Carnipure® Focus
Pregnancy

Maternal nutrition is a burgeoning area, illustrated by an increasing number of research papers. Women are becoming more aware of the importance of maternal nutrition for both the immediate and future health of their children. Even in the industrialized world, due to lifestyle factors such as dieting, vegetarianism, smoking and use of oral contraceptives, a woman's supply of several important nutrients may be significantly below recommended levels, impacting the health of both mother and baby. The importance of taking supplementary folic acid is well established 1–3, but in fact, folate is only part of the whole nutrition story. Most vitamins and minerals as well as other important nutrients, such as Carnipure®, may play a vital role in the optimal health and development of new life.

What is Carnipure®?

Carnipure® is high quality L-carnitine, manufactured by the Swiss life-science company Lonza. Products displaying the Carnipure® quality seal on the packaging show the consumer that they contain high quality L-carnitine from Lonza.

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Metabolic Role of L-carnitine

L-carnitine serves two major functions. It is essential for the transport of long-chain fatty acids into the mitochondrial matrix for subsequent energy generation. It is also responsible for the modulation of the rise in the intramitochondrial acyl-CoA:CoA ratio, which relieves the inhibition of many intramitochondrial enzymes involved in glucose and amino acid catabolism. L-carnitine exists in both free and acyl (ester bond) form in all tissues including plasma. Small quantities of L-carnitine are produced within the human body on a daily basis (approximately 20 mg in adults). For the most part, however, daily L-carnitine requirements are met by food intake, with red meat being the richest source of dietary L-carnitine. Fruits and vegetables contain very little of this nutrient. In situations of high energy requirements, such as pregnancy, the need for L-carnitine can exceed the amount produced by the body and dietary intake [4].

Over the past years the significance of L-carnitine in the pregnant woman's diet has gained attention. Many reports suggest that the fetus is incapable of synthesizing substantial amounts of L-carnitine [5,6]. Adequate blood and tissue concentrations of L-carnitine may be important, though, in enhancing utilization of fat for energy generation, and in promoting growth in neonates [7,8].

Pregnancy-Related Changes in L-carnitine Metabolism

L-carnitine plays a critical part in the well-being of mother and child [9]. A significant decrease in L-carnitine plasma levels is found already by the 8th–12th week of gestation and further decreases with gestational age [10–17]. It is well-established that plasma L-carnitine levels at delivery are decreased to about half those seen in non-pregnant women [18]. The decrease in plasma L-carnitine levels during early pregnancy is probably not only due to an increased requirement by the fetus: at 8 weeks of gestation, the fetus' weight is only 0.22 g, but plasma L-carnitine concentrations are already markedly decreased [14]. Also the increase in total body water during pregnancy cannot explain this large difference [19].

In 50 pregnant Korean women aged 24–28, decreasing L-carnitine plasma levels were observed even though dietary intake of L-carnitine with the normal diet increased from 44.6 µmol / day in early pregnancy to 96.1 µmol / day in late pregnancy [20,21]. In mothers after Caesarean section, skeletal muscle L-carnitine content was found to be reduced to 51 % of the levels found in non-pregnant women [22]. In 12 women examined during late pregnancy (weeks 28–37), renal excretion of L-carnitine esters was found to be about four times higher than in the control group, whereas excretion of free L-carnitine was about the same in both groups despite low plasma L-carnitine concentrations in pregnant women [14].

It is possible that there is an increased need of L-carnitine during pregnancy to perform the metabolic function of facilitating the removal of excess and potentially toxic acyl groups from the cell, which are excreted as acyl-L-carnitine into urine [13,23]. Interestingly, L-carnitine content in amniotic fluid has been found to decrease with gestational age, too [24].

Hormonal changes during pregnancy could also influence plasma concentration and urinary excretion equilibrium. A putative link between L-carnitine and reproductive system hormones has been demonstrated [10]. A recent study indicates that low plasma L-carnitine concentrations are caused by a low availability of precursors for L-carnitine biosynthesis during pregnancy [17].

