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## MTHFR - Folic Acid, Homocysteine and Methionine

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### MTHFR:

MTHFR is a gene (called *methylene-tetra-hydro-folate reductase*), which controls the production of a specific reductase **enzyme** that converts *bio-inactive* folate (folic acid) into *usable bio-active* form called *5-Methylfolate*. The MTHFR **enzyme** functions by adding a methyl group to the synthetic folic acid molecule; a conversion process called *methylation* and takes place within all the cells of the body. The body cannot manufacture folate; therefore, it needs to be ingested through diet and/or supplements. Folate is important in the production of red blood cells, proper growth and division of cells, and in preventing certain neural tube birth defects.

### Folate:

The terms 'folate' and 'folic acid' are forms of vitamin B9 and are often used interchangeably, especially with supplements. The only difference between these two terms is that folate is a naturally occurring bioactive form of vitamin B9; whereas, folic acid refers to the synthetically manufactured form. Natural folate is found in dark green vegetables (e.g. broccoli, spinach) and dried legumes (e.g. chickpeas, beans, lentils) and yeast. The synthetic form is commercially manufactured and added to most *fortified* or enriched foods (e.g. cereals, milk products, flour, rice, oils) and is found in most vitamin supplements and certain prescriptions (e.g. Folgard). Normally, there is little nutritional difference between folate (natural) and folic acid (synthetic), as long as the synthetic form can be converted (metabolized) into its natural or bioactive form (*5-Methylfolate*) within the body's cells. Natural folate has the methyl group already attached and bypasses the enzymatic methylation step (See References).

When a genetic mutation of MTHFR is present, there is a lack of normal amounts of this reductase enzyme, resulting in the body cells inability to convert inactive folic acid to bioactive *5-Methylfolate*. This can **cause a functional metabolic 'folic acid deficiency', even though the blood level of 'folate' is normal**. When this occurs, there is a shift within the cellular pathway causing an increase in blood *homocysteine* levels.

### Homocysteine (HCY):

Homocysteine is an amino acid that is part of the body's normal cellular methylation cycle. Its production within the cell is dependent on normal MTHFR enzyme function and adequate levels of *5-Methylfolate*, along with vitamins B12 and B6. Deficiencies in any of these may be associated with elevated homocysteine levels and certain types of anemia (e.g. Pernicious anemia).

A high level of homocysteine in the blood (called **Hyperhomocysteinemia**) makes the arteries in the body more prone to injury. This leads to inflammation in blood vessel walls, which in turn may

lead to atherosclerosis (cholesterol plaque) formation and progression. Conditions that have been observed (but not necessarily proven) with MTHFR genetic mutations and elevated homocysteine levels include: **cardiovascular disorders** (increased risk of peripheral artery disease, stroke, abdominal aortic aneurysm, hypertension, blood clots), increased risk of **depression, autism, Alzheimer's disease** and other forms of **dementia or cognitive decline, osteoporosis**, certain cancers, and **pregnancy-related (neural tube defects) disorders**.

Individuals with high homocysteine levels typically respond well to supplementation with folate (methyl folate), vitamin B6 (riboflavin) and vitamin B12 (methylcobalamin). It is also important to note that there are many persons with MTHFR mutations who do not have an elevated homocysteine level. Keep in mind that some patients have developed compensatory ways to counter the MTHFR mutation and may have sufficient active folate.

### **Methionine:**

Another amino acid that is essential in the metabolism and growth of the body's cells is called **methionine**. Methionine is found in meat, fish, and dairy products, and it plays an important role in many cell functions. The **MTHFR enzyme also plays an important cellular role by converting homocysteine into methionine**. As in normal folate metabolism a genetic mutation of MTHFR is can also result in the body's cells' inability to convert *homocysteine* into *methionine*, leading to a cellular deficiency.

Supplemental *Methionine* is used to prevent liver damage in acetaminophen (Tylenol) poisoning. It is also used for increasing the acidity of urine, treating liver disorders and improving wound healing. Other uses have included treating depression, alcoholism, allergies, asthma, copper poisoning, schizophrenia, drug withdrawal, and Parkinson's disease.

### **TMG (tri-methyl-glycine)**

TMG is a nutrient supplement that works synergistically with methyl-folate & Vit. B12. In some cases, a patient will not achieve effective lowering of their homocysteine level with 5-MTHF and Vit. B12 alone. *TMG provides extra methyl groups for the methylation of homocysteine to methionine*. **When there is no MTHFR mutation (Green)**, TMG may lower homocysteine levels as a stand-alone supplement.

### **N-Acetyl-Cysteine (NAC)**

NAC supports homocysteine metabolism by *mobilizing (separating) the homocysteine molecule from its binding proteins (albumin)*. N-Acetyl-cysteine has also been shown to *reduce plasma homocysteine levels*.

## **Managing Hyperhomocysteinemia (Elevated Homocysteine)**

- ◆ If **MTHFR Genotype is Abnormal**, treat with **methyl folate**, combined with **co-factors**: methylcobalamin (**B12**), riboflavin (**B2**) and pyridoxal 5-phosphate (**B6**):
  - **Methyl folate** 1-2 mg (1000-2000 micrograms) dose of plus co-factors.
    - If the methyl folate dose of 2 mg **does not** lower homocysteine to the normal range, add **TMG** 1-3 gram twice daily. Also, consider adding **N-Acetyl-cysteine (NAC)** 600 mg, twice a day.
    - If the methyl folate dose of 2 mg decreases HCY **below 7**, lower the methyl folate dose.

- If **homocysteine is Normal** and there are *mental health issues* (anxiety, depression, migraines) add a trail dose of methyl folate plus co-factors.
- ◆ If **MTHFR Genotype is Normal (green) AND** the homocysteine is **Elevated**, treat with **TMG** only.
- ◆ **Lifestyle Recommendations for Elevated Homocysteine:**
  - Exercise regularly
  - Avoid smoking
  - Avoid excess coffee
  - Avoid alcohol – interferes with *methylation*
  - Dietary:
    - Eat an adequate amount of folate-rich green vegetables
    - Follow a Mediterranean/Paleo/Vegetarian Diet
    - Avoid foods fortified with *synthetic* folic acid
- ◆ **Other Indications for using methyl folate and co-factors:**
  - Peripheral neuropathies
  - Chronic pain syndromes
  - Chronic fatigue
  - Fibromyalgia
  - Autism
  - Migraine Headaches

**List of Common MTHFR Mutations & Risk of Elevated Homocysteine & Heart Disease:**

- MTHFR: 677C/C = normal MTHFR gene - None
- MTHFR: 677C/T = heterozygous mutation (one mutation) – None
- MTHFR: **677T/T.** = **homozygous** mutation (two mutations) – **Significant**
- MTHFR: 1298A/A. = normal MTHFR gene - None
- MTHFR: 1298A/C = heterozygous mutation (one mutation) - None
- MTHFR: **1298C/C** = **homozygous** mutation (two mutations) - **Significant**
- MTHFR: **677T/T + 1298A/C** = **compound heterozygous** mutation - **Significant**