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IRON: BIOCHEMICAL, PHARMACOLOGICAL, AND CLINICAL DATA

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Iron is one of the most important macroelements in the body, which takes part in oxidation-reduction processes, and bioenergetics, and is a part of a number of enzymes. Iron deficiency is associated with food, pregnancy, fetal development, and some diseases. First of all, iron deficiency is established in iron-deficiency anemia, in addition to violations of biochemical indicators, immunological shifts and changes in the activity of vital organs and systems. Administration of folic acid during hemodialysis, parathyroid hormone-induced osteofibrosis. It should be noted that renal failure is characterized by a distortion of the relationship between the levels of erythropoietin in the blood plasma and the concentration of hemoglobin when the synthesis of erythropoietin does not increase in proportion to the severity of anemia. Erythropoietin drugs stimulate the synthesis of erythrocytes. With a lack of access to iron from the bone marrow, erythrocytes with a reduced hemoglobin content enter the blood. An adequate amount of available iron stimulates erythropoiesis and also reduces the need for epoetin. Many pathological conditions are associated with iron deficiency. In recent years, in connection with the epidemic of COVID-19, they began to look for new approaches to potentiate the action of the recommended ones, while iron deficiency was established in the blood serum of patients. Biomarkers of anemia in COVID-19 are considered to be deficiency of hemoglobin and transferrin enzyme, transferrin receptors, and hemosiderin. They also found a decrease in the ability of transferrin to bind to iron. The content of protoporphyrin will also change, especially in patients with diabetes. COVID-19 is severe not only in patients with diabetes but also in patients with cardiovascular diseases.

Key words: *iron, transport mechanisms, iron-containing enzymes, iron deficiency, cardiovascular, infectious, neurodegenerative diseases.*

Connection of research with planning and scientific research works. The results of these studies were obtained by the actors during the performance of the research work «Experimental justification of the combined use of cardiotropic drugs» (state registration number 0111U009417).

Introduction. Iron is one of the most important macroelements of the body, which is responsible for redox reactions and bioenergetics. Iron is a component of oxygen-binding proteins (hemoglobin, myoglobin), as well as other iron-binding enzymes (cytochrome-C oxidase, iron lipoproteins, hydroxylases, tyrosine kinases, etc.). Hemoglobin is contained in the blood, and carries oxygen from the lungs to other organs, ensuring aerobic respiration and bioenergetic processes in them. Myoglobin is an iron-containing chromoprotein in skeletal muscles and the heart, which contributes to the creation of an oxygen reserve that is used up when necessary to replenish oxygen. At the same time, myoglobin is transported in the form of oxymyoglobin [1]. Attention is paid to the fact that iron is involved in the synthesis of neurotransmitters, such as serotonin, dopamine, and others [2]. Therefore, in almost all organs, iron-containing enzymes regulate cellular respiration, the Krebs cycle, and DNA synthesis.

The purpose of the research is to analyze the properties of iron and its preparations and their effects on the body.

Object and research methods. On the topic of the study, a search and analysis of scientific literature were conducted in such databases as PubMed, Google Scholar, and Scopus.

Research results and their discussion. Iron reserves in the body are 3-6 g, the daily requirement is 20-30 mg. The need for iron increases in diseases with an increase in cardiac output, and an increase in temperature, which requires taking drugs for oral and parenteral administration. In addition, if it is necessary to replenish iron reserves, it is recommended to take extracts from plants that contain it, such as common apricot (fruit pulp), blueberry fruits, beetroots, and common peach fruits. At the same time, attention should be drawn to the fact that one should not forget that iron can be in the oxidizing form of Fe^{2+} and the reduced form of Fe^{3+}.

Iron in its reduced form can increase the production of free radicals that damage biomolecules, including proteases, lipids, and DNA. In the literature, there are reports of ferro apoptosis and fatal cases caused by the uncontrolled administration of iron preparations – that is why it is necessary to check hemostasis during their administration. Currently, iron preparations for oral administration are produced – iron oxide saccharide, iron fumarate, sulfate, and there are complexes o f iron oxide with polymaltose for parenteral administration – iron hydroxide sucrose complex. Taking iron preparations orally is combined with ascorbic acid, vitamin B12, folic acid, and other vitamin preparations [3].

