Carnitine-HealthProfessional

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Carnitine  
Fact Sheet for Health Professionals  
  
This is a fact sheet intended for health professionals. For a general overview, see our consumer fact sheet.  
  
Introduction  
Carnitine, derived from an amino acid, is the generic term for several compounds, including L-carnitine, acetyl-L-carnitine, and propionyl-L-carnitine [1]. Carnitine is naturally present in many foods especially foods of animal origin and is available as a dietary supplement. Carnitine is also synthesized endogenously in the liver, kidneys, and brain from the amino acids lysine and methionine [2,3]. Carnitine is a conditionally essential nutrient because the requirements for carnitine exceed an individual s ability to synthesize this nutrient only under certain conditions (e.g., premature birth or kidney disfunction) [2].  
  
Carnitine plays a critical role in energy production. It is an essential cofactor that helps transport long-chain fatty acids into the mitochondria so that they can be oxidized to produce energy in the form of adenosine triphosphate (ATP) [4]. Carnitine also helps transport some toxic compounds out of the mitochondria [4].  
  
Carnitine is concentrated in tissues that oxidize fatty acids as a dietary fuel [1,5]. About 95% of total body carnitine is stored in heart and skeletal muscle. Most of the remainder is stored in the liver and kidney, and circulating plasma contains only about 0.5% of the body s carnitine. Excess plasma carnitine is excreted in urine [6].  
  
The body needs about 15 mg/day of carnitine from a combination of dietary sources and endogenous synthesis [7]. Foods of animal origin provide most of the carnitine in American diets. A typical omnivorous diet provides about 24 to 145 mg carnitine daily for a person weighing 165 pounds. In contrast, a vegan diet provides about 1.2 mg carnitine [1].  
  
Endogenous carnitine synthesis does not appear to be affected by dietary carnitine intake or carnitine excretion and is sufficient to meet the carnitine needs of healthy people [1]. A person weighing 165 lb who follows a strict vegetarian diet, for example, synthesizes approximately 14.4 mg/day carnitine [1].  
  
Carnitine status is not routinely assessed in clinical practice, but it can be determined by measuring circulating carnitine. A plasma free carnitine concentration of 20 mcmol/L or less, or a total carnitine concentration of 30 mcmol/L or less, is abnormally low [1]. The ratio of acyl-L-carnitine ester to free L-carnitine can also be used to assess carnitine status because under normal conditions most carnitine is in the free unesterified form. A ratio of 0.4 or greater in plasma or serum indicates abnormal carnitine metabolism and suggests carnitine insufficiency [1,8,9].  
  
Recommended Intakes  
Healthy children and adults do not need to consume carnitine from food or supplements because the liver and kidneys synthesize sufficient amounts to meet daily needs [10,11,12]. In 1989, the Food and Nutrition Board (FNB) of the National Academies of Sciences, Engineering, and Medicine concluded that carnitine is not an essential nutrient [12]. Therefore, the FNB did not establish Dietary Reference Intakes (DRIs) for carnitine [13].  
  
Sources of Carnitine  
Food  
Carnitine is present in animal products, especially red meat [1]. Poultry, fish, and dairy foods also provide some carnitine, but vegetables, fruits, and grains provide negligible amounts [1,12,14].  
  
Dietary carnitine has a bioavailability of about 63% to 75% [1]. The bioavailability of acetyl-L-carnitine has not been well studied [15].  
  
Data on the carnitine content of specific foods are limited. The U.S. Department of Agriculture s (USDA s) FoodData Centralexternal link disclaimer does not include the carnitine content of foods [16]. Table 1 lists several foods and their approximate carnitine content per serving, based on several small studies.  
  
