

ORCID автора та його внесок до статті:
Semkovych Ya.V.: 0000-0002-8319-022X^{ABCDEF}

Адреса для кореспонденції
Семкович Ярослав Васильович
КНП «Івано-Франківська обласна дитяча клінічна лікарня»
Адреса: Україна, 76000, м. Івано-Франківськ, вул. Коновальця 132
Тел.: 0503388506, 0968762277
E-mail: semkovych.doc@gmail.com

A – концепція роботи та дизайн, B – збір та аналіз даних, C – відповідальність за статичний аналіз, D – написання статті, E – критичний огляд, F – остаточне затвердження статті.

Стаття надійшла 20.03.2022 року
Стаття прийнята до друку 15.09.2022 року

DOI 10.29254/2077-4214-2022-3-166-245-249

UDC 616.36-002.2:577.118

Sitkar A. D.

CHARACTERISTICS OF THE CONTENT OF ZINC, COPPER AND SELENIUM IN BLOOD SERUM IN PATIENTS WITH CHRONIC HEPATITIS C WITH DIFFERENT BODY MASS INDEX Uzhhorod national university (Uzhhorod, Ukraine)

siti0095@gmail.com

About 1% of the world's population is infected with the hepatitis C virus. The main clinical form of this infection is chronic hepatitis C (CHC), which develops in an average of 70% of patients. Metabolic disorders caused by the chronic course of HCV infection include changes in the metabolism of trace elements, in particular Zn, Cu, and Se. The aim was evaluate the content of trace elements Zn, Cu and Se in the blood serum of patients with chronic hepatitis C depending on sex, age and body mass index. 62 patients with a verified diagnosis of chronic hepatitis C were under observation, in whom the level of Zn, Cu and Se in blood serum was determined. The control group consisted of 30 healthy people. It was established that serum Zn, Cu and Se levels in CHC patients do not depend on gender and BMI, and there is no correlation with age ($p>0,05$). Zn deficiency was found in 19,4% (12/62) of CHC patients. The level of Zn was statistically significantly lower in CHC patients compared to healthy people (0,649 (0,569; 0,739) mg/l vs. 0,720 (0,645; 0,835) mg/l, $p=0,022$). Regarding the levels of Cu and Se, no difference was found ($p>0,05$). Also, a weak degree of negative correlation ($\rho=-0,271$, $p=0,033$) between the levels of Zn and Cu was established in patients with CHC. The average value of the Cu/Zn ratio in patients with CHC is statistically significantly higher compared to healthy people ($p=0,002$). The obtained data indicate a probable effect of chronic hepatitis C infection on the level of Zn in blood serum, which creates prerequisites for further research.

Key words: chronic hepatitis C, trace elements, zinc.

Connection of the publication with planned research works. The scientific work is a part of the research topic of the Department of Faculty Therapy of Uzhhorod national university: "Combined pathology and correction of homeostasis disorders of Carpathian region residents, taking into account the action of adverse factors", state registration number 0121U110808.

Introduction. More than 71 million people, or about 1% of the world's population, are infected with the hepatitis C virus (HCV) [1]. The main clinical form of this infection is chronic hepatitis C (CHC), which develops in an average of 70% of patients [2]. Liver diseases, in particular CHC, affect the digestion, assimilation, storage and metabolism of nutrients, which can lead to vitamin and micronutrient deficiencies and protein-energy insufficiency [3]. Metabolic disorders caused by the chronic course of HCV infection include changes in the metabolism of such trace elements as zinc (Zn), copper (Cu) and selenium (Se), since their main metabolism takes place in the liver [4]. There are conflicting data on the relationship between blood Zn level and HCV infection [5]. Some studies indicate a decrease in its level in CHC [5, 6, 7], while others do not confirm this connection [8].