Iron preparations for parenteral administration are usually administered intravenously. When taken orally, iron in the form of ferrous iron is mainly absorbed in the enterocytes of the duodenum, although it is possible throughout the intestines. Cells, the precursors of enterocytes, receive information about the body's need for iron, and the apical membrane of differentiated enterocytes promotes the transport of iron into the cells. For this, iron must combine with the protein apoferritin in the form of ferritin. Next, in the blood, iron is combined with protein transferrin in the form of ferrotransferrin. Iron absorption in the intestines is regulated by hemosiderin. The connection of iron with plasma transferrin requires its preliminary oxidation to ferric iron, which occurs with the participation of the transmembrane protein hesperidin, which belongs to the family of multimedia oxidases. The complex of transferrin with iron supplies iron to tissues that have transferrin receptors. The iron in the liposomes is released from

transferrin by lowering the pH and is then transported across the membrane with the help of a special protein. The processes of recovery and oxidation of iron in endosomes during oxidation of transferrin, as well as its transport through membranes, take place with the participation of copper-manganese transport proteins [4]. The depot for iron is the liver and spleen. With an iron deficiency in the liver, the synthesis of hemosiderin, as well as transferrin and transferrin resources, decreases. Transferrin can capture iron in the liver and spleen and transfer it to bone marrow receptors [5]. Iron is stored in a labile depot in cells, the liver, the spleen, and bone marrow. Iron deficiency was primarily noted in iron-deficiency anemia, which requires its mobilization from the depot, but gradually iron reserves are used up, and the hemoglobin level drops. It can occur in various conditions, including inadequate treatment, low compliance of patients to taking iron preparations, insufficient prevention, and inadequate control over treatment [6]. An indicator of iron-deficiency anemia is considered to be a decrease in the level of erythrocytes, which are formed in the bone marrow, provide oxygen, and contribute to the release of carbon dioxide. The development of anemic syndrome is characterized by a drop in the level of erythrocytes and hemoglobin, changes in the frequency and strength of heart contractions, noise in the ears, and flies in front of the eyes. At the same time, changes in biochemical and immunological indicators, the development of tumors, leukemias, and infectious and viral processes are noted. Treatment of iron-deficiency anemia should be carried out according to WHO recommendations, mainly with oral iron preparations for 3-6 months, and stopped when the hemoglobin level normalizes [7-8].

Iron deficiency occurs when it is insufficiently supplied with food (meat) and in such pathological conditions as achlorhydria, chronic diarrhea, disturbances in absorption processes in the digestive tract in intestinal diseases, gastropathy, bleeding, especially in peptic ulcers or after operations, as well as with psoriasis and infectious diseases, pregnancy, lactation. In pregnant women, iron deficiency anemia is associated with endothelial dysfunction, which requires additional treatment [9-10]. The literature analyzes the causes of iron deficiency anemia, but most sources focus on the causes of this condition in pregnant women [11].

In pregnant women, in parallel with iron deficiency, dysfunction of the placenta develops, and possibly of the myocardium, which is associated with a limited supply of nitrogen monoxide. This symptomatology is the basis for prescribing endothelioprotectors to pregnant women [12]. Prescribing complex pharmacotherapy during pregnancy reduces the frequency of hypoxia during pregnancy and childbirth, as well as reduces the frequency of perinatal complications. Manifestations of iron-deficiency anemia are noted in children in the first years of life due to high rates of growth and development, as well as during puberty, especially in girls with the onset of menstruation [13-16]. Infectious and protective diseases of genital organs occupy a significant place in the structure of gynecological morbidity. Acute inflammatory diseases of the genital organs at 70% cases are accompanied by anemia. On the one hand, in the active phase of inflammation, iron catalyzes the formation of tissue-destructive active forms of oxygen, and therefore lowering the level of iron in serum and blood can be a protective mechanism against inflammatory processes. But iron is in the composition of transferrin, an enzyme with antioxidant properties, which is especially manifested in a complex with ascorbic acid. Therefore, it is recommended to prescribe iron preparations containing FE 2+ for the treatment of inflammatory diseases of the pelvic organs in the presence of anemia. Iron sulfide preparations have the highest bioavailability. The appointment of iron preparations during the period of the lowest activity of free radical oxidation is pathogenetically justified. Iron preparations with ascorbic acid are particularly effective [3, 17].

