

## Aluminum a Causal Factor for Stroke

Atherogenesis can be caused by aluminum increasing the concentrations of homocysteine, low density lipoproteins (LDL), cholesterol, and triglycerides and decreasing concentrations of L-carnitine. The connection between strokes and aluminum was shown in 2013 by an occupational toxicology study of aluminum workers:

Forty workers exposed to aluminum while working in an aluminum factory were compared with 40 non-exposed subjects of comparable age who worked in administration at the same factory. The age range of the subjects was 18 to 62. The workers had been chronically exposed to aluminum dust levels of 0.33 to 3.4mg per cubic meter of air without any protective equipment. The study included a clinical examination of medical records of the subjects as well as blood tests for aluminum. Aluminum blood levels of the exposed group were on average nearly 10 times higher than the control group (24mcg/L versus 2.6mcg/L). The results of the clinical examination revealed a higher frequency of stroke, high blood pressure, and ischemic heart disease in the exposed group. In fact 5 of the 40 exposed workers had a stroke and 14 of the 40 had ischemic heart disease. This compared with 2 cases of stroke and 4 cases of ischemic heart disease in the control group. The exposed group also had higher levels of LDL, triglycerides, and cholesterol and lower levels of L-carnitine than the control group<sup>197</sup>.

Aluminum accumulation causes elevated homocysteine levels<sup>194,195</sup> and elevated homocysteine levels can lead to stroke<sup>198-203</sup>. Homocysteine and its' methylated relative methionine are essential amino acids found in the proteins of our body and our diet. They are essential because our bodies can't make them from other biochemicals. When we digest proteins, homocysteine and methionine are set free from protein. Free homocysteine is toxic to our arteries and must be either converted to methionine or further metabolized in order to lower its toxicity.

In addition to elevating homocysteine levels, aluminum also promotes atherogenesis by increasing LDL, triglycerides, and cholesterol and decreasing L-carnitine in the blood<sup>197</sup>. Aluminum's ability to disrupt mitochondrial energy production, as discussed in Chapter 1, results in higher levels of LDL and triglycerides in the blood<sup>204</sup>. This is not only due to aluminum's inhibition of the Krebs (a.k.a. TCA) cycle, but also its inhibition of fatty acid transfer into the mitochondria by L-carnitine<sup>204</sup>.

Do you diet and not lose weight? The reason may be accumulated aluminum in your body inhibiting the production of L-carnitine and the oxidation of fatty acids. L-carnitine acts as a chaperone that facilitates the transfer of large fatty acids into the mitochondria so they can be oxidized and metabolized for energy production. Aluminum lowers L-carnitine levels by inhibiting two enzymes involved in the biosynthesis of L-carnitine<sup>205</sup> and inhibiting the activation of an enzyme (i.e., MS) involved in the biosynthesis of a precursor of L-carnitine (i.e., methionine)<sup>206,207</sup>. Therefore, aluminum impairs the body's ability to use stored fatty acids as an energy source by lowering L-carnitine levels in the blood and thereby reducing the effect of dieting for fat loss. Also since fatty acids are a component of triglycerides, it is not surprising that aluminum accumulation results in both low L-carnitine and high triglyceride levels in the blood<sup>197</sup>. Therefore, aluminum promotes atherogenesis and increases the risk of stroke and ischemic heart disease by several mechanisms as diagrammed in Figure 2.

Obesity resulting from impaired stored fat utilization can be a symptom of aluminum accumulation. Since aluminum is a causal factor for stroke and Alzheimer's disease, obesity resulting from

impaired stored fat utilization is correlated with a person's increased risk of stroke and Alzheimer's disease. Using body mass index ( $BMI = \text{weight in kilograms} / \text{height in meters squared}$ ) as a measure of obesity:

- For each unit of BMI over 25 there is a 6% increased risk of stroke for men<sup>208</sup>.
- Each unit of BMI at midlife predicts earlier onset of AD by 6.7 months<sup>209</sup>.

Lifestyle choices leading to obesity may enhance aluminum accumulation and the impact of aluminum on brain health (see chapter 6). So does aluminum accumulation cause obesity or does obesity result in enhanced aluminum accumulation? This is a perfect example of how causes and symptoms can be difficult to untangle.