Table 1: Carnitine Content of Selected Foods [10]  
Food Milligrams  
(mg) per  
serving  
Beef steak, cooked, 3 ounces 42 122  
Ground beef, cooked, 3 ounces 65 74  
Milk, whole, 1 cup 8  
Codfish, cooked, 3 ounces 3 5  
Chicken breast, cooked, 3 ounces 2 4  
Ice cream, cup 3  
Cheese, cheddar, 2 ounces 2  
Whole-wheat bread, 2 slices 0.2  
Asparagus, cooked, cup 0.1  
Dietary supplements  
Carnitine is available in dietary supplements containing only carnitine or a combination of carnitine and other ingredients [17]. The two main forms of carnitine in dietary supplements are L-carnitine and acetyl-L-carnitine, and amounts range from about 3 mg to 5,000 mg [17].  
  
Absorption of supplemental L-carnitine is about 14% to 18%, much less than that of dietary L-carnitine [1].  
  
Carnitine Deficiency  
Two types of carnitine deficiency states exist. Primary carnitine deficiency is a genetic disorder of the cellular carnitine transporter system that causes a shortage of carnitine within cells. Primary carnitine deficiency usually presents during infancy or early childhood. It can result in epilepsy and encephalopathy in infants; seizures, irregular heartbeat, and breathing problems in adolescents and young adults; and myopathy, rhabdomyolysis, cardiomyopathy, or sudden death in older people. Although some individuals with primary carnitine deficiency do not have symptoms, all affected people have an increased risk of heart failure, hepatic disorders, and coma [18].  
  
Secondary carnitine deficiency results from certain disorders (such as chronic renal failure) that reduce endogenous carnitine synthesis or increase its excretion or from chronic use of pivalate-containing medications that reduce carnitine absorption or increase its excretion [10,19]. Signs and symptoms of secondary carnitine deficiency include hyperammonemic encephalopathy (malaise, seizures, and decreased consciousness caused by elevated ammonia levels), hypoglycemia, hypoketonemia (low level of ketones in the blood), dicarboxylic aciduria (increased concentrations of dicarboxylic acids in the urine), hyperuricemia (excess uric acid in the blood), muscle weakness, myoglobinuria (excess myoglobin in the urine), cardiomyopathy, and sudden death [20].  
  
Primary and secondary carnitine deficiency can be resolved with high doses (20 200 mg/kg/day) of supplemental carnitine [5,21,22,23].  
  
Groups at Risk of Carnitine Inadequacy  
The following groups are among those most likely to have inadequate carnitine status.  
  
Premature infants  
Babies born prematurely have high growth demands but have low carnitine stores and an inadequate ability to synthesize this nutrient [24]. Premature infants may require supplemental carnitine in addition to that supplied in breast milk and fortified infant formula [1]. Many enteral and parenteral formulas for premature infants are fortified with L-carnitine to improve lipid metabolism and promote weight gain [1]. However, a Cochrane Review of six randomized clinical trials in newborns requiring parenteral nutrition (many of whom were premature) did not support the use of parenteral carnitine to improve lipid utilization or weight gain [25].  
  
Individuals with secondary carnitine deficiency due to end-stage renal disease, hemodialysis, or both  
Carnitine homeostasis in individuals with renal diseases can be impaired by reduced synthesis and increased elimination of carnitine by the kidneys. Renal diseases can also reduce carnitine intake from food because patients often have poor appetite and consume fewer animal products [20]. Many patients with end-stage renal disease, particularly those on hemodialysis, become carnitine insufficient.  
  
Low levels of carnitine in blood and muscle stores can contribute to anemia, muscle weakness, fatigue, altered levels of blood fats, and heart disorders. Numerous studies suggest that high doses of supplemental carnitine (often injected) administered to patients on maintenance hemodialysis can correct some or all of these symptoms [26]. However, most of these studies had small numbers of participants and were not double-blind clinical trials. The authors of a meta-analysis of these studies concluded that carnitine supplements might help patients manage their anemia but not their blood-lipid profiles, and that the effects of these supplements on exercise capacity and heart disorders were inconclusive [26].  
  