Anemia in pregnant women with inflammatory diseases is manifested not only by a decrease in the level of erythrocytes and hemoglobin but also by manifestations of anemic hypoxia and intoxication. In the latest clinical recommendations, iron medicines are included among the drugs. It is iron-deficiency anemia that occurs often in patients with heart failure, regardless of the ejection fraction of the left ventricle, as a frequent concomitant condition that worsens the course of heart failure. This is associated with the deterioration of iron absorption in the alimentary canal, as well as the availability of utilized iron from the reticuloendothelial system.

Iron deficiency is now considered a frequent concomitant condition of heart failure regardless of left ventricular ejection fraction. In the CONFIRM-HF study, it was established that the treatment of patients with stable symptoms of heart failure with iron deficiency by intravenous administration of an iron preparation leads to a stable improvement of the oxidative capacity function based on the results of the 6-minute walk test. In patients with iron deficiency, lower body weight, levels of pulsatile blood pressure, hemoglobin, and a higher level of the N-terminal fragment of the precursor of brain natriuretic peptide and interleukin were found. After all, when the level of iron decreases, the supply of oxygen to the tissues is disturbed, which leads to an increased risk of heart attack and death [18].

The expediency of correcting iron deficiency with iron preparations to improve the activity of the cardiovascular system has been established [19]. In chronic renal failure, the development of iron-deficiency anemia due to the shortening of the life of erythrocytes, platelet dysfunction [20], which causes increased bleeding, the effect of anemic toxins on erythrocytes, which reduces the iron content due to inadequate absorption in the intestines and during hemodialysis, is also noted. Administration of folic acid during hemodialysis, parathyroid hormone-induced osteofibrosis. It should be noted that renal failure is characterized by a distortion of the relationship between the levels of erythropoietin in the blood plasma and the concentration of hemoglobin when the synthesis of erythropoietin does not increase in proportion to the severity of anemia. Erythropoietin drugs stimulate the synthesis of erythrocytes. With a lack of access to iron from the bone marrow, erythrocytes with a reduced hemoglobin content enter the blood. An adequate amount of available iron stimulates erythropoiesis and also reduces the need for epoetin. The appointment of the hydroxide saccharide complex drug to patients with chronic renal failure contributed to the improvement of the general condition and the normalization of a number of indicators – he-

moglobin, ferritin in the blood plasma, as well as creatinine [21, 22]. Later, it was noticed that the indicators of ferrokinesis can be markers of both the development of iron-deficiency anemia and the effectiveness of treatment with iron preparations in patients with diagnosed chronic heart failure and chronic kidney disease [23].

Signs of iron deficiency in the blood were observed in persons who were in conditions of hypoxia. After all, it is known that the iron contained in the body can be included in directional (in the composition of bone marrow erythrokaryocytes, circulating erythrocytes, and myoglobin), transport (associated with transferrin), deposited (associated with the enzyme and hemosiderin) iron, as well as what forms a labile pool. When the reserves of iron in the body are sufficient, it is consumed with desquamated epithelium. In the case of iron deficiency, a larger part of it is not retained in the mucous membrane but enters the bloodstream. The main part of iron, which the body needs for synthesis, comes from aging macrophages; during its recirculation – from aging erythrocytes. This process is carried out by ferroportin, heme oxidase, a duodenal transporter of divalent metals, and is regulated by several proteins, which include hereditary hemochromatosis protein, iron-binding elements, an iron-binding protein, which, in turn, is regulated by hemosiderin. In the conditions of the high mountain area, the subjects were found to have an increased total iron-binding capacity of blood serum. The ratio of iron indicators and iron-binding capacity expressed the accumulation of iron by transferrin. Iron deficiency anemia when climbing a mountain was characterized by a decrease in the amount of the enzyme in blood serum. In this case, preparations containing iron ions are indicated, as well as preparations containing trivalent iron hydroxide-polymaltose complexes [24].

They also determined the pathogenetic relationship between metabolic parameters and the state of iron metabolism in diabetes. A certain role is played by the presence of inflammatory processes in these patients, when the content of actual tumor necrosis alpha and SOE increases against the background of a decrease in the level of hemoglobin and hematocrit, the number of erythrocytes and an increase in the concentration of soluble transferrin, which indicates the progression of iron deficiency. At the same time, an increase in SOE was correlated with an increase in the duration of diabetes mellitus, and worse glycemic control. Therefore, the prescription of treatment for patients with diabetes should include ingredients that affect both inflammation and the prognosis of iron deficiency anemia [25].