In general, studies show that Zn deficiency occurs with CHC [9]. It is believed that as a result of HCV-mediated mitochondrial dysfunction, the presence of oxidative stress disrupts Zn homeostasis, as it is a signaling molecule and second messenger in redox reactions [4]. In CHC, decreased Zn levels can also be a consequence of liver fibrosis, which involves different mechanisms. In blood, approximately two-thirds (60%) of circulating Zn is bound to albumin. With hypoalbuminemia, there is a decrease in the total concentration of Zn in blood serum [9, 10, 11]. Liver fibrosis also leads to portal hypertension, and, as a result, to damage to the intestinal mucosa and the formation of portosystemic shunts. The level of Zn in the blood serum decreases due to a decrease in its absorption by the damaged intestinal mucosa and an increase in urinary excretion through the portosystemic shunt [9]. Poor appetite and, as a result, malnutrition often accompany cirrhosis of the liver, which can also be the cause of hypozincemia [4]. In patients with CHC at various stages of the disease, the metabolism of Cu is disturbed, which usually leads to an increase in its level in the blood [12]. HCV infection is associated with low levels of antioxidants, including Se, and increased levels

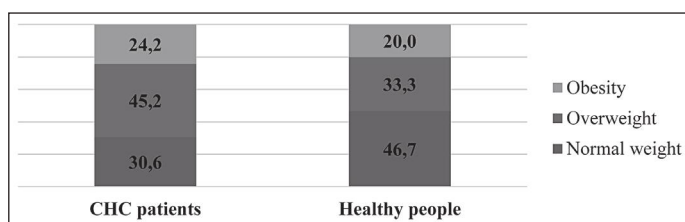


Figure 1 – Distribution of examined persons (in %) depending on BMI.

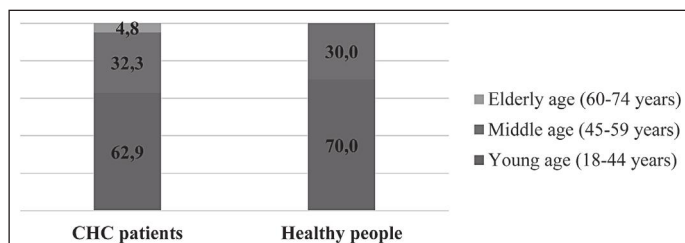


Figure 2 – Distribution of examined persons (in %) depending on age.

of oxidative stress [13]. Violation of the homeostasis of Zn, Cu and Se can increase HCV replication and liver fibrosis and reduce the effectiveness of antiviral therapy [14], which determines the relevance of researching the levels of these microelements in such patients.

Purpose of the study. Evaluate the content of trace elements Zn, Cu and Se in the blood serum of patients with chronic hepatitis C depending on sex, age and body mass index.

Object and research methods. Under observation were 62 patients with a diagnosis of CHC, who were included in the experimental group (the proportion of men was 56,5% (35/62), women – 43,5% (27/62), the average age – 41,7±10,9 years). Criteria for inclusion in the study: patients with a verified diagnosis of CHC who agreed to follow-up. Exclusion criteria were: alcoholic, autoimmune, and toxic liver damage, liver cirrhosis, myocardial infarction in the first 4 months, diseases of the respiratory and gastrointestinal tract in the acute

Table 1 – Average levels of trace elements in the blood serum of the examined persons

Indicator	CHC patients	Healthy people	Reference values
Zn	0,649 (0,569; 0,739)	0,720 (0,645; 0,835)	0,553-1,046 mg/l
Cu	1,04 (0,883; 1,23)	0,935 (0,837; 1,13)	0,7-1,4 mg/l
Se	0,0775 (0,0622; 0,0958)	0,090 (0,0708; 0,10)	0,046-0,14 mg/l

phase, decompensated diseases, diseases of the nervous system, psycho-emotional and mental disorders that prevent conducting this study and the patient's decision to stop participating in the study. The studied patients had no markers of infection with other hepatitis viruses (A, B, D, G, TT) and HIV infection. All patients denied the use of corticosteroids, non-steroidal anti-inflammatory and immunosuppressive drugs. HCV was performed according to the 10th revision of the ICD and verified by the detection of total antibodies of the IgG class to the structural and non-structural proteins of HCV (antiHCV IgG +) by the serological ELISA method, as well as by the indication of the investigated RNA HCV + in the blood by the PCR method with viral load (VL) and genotyping. Testing was performed on a thermal

cycler with a real-time PCR product detection system “iQ 5”, Bio-Rad, USA. The control group consisted of 30 healthy people (the proportion of men – 60,0% (18/30), women – 40,0% (12/30), average age – 38,4±9,68 years). All laboratory studies were performed in the accredited laboratory “Dila”. The level of Zn, Cu and Se in the blood serum was determined. The assessment of body shape was carried out according to generally accepted anthropometric indicators. Body mass index (BMI) was considered anthropometric criteria of obesity. BMI in the range of 18,5–24,9 kg/m² was considered as normal body weight, 25,0–29,9 kg/m² as overweight, >30,0 kg/m² as obesity.