Carnitine and Health  
This section focuses on seven areas of health in which the role of supplemental carnitine is being investigated: Alzheimer s disease and dementia, cardiovascular disease (CVD) and peripheral artery disease, insulin resistance and diabetes, infertility, osteoarthritis, athletic performance enhancement, and weight loss.  
  
Alzheimer s disease and dementia  
Alzheimer s disease is characterized by the accumulation of plaques and the degeneration of neurons in the brain, including cholinergic neurons involved in memory functions [27]. Cholinergic neurons use the neurotransmitter acetylcholine [27], and Alzheimer s disease is often treated by increasing acetylcholine levels or preventing its breakdown [28].  
  
Carnitine might be conditionally essential in individuals with Alzheimer s disease because it may support acetylcholine synthesis and help remove toxic compounds to alleviate mitochondrial dysfunction associated with extensive degeneration of brain structures [2]. Therefore, researchers have examined whether acetyl-L-carnitine supplements benefit individuals with Alzheimer s disease or other forms of dementia, but studies have had mixed results [2,29].  
  
In a 2003 meta-analysis of 21 clinical trials, a total of 1,204 adults with mild cognitive impairment or mild Alzheimer s disease took supplements containing 1.5 to 3.0 g/day acetyl-L-carnitine or placebo for 3 to 12 months. Clinical and psychometric assessment scores were better, and improvements determined by clinicians were greater in supplement users than in the placebo groups [30].  
  
In contrast, a 2003 Cochrane Review of 15 clinical trials (including 13 of those in the meta-analysis described above) had somewhat different findings [29]. The clinical trials assessed the effectiveness of 1 to 3 g/day acetyl-L-carnitine supplementation or placebo over 12 to 52 weeks in participants with mild to moderate dementia or cognitive decline. The results showed that the supplementation decreased symptom severity at 12 and 24 weeks but not at 52 weeks. Similarly, acetyl-L-carnitine supplements improved scores on the Mini Mental State Examination at 24 weeks but not at 12 or 52 weeks and had no effect on the severity of dementia, functional ability, or overall clinical global impression scores. The authors of the Cochrane Review noted that results from studies conducted more recently were less positive than those from earlier studies; they concluded that the routine clinical use of acetyl-L-carnitine supplements to treat the signs and symptoms of dementia was not justified.  
  
The effects of acetyl-L-carnitine supplements in Alzheimer s disease and other forms of dementia remain unclear and continue to be an area of active research [2,31,32].  
  
Cardiovascular disease (CVD) and peripheral artery disease  
Carnitine plays a role in transporting long-chain fatty acids in the myocardial mitochondria, where they are metabolized via oxidation for energy. It is also involved in moderating oxidative stress [33,34] and might decrease markers of inflammation [35]. During ischemic events, carnitine prevents fatty acid ester accumulation, which can lead to fatal ventricular arrhythmias [34]. For these reasons, researchers are examining whether carnitine affects cardiovascular health.  
  
Clinical trials examining the effects of carnitine supplements on CVD have had mixed results. A meta-analysis of 13 clinical trials included a total of 3,629 adults with acute myocardial infarction who took either L-carnitine (from 2.7 g/day for 5 days to 6 g/day for 12 months) or placebo. The study found that L-carnitine significantly reduced rates of all-cause mortality, ventricular arrhythmias, and new-onset angina but did not affect risk of heart failure or myocardial reinfarction [34,36]. The carnitine dose and duration of the clinical trial did not appear to affect outcomes.  
  
Another meta-analysis of 17 clinical trials that included a total of 1,625 adults with chronic heart failure found that 1 g/day to 6 g/day for 7 days to 3 years L-carnitine supplements improved left ventricular ejection fraction by 4.14%, stroke volume by 8.21 mL, and cardiac output by 0.88 L/min compared to routine/conventional treatment [37]. These benefits did not vary by supplement dose or study duration. However, L-carnitine did not affect rates of all-cause mortality or performance on a timed walking test.  
  