Many pathological conditions are associated with iron deficiency. In recent years, in connection with the epidemic of COVID-19, they began to look for new approaches to potentiate the action of the recommended ones, while iron deficiency was established in the blood serum of patients. Biomarkers of anemia in COVID-19 are considered to be deficiency of hemoglobin and transferrin enzyme, transferrin receptors, and hemosiderin. They also found a decrease in the ability of transferrin to bind to iron. The content of protoporphyrin will also change, especially in patients with diabetes. COVID-19 is severe not only in patients with diabetes but also in patients with cardiovascular diseases [26].

Iron is an indispensable trace element for both humans and many bacteria, including mycobacterium tuberculosis. Iron deficiency has been established in patients with tuberculosis and comorbid pathology, as well as HIV infection. The presence of iron deficiency in these patients is shown, and redox reactions, oxygen transport, cellular respiration, trichloroacetic acid cycle, and DNA biosynthesis are determined. In addition, the content of hepcidin was determined, the mechanism of action of which is related to the function of ferroportin, an iron exporter into cells, which leads to the accumulation of intracellular iron and prevention of the toxic effect of free iron. The main prognostic markers in tuberculosis were considered to be a tendency to decrease the content of hemoglobin transferrin in combination with an increase in the content of the enzyme in patients with tuberculosis. There is a point of view that hyper fermentation in tuberculosis is a marker of inflammation [27]. Violation of the processes of iron transport, deposition, and interaction with receptors is observed in such neurodegenerative diseases as Parkinson's disease, Alzheimer's disease, as well as retinal structure disorders [28-30]. Thus, iron remains one of the main macroelements of the body, which participates in oxidation-reduction processes and enzyme activity. With iron deficiency, not only iron deficiency anemia occurs but also a number of pathological conditions, when the efficiency and work of vital organs decrease. The search for new iron compounds and improvement of treatment schemes for iron deficiency conditions is one of the main tasks of modern times. A price analysis of iron-deficiency drugs was conducted, which made it possible to conclude that Actiferin was the most expensive drug according to all indicators, and Sorbifer was the most profitable according to the course of treatment [31]. One of the directions for the creation of new iron preparations is the search for nano drugs due to their inherent better bioavailability and lower toxicity [32].

Conclusions. The current state of research on iron in the functioning of vital organs and the occurrence of diseases present experimenters and clinicians with the task of involving new experimental and clinical methods to expand the understanding of the role of iron in pathobiochemical mechanisms, in pathological conditions, as as well as the search for new approaches to treatment.

Prospects for further research. Further research will be devoted to determining the role and biochemical and clinical studies of other macroelements, such as cobalt, in order to determine the prospects of application.

References

1. Zaharova IN, Machneva EB. Korrektsiya defitsita zheleza: istoricheskie and sovremennyie aspektii. Semeynaya meditsina. 2014;1(57):142-5.
2. Stepurko T, Semyhina T, Barska Y, Zakhozha V, Kharchenko N. Indeks zdorovia. Ukraine-2018: results of zahalnonatsionalnoho doslidzhennia [Internet]. eKMAIR; 2018 [cited 2022 Aug 16]. Dostupno: http://ekmair.ukma.edu.ua/handle/123456789/18335. [in Ukrainian].
3. Vinogradova OP, Kuznetsova MN, Biryuchkova OA. Antianemic preparations in complex treatment of inflammatory diseases of small organs. Obstetrics and Gynecology. 2015;2:49-52.