The research was carried out with the personal signed consent of the patients and in accordance with the methodological recommendations of the Declaration of Helsinki (1975) with redrafting, the International Code of Medical Ethics (1983), the laws of Ukraine, the relevant provisions of the WHO, and was approved by the local ethics commission of the Uzhhorod National University (protocol №6/4 dated 09/07/2021), and all those who participated were informed and, as a result, gave their consent in the consent letter, the structure of which corresponded to the officially agreed one.

Statistical analysis was performed in the jamovi 1.6 program using the independent Student's t-test, the Mann-Whitney U test, the Pearson's chi-squared test with Yates's correction for continuity, the Kruskal-Wallis test, and the Spearman correlation coefficient. The normality of the distribution of interval variables was assessed by the Shapiro-Wilk test. The assessment of the strength of the relationship between the variables was evaluated according to the Chaddock scale. Mean values were described as M±SD and Me (Q1; Q3) depending on the data distribution. The critical level of significance was α=0.05.

Research results and their discussion. The average age of the examined patients with CHC was 41,7±10,9 years, healthy people – 38,4±9,68 years. The proportion of men among CHC patients was 56,5% (35/62), women – 43,5% (27/62), among healthy people – 60,0% (18/30) and 40,0% (12/30), respectively. The distribution of examined persons depending on BMI is shown in figure 1, depending on age – in figure 2.

No statistically significant difference was found between the groups depending on age (t=1,42, df=90, p=0,16), sex (χ²=0,104, df=1, p=0,747) and BMI (χ²=2,29, df=2, p=0,319). Thus, both groups were homogeneous in terms of BMI, sex and age.

The obtained data of laboratory studies on the levels of trace elements in blood serum are shown in table 1.

Table 2 – Levels of trace elements in blood serum (in mg/l) depending on sex

Group		Male	Female	p-value
CHC patients	Zn	0,640 (0,561; 0,738)	0,652 (0,587; 0,749)	U=455, p=0,809
	Cu	1,03 (0,895; 1,21)	1,05 (0,885; 1,25)	U=460, p=0,865
	Se	0,0780 (0,0625; 0,0995)	0,0770 (0,0615; 0,0880)	U=405, p=0,338
Healthy people	Zn	0,765 (0,645; 0,847)	0,708 (0,658; 0,810)	U=91,5, p=0,498
	Cu	0,905 (0,823; 1,06)	0,960 (0,918; 1,15)	U=92,0, p=0,511
	Se	0,0895 (0,0663; 0,0965)	0,0950 (0,0818; 0,103)	U=76,0, p=0,182

It was found that in 19,4% (12/62) of patients with CHC, the serum Zn level was low, and the lowest value was 0,405 mg/l. When comparing the studied groups, it was established that the level of Zn was statistically significantly lower in patients with CHC, compared to healthy people (0,649 (0,569; 0,739) mg/l vs. 0,720 (0,645; 0,835) mg/l, respectively; $U=654$, $p=0,022$). The detected levels of Cu and Se in the examined persons did not exceed the normal limits, and no statistically significant difference was established between the groups regarding the level of Cu ($U=712$, $p=0,069$) and Se ($U=757$, $p=0,149$).

Intragroup comparison of trace element levels depending on sex is shown in **table 2**.

The obtained data showed that the average levels of trace elements in patients with CHC, both in men and in women, were almost at the same level and did not statistically significantly differ ($p>0,05$).

Serum Zn levels were lower in CHC patients compared to healthy people in both normal weight and overweight and obesity. However, the level of Zn did not statistically significantly differ depending on BMI both in patients with CHC ($\chi^2=0,423$, $df=2$, $p=0,809$) and in healthy people ($\chi^2=3,93$, $df=2$, $p=0,140$) (**figure 3**).

