

PHARMACOLOGICAL PROPERTIES AND THERAPEUTIC USE OF METHYLIN COMPOUNDS

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Abstract

Methylin compounds, characterized by the presence of a methylene bridge (-CH₂-) in their structure, are of considerable interest to modern pharmacology due to their wide range of biological activity. Historically, many of these compounds, both synthetic and natural, have found use in medical practice as antiseptics, dyes, and antimicrobials. However, in recent decades, an in-depth study of their pharmacodynamics has opened up new frontiers for their therapeutic use, in particular in the field of protecting the liver from toxic damage. This review summarizes the current data on the pharmacological properties and mechanisms of action of this class of compounds.

Introduction

Main pharmacological properties and mechanisms of action

The pharmacological activity of methylene compounds is multifaceted and is due to their electrochemical properties that allow them to interact with key biological targets. The basis of their action is the ability to easily enter into redox reactions, which determines their pronounced antioxidant activity. They effectively neutralize reactive oxygen and nitrogen species, interrupting chain reactions of free radical oxidation and preventing the development of oxidative stress, a key link in the pathogenesis of toxic damage to hepatocytes.

In addition to their direct antioxidant effects, these compounds demonstrate the ability to modulate intracellular signaling pathways. It has been established that they can inhibit the activity of pro-inflammatory transcription factors such as NF- κ B, which leads to a decrease in the expression of cytokines (TNF- α , IL-6) and suppression of the inflammatory cascade in liver tissue. Another important aspect of their activity is the stabilization of the membranes of hepatocytes and organelles, in particular mitochondria. By preventing the opening of mitochondrial pores and the release of cytochrome C, methylin compounds inhibit the activation of the caspase cascade and thereby inhibit the development of apoptosis of liver cells. An additional positive effect is the stimulation of the synthesis of endogenous antioxidants, such as glutathione, and the activation of phase II detoxification enzymes, which enhances the protective potential of the hepatocyte.

Therapeutic Applications and Prospects

Traditionally, methylin compounds such as methylene blue have been used as antidotes for methemoglobinaemia and antiseptics. However, due to the mechanisms described above, their use is being reviewed and expanded in the context of the therapy of liver diseases. Experimental models demonstrate their high efficacy in protecting against hepatotoxicity induced by paracetamol, carbon tetrachloride, ethanol and other poisons. They contribute not only to the



prevention of the death of hepatocytes, but also to accelerate the regeneration of liver tissue due to the modulation of growth factors.

of particular interest is the creation of complex preparations based on them, where the methylin component is synergistically combined with other hepatoprotective agents, such as phospholipids or glycyrrhizic acid. Such combinations make it possible to simultaneously act on several pathogenetic links of liver damage, which significantly increases therapeutic efficacy. A promising area is also the development of targeted delivery systems based on nanotechnology, which will increase the bioavailability and selectivity of the action of these compounds in relation to hepatocytes.

Table 1. Main pharmacological effects of methyline compounds and their mechanisms.

Pharmacological effect	Key implementation mechanisms
Antioxidant	Direct binding of ROS and AFA; activation of glutathione synthesis; increased activity of superoxide dismutase and catalase.
Antiphlogistic	Inhibition of the transcription factor NF-κB; decreased production of pro-inflammatory cytokines (TNF-α, IL-1β, IL-6).
Anti-apoptotic	Stabilization of mitochondrial membranes; inhibition of cytochrome C release; decreased activity of caspas-3 and -9.
Membrane-stabilizing	Embedding hepatocyte membranes into the lipid bilayer; decreased phospholipase activity; inhibition of lipid peroxidation.
Metabolic	Induction of enzymes of the second phase of detoxification (glutathione-S-transferase); improvement of microcirculation and oxygenation of liver tissue.

The analysis of the literature confirms that methylin compounds are a highly promising class of compounds with a multicomponent mechanism of pharmacological action. Their ability to exert antioxidant, anti-inflammatory, and anti-apoptotic effects simultaneously makes them ideal candidates for the development of modern hepatoprotective agents. An integrated approach, consisting in the creation of combined drugs based on them, opens up new opportunities for the effective treatment of toxic liver lesions, which requires further targeted preclinical and clinical studies.



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