4. Gromova OA, Torshin IY, Hadzhidis AK. Analiz mokulekyarnyih mehanizmov vozdeystviya zheleza (ii), medi, margantsa v patogeneze zhelezodefitsitnoy anemii. Clinical Pharmacology and Pharmacoeconomics. 2010;1:1-9.
5. Belovol AN, Knyazkova II. Ot metabolyzma zheleza – k voprosam pharmakolohycheskoi korrektsyy eho defytsyta [Internet]. Repository of Kharkiv National Medical University; 2015 [cited 2022 Aug 16]. Dostupno: http://repo.knmu.edu.ua/handle/123456789/11697. [in Ukrainian].
6. Rumyantsev AG, Zaharova IN, Chernov VM, Tarasova IS, Zaplatnikov AL, Korovina NA, et al. Rasprostranennost zhelezodefitsitnyih sostoyaniy i faktorii, na nee vliyayuschie. Meditsinskiy sovet. 2015;6:62-6.
7. Baird-Gunning J, Bromley J. Correcting iron deficiency. Australian Prescriber. 2016;39(6):193-9. DOI: 10.18773/austprescr.2016.069.
8. Camaschella C. Iron-deficiency anemia. New England Journal of Medicine. 2015;372(19):1832-43. DOI: 10.1056/nejmra1401038.
9. Zaporozhan VN, Ancheva IA. Pharmacocorrection of endothelial dysfunction, occurred during comorbid deficiency anemia as a means of preventing complications of pregnancy and childbirth. HEALTH OF WOMEN. 2015;98(2):71-4. DOI: 10.15574/hw.2015.98.71.
10. Venkataramani V. Iron homeostasis and metabolism: Two sides of a coin. Ferroptosis: Mechanism and Diseases. 2021;1301:25-40. DOI: 10.1007/978-3-030-62026-4_3.
11. Magomedova AP, Lomova NA, Karapetyan TE, Amiraslanov EY. Latentnyiy defitsit zheleza and zhelezodefitsitnaya anemia beremennyih: posledstviya dlya materi i ploda, vozmozhnyie puti resheniya. Meditsinskiy sovet. 2021;4:170-3.
12. Gaillard R, Steegers EAP, Tiemeier H, Hofman A, Jaddoe VWV. Placental vascular dysfunction, fetal and childhood growth, and cardiovascular development. Circulation. 2013;128(20):2202-10. DOI: 10.1161/circulation aha.113.003881.
13. Arzoo S, Yousof S, Rahman J, Chowdhury S. Iron deficiency anemia in pregnancy: Intravenous iron sucrose versus oral iron sulfate. Bangladesh Journal of Obstetrics & Gynaecology. 2020;33(1):40-4. DOI: 10.3329/bjog. v33i1.43541.
14. Dalal M, Goyal R, Nanda S, Dahiya P, Dahiya K, Madan S. Oral versus intravenous iron for treatment of iron deficiency anemia in pregnancy: A randomized controlled trial. Indian Journal of Public Health Research & Development. 2018;9(6):4-6. DOI: 10.5958/0976-5506.2018.00513.2.
15. Rogozińska E, Daru J, Nicolaides M, Amezcua-Prieto C, Robinson S, Wang R, et al. Iron preparations for women of reproductive age with iron deficiency anemia in pregnancy (Frida): A systematic review and network meta-analysis. The Lancet Haematology. 2021;8(7):503-12. DOI: 10.1016/s2352-3026(21) 00137-x.
16. Gopchuk OM. Iron deficiency anemia. Women's Health. 2019;9(145):32-7.
17. Ganz T. Anemia of inflammation. New England Journal of Medicine. 2019;381(12):1148-57. DOI: 10.1056/nejmra1804281.
18. Liu Z, Sun R, Li J, Cheng W, Li L. Relations of anemia with the all-cause mortality and cardiovascular mortality in the general population: A meta-analysis. The American Journal of the Medical Sciences. 2019;358(3):191-9. DOI: 10.1016/j.amjms.2019.05.016.
19. Voronkov LG, Gorbachova VV, Liashenko AV, Gavrilenko TI, Mkhitaryan LS, Yakushko LV, et al. Clinical and instrumental characteristics of patients with chronic heart failure and reduced left ventricular ejection fraction without anemia, depending on the presence of iron deficiency. Ukrainian Journal of Cardiology. 2018;(6):101-8. DOI: 10.31928/1608-635x-2018.6.101108.
20. Ponikowski P, van Veldhuisen DJ, Comin-Colet J, Ertl G, Komajda M, Mareev V, et al. Beneficial effects of long-term intravenous iron therapy with ferric carboxymaltose in patients with symptomatic heart failure and iron deficiency. European Heart Journal. 2014;36(11):657-68. DOI: 10.1093/eurheartj/ehu385.
21. Hörl WH. Anemia management and mortality risk in chronic kidney disease. Nature Reviews Nephrology. 2013;9(5):291-301. DOI: 10.1038/nrneph. 2013.21.
22. Nikitin OD. Efektyvnist ta bezpeka zastosuvannia preparatu Sufer® v korektsii anemii u patsiientiv iz khronichnoiu nyrkovoiu destatnistiu. Ukrainskyi medychnyi chasopys. 2015;1:49-51. [in Ukrainian].
23. Ryndina NH, Kravchun PH, Mishyna MM. Pokaznyky ferokinezu yak prohnostychni markersy yakosti zhyttia anemichnykh khvorykh na khronichnu sertsevu dostastatnist, poiednanu z khronichnoiu khvoroboiu nyrok, ta yikh dynamika pid vlividom terapevtychnoi korektsii. Zdobutky klinichnoi i eksperimentalnoi medytsyny. 2013;2:152-4. [in Ukrainian].
24. Popovich MY. Iron deficiency anemia in Zakarpattya High mountain region: Relevance, diagnosis, and comprehensive treatment. Hematology Transfusiology Eastern Europe. 2020;(3):372-82. DOI: 10.34883/pi.2020. 6.3.023.
25. Musina NN, Saprina TV, Prohorenko TS, Zima AP, Prokonich DA. Specifics of *inflammation parameters*, ferrokinetics and structure of anemic syndrome in patients with diabetes. Conference Proceedings; 2021. p. 72-80. DOI: 10.14341/conf.22-25.09.21-378.
26. Taneri PE, Alejandro Gómez-Ochoa S, Llanaj E, Francis Raguindin P, Rojas LZ, Wyssmann BM, et al. Anemia and iron metabolism in COVID-19: A systematic review and meta-analysis. European journal of epidemiology. 2020;35(8):763-73. DOI: 10.1101/2020.06.04.20122267.
27. Borodulina EA, Yakovleva EV. Metabolism of iron in the organism and indicators reflecting changes in lung tuberculosis. Clinical laboratory diagnostics. 2016;65(2):149-54.
28. Shahandeh A, Bui BV, Finkelstein DI, Nguyen CT. Therapeutic applications of chelating drugs in iron metabolic disorders of the brain and retina. Journal of Neuroscience Research. 2020;98(10):1889-904. DOI: 10.1002/jnr.24685.
29. Shu W, Dunaief J. Potential treatment of retinal diseases with Iron Chelators. Pharmaceuticals. 2018;11(4):112. DOI: 10.3390/ph11040112.
30. Ward RJ, Zucca FA, Duyn JH, Crichton RR, Zecca L. The role of iron in Brain Aging and Neurodegenerative Disorders. The Lancet Neurology. 2014;13(10):1045-60. DOI: 10.1016/s1474-4422(14)70117-6.
31. Kostromitska IO, Misiurova AV, Propisnova VV. Kliniko-farmatsevtychnyi analiz Fe-vmisnykh preparativ, provedenyi na bazi apteky «Fetida» m. Kharkiv. Pharmacoeconomics in Ukraine: status and prospects. 2021 May 21;1:65-6. [in Ukrainian].
32. Nikravesh N, Borchard G, Hofmann H, Philipp E, Flühmann B, Wick P. Factors influencing safety and efficacy of intravenous iron-carbohydrate nanomedicines: From production to clinical practice. Nanomedicine: Nanotechnology, Biology and Medicine. 2020;26:102178. DOI: 10.1016/j.nano.2020.102178.