Serum Cu levels were slightly higher in CHC patients compared to healthy people in both normal and overweight and obesity. However, the level of Cu did not statistically significantly depend on BMI either in patients with CHC ($\chi^2=0,147$, $df=2$, $p=0,929$) or in healthy individuals ($\chi^2=1,34$, $df=2$, $p=0,512$) (**figure 4**).

Se level was higher in CHC patients only in the overweight subgroup (**figure 5**). However, similar to the levels of Zn and Cu, both in patients with CHC ($\chi^2=3,071$, $df=2$, $p=0,215$) and in healthy people ($\chi^2=4,02$, $df=2$, $p=0,134$) no statistically significant relationship was found between BMI and serum Se levels.

It was established that there is no statistically significant relationship between the levels of trace elements and age in both groups (**tables 3 and 4**). However, a weak degree of negative correlation ($\rho=-0,271$, $p=0,033$) was found between the levels of Zn and Cu in patients with CHC.

The average value of the Cu/Zn ratio in the group of patients was 1,59 (1,38; 1,95), in the group of healthy people – 1,25 (1,09; 1,54) and was statistically significantly higher in patients with CHC ($U=566$, $p=0,002$).

In CHC, in general, there is a decrease in the level of Zn [9]. Thus, according to the results of the study by Pourhassan et al. 2015 [6], serum Zn levels were significantly lower in patients with CHC (but not cirrhosis) compared to controls. In a study by Guo et al. 2012 [7], a difference was established in the concentrations of Zn and Cu in the blood plasma of patients with chronic HCV infection compared to the control group, in particular, Zn levels were significantly lower in subjects with HCV, but Cu levels, as well as the Cu/Zn ratio, were significantly higher. In other studies, Zn levels were lower and Cu levels were higher in CHC patients compared to controls

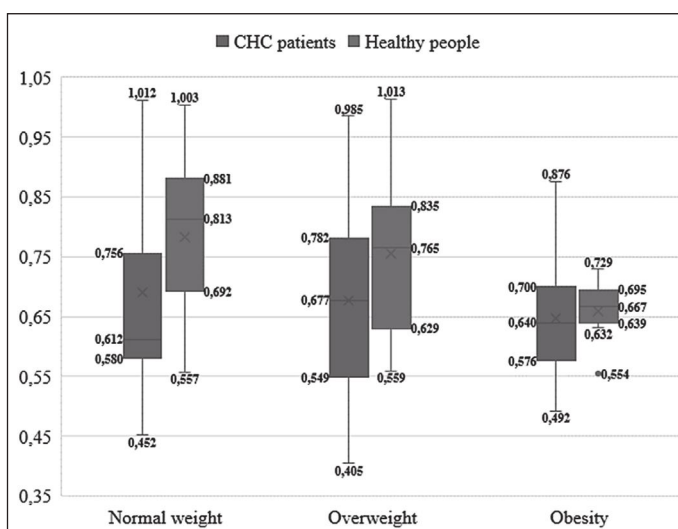


Figure 3 – Serum Zn level (in mg/l) depending on BMI.

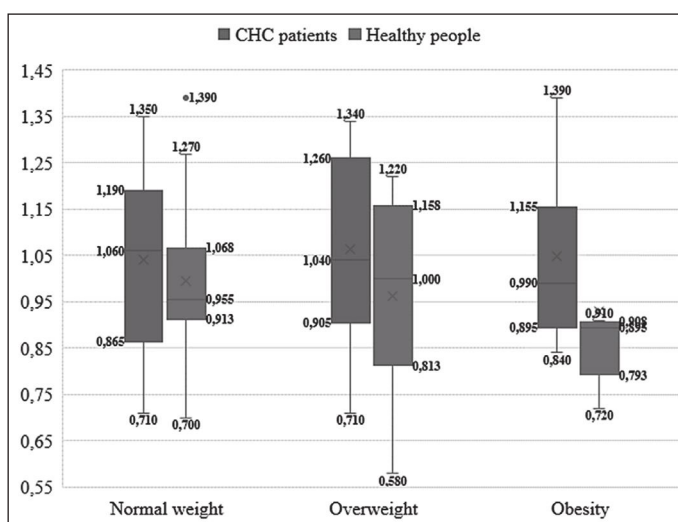


Figure 4 – Serum Cu level (in mg/l) depending on BMI.