Other research has raised concerns about the negative cardiovascular effects of chronic exposure to carnitine. A 2013 study that included 2,595 adults age 54 71 years undergoing elective cardiac evaluation found that L-carnitine is metabolized by intestinal microbiota to trimethylamine-N-oxide (TMAO), a proatherogenic substance that is associated with increased CVD risk [38]. Because of differences in intestinal bacteria composition, omnivorous study participants produced more TMAO than vegans or vegetarians after consumption of L-carnitine. The study also found dose-dependent associations between fasting plasma L-carnitine concentrations and risk of coronary artery disease, peripheral artery disease, and CVD, but only in participants with concurrently high TMAO levels.  
  
A 2022 clinical trial also found potentially deleterious outcomes in 157 individuals age 58 to 75 years with metabolic syndrome who received 1 g supplemental L-carnitine or placebo twice a day for 6 months [39]. Although the results showed no differences in total plaque volume between groups, total cholesterol and low-density lipoprotein cholesterol levels were higher in participants taking L-carnitine. L-carnitine supplementation was also associated with 9.3% greater carotid arterial plaque stenosis in males who ate less red meat and had lower baseline stenosis and total plaque volume than other participants.  
  
Peripheral artery disease is a vascular disorder usually caused by atherosclerosis and its resulting arterial stenosis and occlusion. It is prevalent among older adults, although it is often underdiagnosed [40,41]. Researchers have examined whether propionyl-L-carnitine, an acyl derivative of L-carnitine, mitigates the cramping leg pain of intermittent claudication, the main symptom of peripheral artery disease, but findings from studies have been mixed. A systematic review of three randomized clinical trials compared 234 participants who took 2 g/day oral propionyl-L-carnitine for 4 to 6 months with 222 patients who took placebo [42]. In one trial, participants supplemented with propionyl-L-carnitine had improved peak walking times (walking until pain could not be tolerated), self-reported improvements in walking distance and speed, and decreased pain. The other two trials showed no benefit of propionyl-L-carnitine on peak walking time compared with placebo.  
  
More research is needed to fully understand the effects of carnitine on cardiovascular health.  
  
Insulin resistance and diabetes  
Insulin resistance plays an important role in the development of type 2 diabetes. Because insulin resistance may be associated with mitochondrial dysfunction and a defect in fatty-acid oxidation in muscle [43,44,45,46], carnitine supplementation has been studied for its possible effects on insulin resistance and diabetes.  
  
A 2023 meta-analysis of 41 randomized clinical trials examined the effects of L-carnitine supplementation on glycemic markers in 2,900 men and women age 18 years and older [47]. Most participants had health conditions such as type 2 diabetes, obesity, polycystic ovary syndrome, or nonalcoholic fatty liver disease. L-carnitine supplements at doses of 0.25 to 4 g/day for 2 to 52 weeks reduced fasting blood glucose, insulin resistance, and glycosylated hemoglobin (HbA1c) but not serum insulin levels.  
  
Other meta-analyses have had a narrower focus, examining only studies in specific populations. A 2017 meta-analysis included five randomized clinical trials (three of which were included in the 2023 meta-analysis described above) in a total of 631 adults with insulin resistance who took 2 or 3 g/day L-carnitine or placebo for 4 weeks to 12 months [48]. The L-carnitine improved measures of insulin resistance, and the benefits at 12 months exceeded those at 3 months.  
  
A systematic review and meta-analysis of four randomized clinical trials (all of which were included in the 2023 meta-analysis described above) with a total of 284 adults with type 2 diabetes compared the metabolic effects of L-carnitine with those of placebo [44]. The results showed that 2 or 3 g/day L-carnitine for 12 to 52 weeks reduced levels of fasting plasma glucose, total cholesterol, LDL cholesterol, and apolipoproteins B100 and A1 but not triglycerides, lipoprotein (a), or HbA1c.  
  
