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MODERN APPROACHES TO ANTIOXIDANT THERAPY FOR METABOLIC SYNDROME

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Introduction. Metabolic syndrome (MS) is a complex condition combining abdominal obesity, insulin resistance, dyslipidemia, and arterial hypertension and is associated with a high risk of developing cardiovascular diseases and type 2 diabetes mellitus. One of the key mechanisms in the pathogenesis of MS is oxidative stress; therefore, antioxidant therapy, including vitamins C and E, coenzymes, and vitamin-like substances, is considered a potential adjunct to comprehensive correction of metabolic disturbances [1,2].

Relevance. According to the WHO STEPS 2019 data for Ukraine, 59.0% of the adult population were overweight, 24.8% had obesity, 34.8% had elevated blood pressure, 7.1% had elevated fasting glycemia, and 66.4% had insufficient fruit and vegetable intake, indicating a substantial prevalence of cardiometabolic risk factors associated with the development of MS [3]. At the same time, domestic sources confirm the important role of oxidative stress in individuals at high cardiovascular risk and in metabolic syndrome, giving the issue not only medical and biological but also clearly pronounced national preventive significance.

Objective. To analyse the potential efficacy and safety of antioxidant therapy in metabolic syndrome, with particular attention to the role of vitamins C and E, coenzymes, and vitamin-like substances, as well as to outline the prospects of modern mitochondria-targeted antioxidant strategies in the context of emerging concepts of redox-dependent mechanisms underlying metabolic disturbances.

Materials and Methods. A review of contemporary international and Ukrainian publications indexed in PubMed, Scopus, Cochrane, and specialised scientific journals was conducted. Systematic reviews, meta-analyses, clinical studies, and recent review papers addressing the effects of antioxidants on markers of oxidative stress, insulin resistance, lipid profile, and endothelial function in patients with MS were analysed.

Results and Discussion. Vitamin C is a potent water-soluble antioxidant, whereas vitamin E is the principal lipophilic membrane-stabilising antioxidant. According to contemporary reviews and meta-analyses, antioxidant support using these agents may be associated with reduced oxidative stress markers and modest improvement in selected cardiometabolic parameters; however, the magnitude of the effect depends on dose, duration of administration, population characteristics, and study design. This does not justify considering vitamins C and E as a self-sufficient treatment modality, but it does support their pathogenetic rationale as part of comprehensive therapy [1,2].

Among coenzymes and vitamin-like substances, coenzyme Q10, alpha-lipoic acid, and L-carnitine are of greatest interest. Coenzyme Q10 has demonstrated a potentially favourable effect on inflammatory markers, including C-reactive protein, interleukin-6, and tumour necrosis factor-α, although study results remain heterogeneous [4]. Alpha-lipoic acid is regarded as a multifunctional antioxidant with potential effects on insulin resistance, lipid metabolism, and blood pressure; however, the available data also require further clinical verification [5]. According to a meta-analysis of randomised trials, L-carnitine may improve individual MS biomarkers, primarily waist circumference, blood pressure, and glycemic parameters. Thus, classical antioxidants and vitamin-like agents have a pathogenetic rationale, but the clinical evidence for their effects remains mostly moderate and heterogeneous.

An important hallmark of the current stage of this field's development is the transition from nonspecific antioxidant supplementation to targeted modulation of mitochondrial dysfunction. In 2025, a scoping review was published on MitoQ, a mitochondria-targeted derivative of coenzyme Q10 that accumulates in mitochondria more efficiently than unmodified CoQ10. According to the synthesised data from this review, MitoQ is considered a promising agent for the prevention and correction of

cardiometabolic disorders, with potential effects on insulin secretion, lipid profile, mitochondrial function, and hepatic manifestations of metabolic dysfunction. At the same time, the authors emphasise that further studies are required to determine optimal doses, duration of administration, and target patient groups for clinical implementation [6]. This very direction adds a new dimension to the issue of antioxidant therapy in MS, as the emphasis shifts from a general antioxidant effect to selective correction of mitochondrial redox imbalance.

Another novel pathogenetic perspective is ferroptosis, a form of programmed cell death induced by iron-dependent lipid peroxidation. A 2025 review demonstrated that ferroptosis is an important component of obesity-associated metabolic diseases, including insulin resistance, type 2 diabetes mellitus, hyperlipidemia, arterial hypertension, and metabolic dysfunction-associated fatty liver disease [7]. This approach is conceptually important for interpreting the limited clinical efficacy of traditional antioxidants: the current understanding of redox-dependent damage in MS no longer focuses solely on excess free radicals, but also encompasses the complex interplay among iron, lipid peroxidation, mitochondrial dysfunction, and regulation of cell death. Therefore, the prospects for the pharmacological correction of MS are associated not only with classical antioxidants but also with more precise, mechanistically oriented interventions.

Thus, antioxidant therapy in MS is reasonably regarded as an adjunctive, pathogenetically substantiated, yet clinically heterogeneous component of comprehensive patient management. Under Ukrainian conditions, it should be combined with lifestyle modification, control of body weight, blood pressure, glycemia, and lipid profile. The scientific novelty of the current stage lies in the transition from general antioxidant support to mitochondria-targeted strategies and to the study of redox-dependent mechanisms, particularly ferroptosis, as potential therapeutic targets.

Conclusions. Vitamins C and E, coenzyme Q10, alpha-lipoic acid, and L-carnitine may exert favourable effects on individual markers of oxidative stress and metabolic parameters in MS; however, their clinical effects remain heterogeneous. At present, interest is focused not so much on traditional antioxidants per se as on novel mitochondria-targeted approaches, particularly MitoQ, as well as on ferroptosis as a new pathogenetic target. This supports the development of more precise and mechanistically grounded pharmacological correction of cardiometabolic disorders in metabolic syndrome.

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ЗМІНИ ІМУННОГО ТА ПСИХОЕМОЦІЙНОГО СТАТУСУ У ДІТЕЙ ВНАСЛІДОК ДІЇ СТРЕСОВИХ ФАКТОРІВ

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Актуальність. Стрес – неспецифічна відповідь організму на подразнюючий фактор [1]. В умовах сьогодення кількість стресових чинників стало набагато більше, що негативно впливає на стан організму, особливо серед дітей. Згідно з даними Всесвітньої організації охорони здоров`я кожна 7 дитина має порушення психічного благополуччя [2]. Стресові чинники впливають на більшість систем організму і, в першу чергу, на імунну та нервову. Діти у різні періоди віку сприймають травматичні події по-різному, тому при оцінці стану потрібно враховувати вказані фактори.

Мета: вивчення ролі змін імунного та психоемоційного статусу у дітей через частий вплив стресових чинників та методи профілактики даного стану.

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