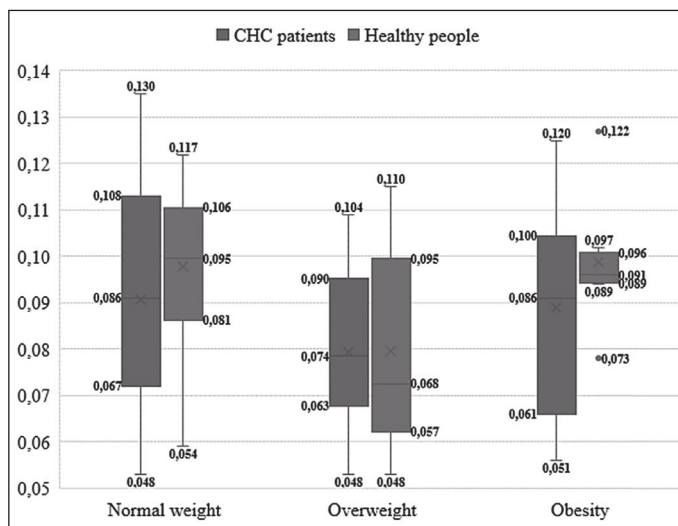


Figure 5 – Serum Se level (in mg/l) depending on BMI.

[15]. Interestingly, according to the results of the study by Suda et al. 2019 [16] Zn deficiency was observed in 27 (87,1%) patients with CHC, despite a good functional state of the liver. In our study, the level of Zn was statistically significantly lower in patients with CHC, compared

Table 3 – Correlations between age and levels of trace elements in patients with CHC

		Age	Zn	Cu	Se
Age	ρ	–			
	p	–			
Zn	ρ	–0,121	–		
	p	0,350	–		
Cu	ρ	0,065	–0,271	–	
	p	0,616	0,033	–	
Se	ρ	0,081	–0,016	0,077	–
	p	0,530	0,899	0,551	–

to healthy people, and Zn deficiency was observed in 19,4% (12/62) of patients. This indicates a likely effect of chronic HCV infection on serum Zn levels.

The metabolism of Cu and Zn is closely related in the liver. Excessive Zn intake can lead to Cu deficiency due to metallothionein-mediated inhibition of intestinal Cu absorption [2]. In our study, a negative correlation of these trace elements was found, which indicates their antagonism in certain metabolic pathways both in normal and liver diseases [12]. Also, the Cu/Zn ratio was statistically significantly higher in CHC patients, probably due to lower Zn levels in this group compared to healthy controls.

Regarding trace elements Cu and Se, there are much fewer clinical studies, compared to Zn, regarding their association with chronic HCV infection [4]. In our study,

Table 4 – Correlations between age and levels of trace elements in healthy people

		Age	Zn	Cu	Se
Age	ρ	–			
	p	–			
Zn	ρ	0,040	–		
	p	0,832	–		
Cu	ρ	0,342	0,151	–	
	p	0,064	0,425	–	
Se	ρ	–0,051	–0,030	–0,085	–
	p	0,787	0,877	0,656	–

the detected levels of Cu and Se in the examined persons did not exceed the reference values, and no statistically significant difference in the levels of these trace elements was established between the groups.

Conclusions. Significantly lower levels of Zn are registered in patients with CHC compared to healthy people, and 19,4% of patients are found to be deficient. This indicates a probable influence of chronic HCV infection on Zn content in blood serum. Also, it was established that serum Zn, Cu and Se levels in CHC patients do not depend on sex and BMI, and there is no correlation with age.

Prospects for further research is to study the possibility of correcting Zn deficiency in blood serum in patients with CHC.