Benefits of Carnipure® Supplementation during Pregnancy

Both low L-carnitine levels and a high ratio of acyl-L-carnitine to total L-carnitine indicate an L-carnitine insufficiency in pregnant women [10]. Similar low levels of free L-carnitine are found in patients with L-carnitine deficiency. It is very important for pregnant women to have an adequate supply of L-carnitine in order to maintain the infant's L-carnitine status [4].

Definition: Secondary L-carnitine Deficiency
L-carnitine deficiency is defined as a metabolic state in which the L-carnitine concentration in plasma and tissues falls below 10–20 % of normal values. Generally, a secondary L-carnitine deficiency is characterized by a free L-carnitine plasma level of <20 µmol / L and/or a ratio of acyl-L-carnitine to free L-carnitine that is less than 0.4. In non-pregnant, healthy women average plasma total L-carnitine concentration is around 40 µmol / L. Sufficient free L-carnitine is a prerequisite for normal functioning of cells and organelles.

Latest research shows that daily supplementation with 500 mg of Carnipure® starting at week 12 of gestation and continuing up to delivery can prevent the continuous decrease of L-carnitine plasma levels. At delivery, concentrations of free L-carnitine, L-carnitine esters and total L-carnitine in plasma were significantly higher in the Carnipure® than in the placebo group (Fig 1) [16].

Similarly, other trials in pregnant women showed that the inclusion of 1 g L-carnitine/day starting the 20th week of gestation up to parturition can significantly increase total and free L-carnitine along with a corresponding decrease in short-chain acyl-L-carnitine in maternal plasma, cord blood and placenta [23,25].

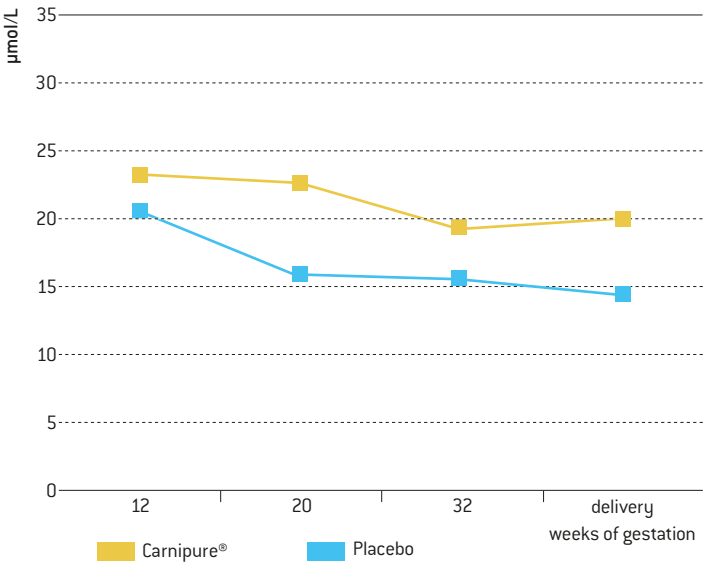

Fig. 1
A continuous decrease in total L-carnitine was observed in the placebo group from week 12 of gestation till delivery, which was prevented by supplementation with 500 mg Carnipure® [16]

L-carnitine and the Placenta

The placenta is a unique organ in a sense that, although genetically of fetal origin, it has to interact with maternal circulation to provide the fetus with all nutrients needed for growth and serve as an excretory organ to eliminate waste products of fetal metabolism [26]. The positive correlation between maternal and fetal levels of free and acyl-L-carnitine indicates placental transfer of these substances [27]. It is known that perinatal oral L-carnitine supplementation to the mother enhances L-carnitine availability to the fetus [13].

