

# Choline Supplementation for the Aging Brain and Other Therapeutic Applications

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Choline is an essential nutrient required to maintain cell membrane integrity and structure, as phosphatidylcholine is an important phospholipid, which helps contribute to the formation of the lipid bilayer within the cell membrane of each cell in the body. Choline also is required to transport fats in and out of cells, and is a building block (precursor) to the synthesis of acetylcholine - an important neurotransmitter required for memory and other brain functions.<sup>1,2</sup>

In choline deficiency, fats become trapped in the liver, which can lead to fatty liver degeneration. In the body, choline can be synthesized from the amino acids methionine or serine, but recently, it has been designated as an essential dietary nutrient.<sup>3</sup> Most supplemental choline is in the form of lecithin, which usually contains 10%-20% phosphatidylcholine. Higher yields of phosphatidylcholine (i.e., 90% grade) are now available, which are generally labeled as phosphatidylcholine (not lecithin).<sup>4</sup>

Like folic acid, vitamin B<sub>12</sub> and S-adenosylmethionine, choline acts as a methyl donor in vital reactions required especially for liver function (lipotropic effect).<sup>4</sup> Phosphatidylcholine is an integral part of the structure and assembly system of the plasma lipoproteins (e.g., very low-density lipoproteins, which transport fat and cholesterol out of the liver) and of the microsomal membranes involved in the assembly and secretion process.<sup>3</sup>

As such, the principal uses of supplemental choline center around the treatment of liver disorders, hypercholesterolemia, and brain function. In recent years, researchers have discovered that a new form of choline, known as CDP-choline, is very effective in the management of neurodegenerative conditions such as senile dementia, Alzheimer's disease and Parkinson's disease. CDP-choline is an abbreviation for cytidine 5-diphosphocholine or citidinediphosphocholine or citicholine. This form of choline is an essential intermediate in the biosynthetic pathway of the structural phospholipids of cell membranes, especially in that of phosphatidylcholine.

After oral administration, both the choline and cytidine from CDP-choline have been shown to cross the blood-brain barrier and reach the central nervous system, where they are incorporated into the phospholipid fraction of the brain cell membrane and microsomes. CDP-choline supplementation has been shown to activate the synthesis of structural phospholipids in the brain and other neuronal membranes, increase cerebral metabolism and act on the levels of various neurotransmitters. Human trials reveal it is effective in cases of senile cognitive impairment (e.g., Alzheimer's disease), slowing the evolution of the disease, and in the management of Parkinson's disease.

Furthermore, CDP-choline also has been shown experimentally to increase noradrenaline and dopamine levels in the central nervous system. Due to these pharmacological activities, CDP-choline

has a neuroprotective effect in situations of hypoxia (oxygen starvation) and ischemia, as demonstrated that CDP-choline restores the activity of mitochondrial ATPase and of membrane sodium-potassium ATPase, inhibits the activation of phospholipase A2, which otherwise triggers the formation of inflammatory prostaglandin-2 production. CDP-choline also has been shown to accelerate the resorption of cerebral edema in various experimental models. In studies carried out on the treatment of patients with head trauma, CDP-choline accelerated the recovery from post-traumatic coma and the recuperation of walking ability. Its use achieved a better final functional result and reduced the hospital stay of these patients, in addition to improving the cognitive and memory disturbances normally observed after head trauma of lesser severity and which constitute the disorder known as post-concussion syndrome.

Of particular note is the fact that CDP-choline is well-tolerated by patients, and no serious side-effects have occurred in any of the groups of patients treated with CDP-choline. Toxicology studies also indicate that it is a safe intervention and highlight the fact that it produces no adverse effects on the brain's cholinergic system.<sup>5,6,7,8</sup>

### Clinical Application and Mechanism of Action

1. Liver Disorders: Choline supplementation in the form of phosphatidylcholine is authorized in Germany for the treatment of the following liver disorders:

- acute viral hepatitis
- alcohol-induced fatty liver
- chronic hepatitis
- cirrhosis of the liver
- decreased bile solubility (i.e., estrogen replacement therapy)
- diabetic fatty liver
- drug-induced liver damage
- toxic liver damage

The standard dosage recommendation is 350 mg, three times daily with meals (std. grade containing 90% phosphatidylcholine). Phosphatidylcholine supplementation also protects against alcohol-induced liver abnormalities and cirrhosis in baboons; presumably, it exerts the same effects in humans.<sup>4</sup> However, at this time, no clear-cut evidence from human trials has shown conclusively that choline protects humans against alcohol damage or is beneficial in the treatment of cirrhosis.<sup>3</sup> Nevertheless, its lipotropic effect is well-established, suggesting that it can help prevent or reverse fatty liver symptoms, as is the case with other lipotropic nutrients.