Additional clinical trials with larger samples are needed to determine whether L-carnitine supplements can reduce the risk of diabetes or the severity of its clinical manifestations.  
  
Infertility  
Carnitine might play a role in sperm maturation, sperm motility, and spermatogenesis [49]. It might also reduce oxidative stress, which could improve oocyte growth and maturation [50]. Therefore, researchers are examining whether supplemental carnitine improves sperm count, concentration, and motility as well as pregnancy rates.  
  
A systematic review and meta-analysis of three randomized clinical trials examined the effects of 1 g/day to 3 g/day L-carnitine or acetyl-L-carnitine for 2 to 6 months on sperm parameters in 201 men age 20 to 40 years who had infertility [51]. Compared to placebo, supplemental carnitine improved sperm motility by 7.84% and morphology by 4.91% but did not affect sperm concentration.  
  
A 2022 Cochrane Review assessed the effectiveness of carnitine supplementation on male subfertility (delays in conception due to low sperm concentration) [52]. The review included six randomized clinical trials in a total of 1,089 men with subfertility who took 1,000 to 3,000 mg/day carnitine for 8 weeks to 6 months. In some trials, carnitine was compared with placebo, whereas in others, it was compared with antioxidants (such as vitamin C or vitamin E) or a control group that received no treatment. Carnitine supplementation increased sperm motility and concentration at some timepoints (e.g., 3 months) but did not affect rates of live birth or pregnancy.  
  
Researchers have also examined whether carnitine might improve ovulation and pregnancy rates in females with polycystic ovary syndrome (PCOS), a condition that commonly causes infertility. In one 26-month randomized controlled trial, 170 women younger than 35 years took clomiphene citrate and either 3 g/day supplemental L-carnitine or placebo from day 3 of their menstrual cycle until the day of their first positive pregnancy test result [53]. Individuals in the group taking L-carnitine had 64.4% higher ovulation rates and thicker endometrial tissue (10.1 mm vs. 6.8 mm) than those in the placebo group. In addition, more participants in the L-carnitine group became pregnant than those who took placebo, and they had fewer miscarriages.  
  
In a 3-month randomized controlled trial, 280 women with PCOS received either 3 g L-carnitine or placebo [54,55]. Participants who took L-carnitine supplements had improved menstrual cycle regularity and higher ovulation and pregnancy rates, but miscarriage rates did not differ between the groups.  
  
More research is needed to determine whether carnitine supplements affect male infertility or pregnancy rates in women with PCOS.  
  
Osteoarthritis  
Some research suggests that carnitine reduces levels of C-reactive protein, a biomarker of systemic inflammation, and levels of malondialdehyde, a lipid peroxidation product that induces pain and disability in patients with osteoarthritis [56]. In addition, levels of acylcarnitines (conjugated carnitine esters) are lower in people with osteoarthritis than in age- and gender-matched healthy individuals [57]. For these reasons, investigators are studying whether L-carnitine supplements can relieve osteoarthritis symptoms [56,58], but study results have been mixed.  
  
A randomized clinical trial examined the anti-inflammatory effects of L-carnitine supplementation for osteoarthritis management in 69 women age 40 to 60 years with mild to moderate osteoarthritis in both knees [59]. The women took 250 mg L-carnitine three times a day or placebo for 8 weeks. Serum levels of several inflammation biomarkers and pain scores were lower in the carnitine group than in the placebo group: Interleukin-1-beta levels decreased 5.53%, matrix metalloproteinase-1 levels decreased 9.10%, and the visual analog scale of pain decreased 52.67%.  
  
In another randomized clinical trial, 76 women (average age 55 years) with obesity and knee osteoarthritis took 1 g/day L-carnitine or placebo for 12 weeks [56]. In comparison with placebo, carnitine did not reduce osteoarthritis pain or stiffness or increase physical function.  
  
Larger studies with samples that include both men and women are needed to determine whether carnitine supplementation helps manage osteoarthritis symptoms.  
  
