>

Baby's First Test
<http://www.babysfirsttest.org>

Medline Plus
<https://medlineplus.gov/genetics/condition/primary-carnitine-deficiency/>

Mito Action
<http://www.mitoaction.org>

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