2. Hypercholesterolemia: Although still controversial, lecithin supplementation has been shown to affect hypercholesterolemia in several studies. Childs, et al., noted that a slight, but significant increase in high-density lipoprotein (HDL), accompanied by a decrease in low-density lipoprotein cholesterol levels, occurred with lecithin supplementation. Comparable findings also were reported by Wong, et al. Other intervention trials have demonstrated that high-dose supplementation with phosphatidylcholine products (70%-90% std. grade) have reduced total serum cholesterol by 9%-33%, triglycerides 25%-33% and increased HDL by 46%. The daily dosage ranged from 1,500 mg once per day to 3,500 mg, three times per day (taken before meals).<sup>4</sup>

3. Alzheimer's Disease: Although dietary choline has been shown to increase brain levels of choline

and provide a necessary precursor for the memory neurotransmitter, acetylcholine, clinical trials using phosphatidylcholine in Alzheimer's disease are largely disappointing. Better results have been demonstrated with CDP-choline (citadinediphosphocholine), phosphatidylserine, acetyl-L-carnitine and ginkgo biloba.<sup>3,4,5,6,7,8</sup>

4. Bipolar Depression (Manic-Depressive): High doses of phosphatidylcholine supplementation (15-30 grams per day) have been shown to be effective in the treatment of bipolar depression. Some researchers believe Lithium, used to treat bipolar depression, promotes increased brain acetylcholine activity. Bipolar depression requires the supervision of a trained professional, and the arbitrary supplementation with phosphatidylcholine is inadequate treatment by itself.

5. Tardive Dyskinesia: Relatively large doses of choline or lecithin can improve tardive dyskinesia.<sup>3,4</sup>

#### Dosage and Standardized Grade

- Liver disorders: 350-500 mg (90% std. grade containing phosphatidylcholine), three times daily.<sup>4</sup>
- High cholesterol (cholesterol-lowering): 500-900 mg (90% std. grade containing phosphatidylcholine), three times daily.<sup>4</sup>
- Neurodegenerative conditions (early dementia, tardive dyskinesia, Parkinson's disease, bipolar depression): 5,000 to 10,000 mg (90% std. grade containing phosphatidylcholine), three times daily, may be considered for early dementia, tardive dyskinesia and bipolar depression. All of these conditions are associated with a deficiency in brain cholinergic transmission or low brain levels of acetylcholine. Note that the treatment dose for Alzheimer's disease, when using CDP-choline, is 1,000 mg per day. The same holds true for Parkinson's disease, as studies show this form of choline can further improve symptoms in Parkinson's patients, who were receiving treatment with L-dopa plus a dopa-decarboxylase inhibitor drug.<sup>4,5,6,7,8</sup>

#### Adverse Side-Effects, Toxicity and Contraindications

Choline and phosphatidylcholine are well-tolerated and extremely nontoxic. Phosphatidylcholine supplementation can worsen depression in some cases.<sup>3,4</sup> At higher dosages, phosphatidylcholine may cause reduced appetite, nausea, abdominal bloating, gastrointestinal pain, and diarrhea. Choline at high dosages (i.e., 20 grams) produces a fish odor.<sup>3,4</sup> Choline bitartrate and choline chloride also are generally recognized as safe forms of choline supplementation.<sup>3</sup>

#### Drug-Nutrient Interactions

There are no well-known drug interactions with lecithin, phosphatidylcholine or choline.<sup>4</sup>

#### Conclusion

Research indicates that CDP-choline elevates brain levels of the memory chemical acetylcholine and provides an important part of the structure of the nerve cell membrane, facilitating optimal nerve conduction. As such, CDP-choline may be considered as part of a cocktail of natural agents to help prevent age-related cognitive decline that commonly occurs after age 60, in addition to its therapeutic applications reviewed in this article. For brain support after age 60, some anti-aging experts recommend low- to moderate-dose supplementation with a combination of CDP-choline, acetyl-L-

carnitine, *Bacopa monnieri*, huperzine A and phosphatidylserine.

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