Athletic performance enhancement  
Carnitine helps preserve muscle glycogen and promote fat oxidation. It also spares the use of amino acids as energy sources during exercise, making them potentially available for new protein synthesis [6], and decreases the accumulation of lactate [60]. However, research findings on the effectiveness of supplemental carnitine on athletic performance are mixed [6].  
  
One study randomly assigned 14 recreational athletes age 24 28 years with an average body mass index (BMI) of 23 to consume a carbohydrate solution with or without 2.0 g of L-carnitine tartrate twice a day for 24 weeks [61]. At the end of the trial, perceived exertion on a cycle ergometer at a workload of 50% and then 80% of maximal oxygen consumption (VO2max, a measure of aerobic fitness and endurance capacity) was lower in the carnitine group (14.0, Borg scale) than in the control group (16.2).  
  
In another study, 24 men age 18 40 years (eight omnivores and 16 vegetarians) took 1 g L-carnitine twice daily for 12 weeks [62]. Each participant performed a 60-minute cycling exercise at 75% VO2max at the beginning and end of the trial. Carnitine supplementation had no significant effect on VO2max, blood lactate concentration, skeletal muscle energy metabolism, or physical performance in either the vegetarians or the omnivores. Carnitine supplementation increased skeletal muscle carnitine stores in the vegetarians, but not the omnivores, by approximately 13%.  
  
A 2018 comprehensive review summarized the effects of supplemental L-carnitine on exercise performance and recovery in well-trained athletes (age 16 36 years) and recreationally active adults (age 18 50 years) [63]. The review included 11 clinical trials (one of which was the trial described above) in a total of 251 well-trained athletes who took 1 to 4 grams L-carnitine or placebo a single time or once or twice daily for up to 6 months. L-carnitine supplements reduced lactate levels and heart rate; increased lipid metabolism, VO2max, oxygen consumption, and L-carnitine plasma concentrations; improved performance; and hastened recovery in some of the studies. However, the supplements did not affect performance or maximal exercise test results in other studies. In 17 studies that included recreationally active adults, a total of 237 participants took 2 g L-carnitine once or 2 to 4 g L-carnitine or placebo once or twice daily for up to 3 months. L-carnitine decreased plasma lactate concentrations, pyruvate concentrations, and muscle soreness and increased VO2max and recovery in some studies. However, in other studies, L-carnitine did not affect lactate, heart rate, VO2max, endurance, performance time, or perceived exertion during exercise.  
  
A systematic review of 11 randomized clinical trials examined the effects of oral L-carnitine supplementation on high- and moderate-intensity exercise performance in a total of 203 physically active and untrained adults age 18 to 46 years [64]. Participants took 3 to 4 g/day L-carnitine for 1 week or 1 to 3 g/day for 4 to 24 weeks or placebo (or, in one study also described above, a carbohydrate solution). The studies had mixed results. Some studies found significant improvements in VO2max, peak power, maximum sprinting power, perceived exertion, and number of repetitions and volume lifted in a leg press in the L-carnitine group. However, other studies found no differences in VO2max, fatigue, maximum and average power, or total work on a cycle ergometer. No studies found that L-carnitine supplementation improved moderate-intensity exercise performance.  
  
Overall, the evidence on supplemental carnitine s effectiveness for performance enhancement is mixed, and additional investigations are needed.  
  
Weight loss  
Because carnitine transports fatty acids into the mitochondria and acts as a cofactor for fatty acid oxidation, researchers have proposed using L-carnitine supplements to promote weight loss, often in conjunction with a low-calorie diet, exercise, or prescription weight-loss drugs [65]. Weight loss has been a secondary outcome in most studies, and these studies have had equivocal results.  
  