ЗАЛІЗО: БІОХІМІЧНІ, ФАРМАКОЛОГІЧНІ, КЛІНІЧНІ ДАНІ

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Резюме. Залізо є одним з найголовніших макроелементів в організмі, що приймає участь в організмі та приймає участь в окислювально-відновних процесах, біоенергетиці, входить до складу ряду ферментів.

Мета дослідження. Проаналізувати властивості заліза та його препаратів і впливу на організм.

Об'єкт і методи дослідження. З теми дослідження провели пошук та аналіз наукової літератури в таких базах даних як PubMed, Google Scholar, Scopus.

Результати. Дефіцит заліза в першу чергу був відмічений при залізодефіцитній анемії, що потребує його мобілізації з депо, але поступово запаси заліза витрачаються, що і призводить до падіння рівня гемоглобіну до показників нижче норми. Залізодефіцитна анемія виникає при різних станах, в тому числі, неадекватному лікуванні, низькому комплайенсі хворих до прийому препаратів заліза, недостатній профілактиці, неадекватному контролі за лікуванням пацієнтаЛікування залізодефіцитної анемії необхідно проводити за рекомендаціями ВООЗ переважно пероральними препаратами заліза протягом 3-6 місяців, припиняють тільки при тривалій нормалізації рівня гемоглобіну. В останніх клінічних рекомендаціях по веденню хворих з різноманітною патологією серед препаратів внесені і лікарські засоби заліза. Саме залізодефіцитна анемія зустрічається часто у хворих з серцевою. Це пов'язують з погіршенням абсорбції заліза в травному каналі, а також доступності утилізованого заліза з ретикуло-ендотеліальної системи. Ознаки дефіциту заліза в крові спостерігали у осіб, що перебували в умовах гіпоксії. Визначили також патогенетичний зв'язок між метабо-

