Methylene blue enhances memory

Methylene blue is a common and cheap dye used in biology and medicine. Neurometabolic mechanisms for memory enhancement and neuroprotection of methylene blue.

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Source
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Abstract
This paper provides the first review of the memory-enhancing and neuroprotective metabolic mechanisms of action of methylene blue in vivo. These mechanisms have important implications as a new neurobiological approach to improve normal memory and to treat memory impairment and neurodegeneration associated with mitochondrial dysfunction. Methylene blue’s action is unique because its neurobiological effects are not determined by regular drug-receptor interactions or drug-response paradigms. Methylene blue shows a hormetic dose-response, with opposite effects at low and high doses. At low doses, methylene blue is an electron cycler in the mitochondrial electron transport chain, with unparalleled antioxidant and cell respiration-enhancing properties that affect the function of the nervous system in a versatile manner. A major role of the respiratory enzyme cytochrome oxidase on the memory-enhancing effects of methylene blue is supported by available data. The memory-enhancing effects have been associated with improvement of memory consolidation in a network-specific and use-dependent fashion. In addition, low doses of methylene blue have also been used for neuroprotection against mitochondrial dysfunction in humans and experimental models of disease. The unique auto-oxidizing property of methylene blue and its pleiotropic effects on a number of tissue oxidases explain its potent neuroprotective effects at low doses. The evidence reviewed supports a mechanistic role of low-dose methylene blue as a promising and safe intervention for improving memory and for the treatment of acute and chronic conditions characterized by increased oxidative stress, neurodegeneration and memory impairment.

See also: Protective role of methylene blue in Alzheimer’s disease via mitochondria and cytochrome c oxidase.

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Source
Abstract

The key cytopathologies in the brains of Alzheimer’s disease (AD) patients include mitochondrial dysfunction and energy hypometabolism, which are likely caused by the accumulation of toxic species of amyloid-beta (Abeta) peptides. This review discusses two potential approaches to delay the onset of AD. The first approach is use of diaminophenothiazines (e.g., methylene blue; MB) to prevent mitochondrial dysfunction and to attenuate energy hypometabolism. We have shown that MB increases heme synthesis, cytochrome c oxidase (complex IV), and mitochondrial respiration, which are impaired in AD brains. Consistently, MB is one of the most effective agents to delay senescence in normal human cells. A key action of MB appears to be enhancing mitochondrial function, which is achieved at nM concentrations. We propose that the cycling of MB between the reduced leucomethylene blue (MBH2) and the oxidized (MB) forms may explain, in part, the mitochondria-protecting activities of MB. The second approach is use of naturally occurring osmolytes to prevent the formation of toxic forms of Abeta. Osmolytes (e.g., taurine, carnosine) are brain metabolites typically accumulated in tissues at relatively high concentrations following stress conditions. Osmolytes enhance thermodynamic stability of proteins by stabilizing natively-folded protein conformation, thus preventing aggregation, without perturbing other cellular processes. Experimental evidence suggests that the level of carnosine is significantly lower in AD patients. Osmolytes may inhibit the formation of Abeta species in vivo, thus preventing the formation of soluble oligomers. Osmolytes are efficient antioxidants that may also increase neural resistance to Abeta. The potential significance of combining MB and osmolytes to treat AD are discussed.