References

- Blach S, Zeuzem S, Manns M, Altraif I, Duberg AS, Muljono DH, et al. Global prevalence and genotype distribution of hepatitis C virus infection in 2015: a modelling study. *The Lancet Gastroenterology & hepatology*. 2017 Mar 1;2(3):161-76. DOI: 10.1016/S2468-1253(16)30181-9.
- Sierhieieva TA. Hepatyt C v Ukraini: zakhvoriuvanist, poshyrenist, seroprevalentnist, seromonitoring. *Clinical immunology. Allergology. Infectology*. 2020;5(126):5-16. Dostupno: <https://kiai.com.ua/ua/archive/2020/5%28126%29/pages-5-16/gepatit-s-v-ukrayini-zahvoryuvanist-poshyrenist-seroprevalentnist-seromonitoring>. [in Ukrainian].
- Gottschall CB, Pereira TG, Rabito EI, Alvares-Da-Silva MR. Nutritional status and dietary intake in non-cirrhotic adult chronic hepatitis C patients. *Arq Gastroenterol*. 2015 Jul-Sep;52(3):204-9. DOI: 10.1590/S0004-28032015000300010.
- Gupta S, Read SA, Shackel NA, Hebbard L, George J, Ahlenstiel G. The role of micronutrients in the infection and subsequent response to hepatitis C virus. *Cells*. 2019 Jun 17;8(6):603. DOI: 10.3390/cells8060603.
- Mohamed AA, Abbassi MM, Hamed WA, EzzEl-Arab MA, Aref AM. Can zinc levels predict response to pegylated-interferon and ribavirin therapy in hepatitis C genotype 4 infected Egyptian patients? *Acta Gastroenterol Belg*. 2014 Jun;77(2):217-23. Available from: <https://pubmed.ncbi.nlm.nih.gov/25090819/>.
- Pourhassan A, Fouladi DF, Samani SM, Morshedi Asl S. Serum Zinc and Haptoglobin in Noncirrhotic Azeri Patients with Chronic Active Hepatitis C: a Case–Control Study. *Biological trace element research*. 2015 Oct;167(2):187-93. DOI: 10.1007/s12011-015-0309-4.
- Guo CH, Chen PC, Lin KP, Shih MY, Ko WS. Trace metal imbalance associated with oxidative stress and inflammatory status in anti-hepatitis C virus antibody positive subjects. *Environmental toxicology and pharmacology*. 2012 Mar 1;33(2):288-96. DOI: 10.1016/j.etap.2011.12.018.
- Cesur S, Cebeci SA, Kavas GO, Yılmaz N, Buyukkagnici DI. Serum copper and zinc concentrations in patients with chronic hepatitis C. *Journal of Infection*. 2005 Jul 1;51(1):35-7. DOI: 10.1016/j.jinf.2004.08.003.
- Ko YL, Morihara D, Shibata K, Yamauchi R, Fukuda H, Kunitomo H, et al. Factors attenuating zinc deficiency improvement in direct-acting antiviral agent-treated chronic hepatitis C virus infection. *Nutrients*. 2018 Nov 2;10(11):1620. DOI: 10.3390/nu10111620.
- Gupta SHH, Read S, Wijaya R, George J, Ahlenstiel G. The effect of fibrosis and direct-acting antiviral therapy on serum zinc levels in chronic hepatitis C infection. *J. Gastroenterol. Hepatol*. 2018;33:34-81. DOI: 10.3390/cells8060603.
- Mohammad M, Zhou Z, Cave M, Barve A, McClain CJ. Zinc and liver disease. *Nutr Clin Pract*. 2012;27(1):8-20. DOI: 10.1177/0884533611433534.
- Lin CC, Huang JF, Tsai LY, Huang YL. Selenium, iron, copper, and zinc levels and copper-to-zinc ratios in serum of patients at different stages of viral hepatic diseases. *Biological trace element research*. 2006 Jan;109(1):15-23. DOI: 10.1385/BTER:109:1:015.
- Khan MS, Dilawar S, Ali I, Rauf N. The possible role of selenium concentration in hepatitis B and C patients. *Saudi journal of gastroenterology: official journal of the Saudi Gastroenterology Association*. 2012 Mar;18(2):106. DOI: 10.4103/1319-3767.93811.
- Guo CH, Chen PC, Ko WS. Status of essential trace minerals and oxidative stress in viral hepatitis C patients with nonalcoholic fatty liver disease. *International Journal of Medical Sciences*. 2013;10(6):730. DOI: 10.7150/ijms.6104.
- Mohammed MA, El-dien Abd Elmaksoud MD, Abd El Maksoud N, El-Mezayen HA, El-Garaam H. Serum levels of trace elements in Egyptian patients with chronic hepatitis C under interferon therapy. *Journal of Genetic Engineering and Biotechnology*. 2012 Jun 1;10(1):81-6. DOI: 10.1016/j.jgeb.2012.03.001.
- Suda T, Okawa O, Shirahashi R, Tokutomi N, Tamano M. Changes in serum zinc levels in hepatitis C patients before and after treatment with direct-acting antiviral agents. *Hepatology Research*. 2019 Nov;49(11):1353-6. DOI: 10.1111/hepr.13409.