літними параметрами та станом обміну заліза при цукровому діабеті. Певну роль грає наявність у цих хворих процесів запалення, коли підвищується вміст фактору некрозу пухлин альфа та ШОЕ на фоні пониження рівня гемоглобіну і гематокриту, кількості еритроцитів і підвищення концентрації розчинного трансферину, що свідчить про прогресування дефіциту заліза. Біомаркерами анемії при COVID-19 вважають дефіцит гемоглобіну і ферменту трансферину, рецепторів трансферину, гемосидерину. Встановлено падіння здібності трансферину до зв'язку з залізом. Змінється вміст протопорфірину. Сучасно випускають препарати заліза для перорального призначення – оксид заліза сахарит, заліза фумарат, сульфат, також існують комплекси оксиду заліза з полімальтозою для парентерального введення – заліза гідроксид цукрозний комплекс. Прийом препаратів заліза всередину комбінують з кислотою аскорбіновою, вітаміном В12, кислотою фолієвою та іншими вітамінними препаратами. Препарати заліза для парентерального введення вводять внутрішньовенно.

Висновки. Сучасний стан дослідження заліза в функціонуванні життєвоважливих органів і виникненні захворювань ставить перед науковцями і клініцистами завдання щодо залучення нових експериментальних та клінічних методик для розширення уявлень про роль заліза в патобіохімічних механізмах, при патологічних станах, а також пошуку нових підходів до лікування.

Ключові слова: залізо, механізми транспорту, залізовмісні ферменти, залізодефіцит, серцево-судинні, інфекційні, нейродегенеративні хвороби.

IRON: BIOCHEMICAL, PHARMACOLOGICAL, AND CLINICAL DATA

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Abstract. Iron is one of the most important macroelements in the body, which takes part in oxidation-reduction processes, and bioenergetics, and is a part of a number of enzymes. Iron deficiency is associated with food, pregnancy, fetal development, and some diseases. First of all, iron deficiency is established in iron-deficiency anemia, in addition to violations of biochemical indicators, immunological shifts and changes in the activity of vital organs and systems.

The purpose of the study was to analyze the properties of iron and its preparations and their effects on the body.

Object and research methods. On the topic of the study, a search and analysis of scientific literature was conducted in such databases as PubMed, Google Scholar, Scopus.

Results and discussion. Iron reserves in the body are 3–6 g, the daily requirement is 20–30 mg. The need for iron increases in diseases with an increase in cardiac output, an increase in temperature, which requires taking drugs for oral and parenteral administration. In addition, if it is necessary to replenish iron reserves, it is recommended to take extracts from plants that contain it, such as common apricot (fruit pulp), blueberry fruits, beet roots, and common peach fruits. At the same time, it should be noted that iron can be in the oxidizing form of Fe^{2+} and the reduced form of Fe^{3+}.

It was determined that changes in iron metabolism and transport occur in pregnant women, which, in turn, is associated with changes in endothelial protective function. In modern methodological recommendations for the treatment of chronic heart failure, iron preparations are also included in the list of mandatory drugs, because in this condition, in addition to iron deficiency, disorders of the functions of the cardiovascular system have been found. A decrease in iron content has also been determined in various hypoxic conditions. Next they showed changes in iron metabolism in infectious diseases, such as COVID-19, tuberculosis, and HIV infection. In recent years, changes in iron content in neurodegenerative diseases have been noticed. Today, there are oral and parenteral iron preparations, but research is underway to create iron preparations that may have a more targeted effect and less toxicity.

Conclusion. The current state of iron research in the functioning of vital organs and the occurrence of diseases presents scientists and clinicians with the task of involving new experimental and clinical methods to expand the understanding of the role of iron in pathobiochemical mechanisms, in pathological conditions, as well as the search for new approaches to treatment.

Key words: iron, transport mechanisms, iron-containing enzymes, iron deficiency, cardiovascular, infectious, neurodegenerative diseases.

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