The umbilical cord blood contains significantly higher levels of free and total L-carnitine than the corresponding maternal levels [15,28]. The L-carnitine content was found to be 7 to 10 times higher in murine placentas than in tissues such as the heart, which preferentially uses L-carnitine for energy production [26]. Women supplemented with Carnipure® were found to have significantly higher concentrations of esterified and total L-carnitine in the umbilical cord plasma than women in the placebo group [16].

Maternofetal transport of L-carnitine is thought to be important in preparing the fetus for its lipid-rich postnatal milk diet [29]. The placental brush border membrane forms the interface between the fetus and the maternal circulation, and brush border membrane transport is the first step of uptake from mother to fetus. The human placental L-carnitine uptake is mediated by the high-affinity L-carnitine transporter OCTN2 [29–31].

For a long time, the human fetus and placenta were considered to be primarily dependent on glucose oxidation for energy metabolism. Recently, new data support the fact that the placenta is capable of fatty acid oxidation as well. Several key enzymes of the fatty acid oxidation process, especially CPT2, have been found to be expressed and active in the placenta throughout gestation [32].

These findings, however, bring up the issue of L-carnitine status in this tissue again. Today it seems the placental L-carnitine transport system may have dual functions: to transfer L-carnitine from the mother to the developing fetus and to provide L-carnitine to the placenta for its own metabolic needs [26].

This may also explain the remarkable association between severe maternal pregnancy complications and the carriage of a fetus with an inborn error of mitochondrial long-chain fatty acid oxidation [26, 32]. Some authors have also suggested that L-carnitine deficiency leads to intrauterine growth retardation [26], and others have postulated that L-carnitine supplementation could improve placental insufficiency [33].

Pregnancy-Related Changes in Lipid Metabolism

It is well-known that during pregnancy free fatty acids, free cholesterol and cholesterol esters are elevated in maternal plasma and increase significantly during the course of gestation [21, 34]. In healthy adults, Carnipure® supplementation has been shown to stimulate *in vivo* long chain fatty acid metabolism [35, 36]. The researchers concluded that these studies may be important for people who exercise or have a high energy demand such as during pregnancy.

The fetus accumulates nutrients for energy metabolism, tissue turnover, and growth from the maternal plasma via placental transfer [18]. Both the developing fetus and the placenta require fatty acids for the synthesis of complex lipids necessary for the biogenesis of plasma membranes, intracellular membranes, organelles, triglyceride stores and secreted products such as lipoproteins, bile and pulmonary surfactant. It is estimated that close to 50 % of the fatty acids required by the fetus are derived from the mother. High levels of free fatty acids are an important cause of insulin resistance, though [34].

Healthy Glucose and Lipid Levels

Maintaining healthy blood glucose and lipid levels during pregnancy is a common concern [34, 37–39]. L-carnitine supplementation can increase the amount of whole body glucose utilization, and an increase of both glucose uptake and glucose oxidation has been reported [40]. In a recent study, 14 pregnant women were supplemented with 2 g Carnipure® from the 20th week of gestation until parturition. Their plasma free fatty acids were significantly lower than those of non-supplemented pregnant controls, indicating that Carnipure® tartrate supplementation could help in supporting healthy blood glucose and lipid levels during pregnancy [41].

There is evidence that L-carnitine may support normal gestation. For many years scientists have recommended that pregnant women with imminent preterm births supplement with L-carnitine [42]. Since L-carnitine has no known side effects [43], it may be beneficial for most pregnant women [13].

Conclusion

The healthier a mother-to-be is, the healthier her baby is likely to be. Overall, there is increasing evidence that Carnipure® may play an important role during pregnancy, particularly in women following a meat-reduced or vegetarian diet for whom daily L-carnitine intake may be too low to meet the increased needs during pregnancy. Due to its excellent safety profile, Carnipure® supplementation may be appropriate for pregnant women to restore their L-carnitine plasma levels and at the same time decrease plasma free fatty acids. Of course, pregnant women should always consult a physician before taking any dietary supplement.

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