In a randomized clinical trial in 258 adults age 47 59 years with uncontrolled type 2 diabetes, participants who took 2 g/day L-carnitine plus the prescription medication orlistat (360 mg/day) for 1 year lost more weight (11.3 kg) than those who took orlistat alone (9.5 kg) [66]. However, in another randomized clinical trial, 2 g/day L-carnitine alone for 6 months did not affect weight loss in 94 men and women who were overweight (age 43 58 years; BMI range 24.6 29.8) and had newly diagnosed type 2 diabetes [67]. A 2016 systematic review and meta-analysis combined the results from nine randomized clinical trials in adults (including the two described above) that assessed carnitine s effects on weight loss [65]. The trials included a total of 911 participants. In eight trials, doses ranged from 1.8 to 4 g/day L-carnitine for 30 to 360 days; in the ninth trial, the dose was 15 mg/kg/day for 182 days. Study participants who took carnitine supplements lost an average of 1.33 kg more weight than those who took a placebo, regardless of the study duration or L-carnitine dose.  
  
Larger studies are needed to determine whether carnitine supplementation affects weight loss.  
  
Health Risks from Excessive Carnitine  
Carnitine does not have an established tolerable upper intake level. However, doses of approximately 3 g/day of carnitine supplements can cause nausea, vomiting, abdominal cramps, diarrhea, and a fishy body odor [10,11]. It can also cause muscle weakness in people with uremia and seizures in those with seizure disorders.  
  
Some research indicates that intestinal bacteria metabolize unabsorbed carnitine to form TMAO and gamma-butyrobetaine [68], which might increase the risk of CVD [38,39,69,70,71]. This effect appears to be more pronounced in people who consume meat than in vegans or vegetarians. The implications of these findings are not well understood and require more research.  
  
Interactions with Medications  
Several types of medications have the potential to interact with carnitine supplements. A few examples are provided below. People taking these and other medications on a regular basis should discuss their carnitine intake with their healthcare providers.  
  
Pivalate-conjugated antibiotics  
Carnitine interacts with pivalate-conjugated antibiotics, such as pivampicillin, that are used to prevent urinary tract infections [72]. Chronic administration of these antibiotics can lead to carnitine depletion. However, although tissue carnitine levels in people who take these antibiotics may become low enough to limit fatty acid oxidation, no cases of illness due to carnitine deficiency in this population have been described [10,15,73].  
  
Valproic acid and other anticonvulsants  
Treatment with the anticonvulsants valproic acid, phenobarbital, phenytoin, and carbamazepine reduces blood levels of carnitine [74,75,76,77]. In addition, the use of valproic acid with or without other anticonvulsants may cause hepatotoxicity and increase plasma ammonia concentrations, leading to encephalopathy [76,78]. This toxicity may also occur after acute valproic acid overdoses. Intravenous L-carnitine administration might help treat valproic acid toxicity in children and adults, although the optimal regimen has not been identified [78,79,80].  
  
Carnitine and Healthful Diets  
The federal government s 2020 2025 Dietary Guidelines for Americans notes that Because foods provide an array of nutrients and other components that have benefits for health, nutritional needs should be met primarily through foods. In some cases, fortified foods and dietary supplements are useful when it is not possible otherwise to meet needs for one or more nutrients (e.g., during specific life stages such as pregnancy).   
  
For more information about building a healthy dietary pattern, refer to the Dietary Guidelines for Americansexternal link disclaimer and the USDA s MyPlateexternal link disclaimer.  
  
The Dietary Guidelines for Americans describes a healthy eating pattern as one that  
Includes a variety of vegetables, fruits, whole grains, fat-free or low-fat milk and milk products, and oils.  
Dairy foods, such as milk, yogurt, and cheese, naturally contain carnitine.  
Includes a variety of protein foods, including seafood, lean meats and poultry, eggs, legumes (beans and peas), nuts, seeds, and soy products.  
Red meat and other foods derived from animals, including fish, poultry, and eggs, are sources of carnitine.  
Limits saturated and trans fats, added sugars, and sodium.  
Stays within your daily calorie needs.  
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