ХАРАКТЕРИСТИКА ВМІСТУ ЦИНКУ, МІДІ Й СЕЛЕНУ В СИРОВАТЦІ КРОВІ У ХВОРИХ НА ХРОНІЧНИЙ ГЕПАТИТ С З РІЗНИМ ТРОФОЛОГІЧНИМ СТАТУСОМ
Сіткар А. Д.

Резюме. *Вступ.* Понад 71 млн людей, або близько 1% населення світу інфіковані вірусом гепатиту С. Основною клінічною формою даної інфекції є хронічний гепатит С (ХГС), що формується в середньому в 70% хворих. Порушення обміну речовин, зумовлене хронічним перебігом HCV-інфекції, включає і зміни в метаболізмі мікроелементів, зокрема цинку (Zn), міді (Cu) та селену (Se), оскільки їх основний обмін відбувається саме в печінці. Порушення гомеостазу даних мікроелементів може посилювати реплікацію HCV і фіброз печінки та знижувати ефективність протівірусної терапії, що і зумовлює актуальність дослідження рівнів даних мікроелементів у таких хворих. *Метою дослідження* було оцінити вміст мікроелементів Zn, Cu та Se в сироватці крові у хворих на ХГС залежно від статі, віку та трофологічного статусу. *Об'єкт і методи дослідження.* Під спостереженням знаходились 62 пацієнти з верифікованим діагнозом ХГС у яких визначали рівень Zn, Cu та Se сироватки крові. Контрольну групу склали 30 практично здорових осіб. *Результати.* Статистично вірогідної різниці між досліджуваними групами залежно від віку ($p=0,16$), статі ($p=0,747$) та ІМТ ($p=0,319$) виявлено не було, тобто вони були однорідні щодо трофологічного статусу та у статеві-віковому аспекті. Частка хворих на ХГС, у яких рівень Zn сироватки крові був нижче норми, становила 19,4% (12/62). Рівень Zn був статистично вірогідно менший у хворих на ХГС, у порівнянні із здоровими (0,649 (0,569; 0,739) мг/л проти 0,720 (0,645; 0,835) мг/л; $p=0,022$). Виявлені рівні Cu та Se у обстежуваних осіб не виходили за межі норми, та між групами не встановлено статистично вірогідної різниці щодо рівня Cu ($p=0,069$) та Se ($p=0,149$). У хворих на ХГС середні рівні мікроелементів як у чоловіків, так і в жінок знаходились майже на одному рівні й статистично вірогідно не відрізнялись ($p>0,05$). Рівні досліджуваних мікроелементів не залежали від трофологічного статусу та не корелювали з віком у обох групах ($p>0,05$). У хворих на ХГС знайдено слабкий ступінь негативної кореляції ($p=-0,271$, $p=0,033$) між рівнями Zn та Cu. Середнє значення співвідношення Cu/Zn у групі хворих було статистично вірогідно вищим порівняно із здоровими ($p=0,002$). *Висновки.* Отримані дані вказують на ймовірний вплив хронічної HCV-інфекції на рівень Zn сироватки крові, що створює передумови для подальших досліджень.

Ключові слова: хронічний гепатит С, мікроелементи, цинк.

CHARACTERISTICS OF THE CONTENT OF ZINC, COPPER AND SELENIUM IN BLOOD SERUM IN PATIENTS WITH CHRONIC HEPATITIS C WITH DIFFERENT BODY MASS INDEX

Sitkar A. D.

Abstract. *Introduction.* More than 71 million people, or about 1% of the world's population, are infected with the hepatitis C virus. The main clinical form of this infection is chronic hepatitis C, which develops in an average of 70% of patients. Metabolic disorders caused by the chronic hepatitis C infection include changes in the metabolism of trace elements, in particular zinc (Zn), copper (Cu) and selenium (Se), since their basic metabolism takes place in the liver. Violation of the homeostasis of these trace elements can increase hepatitis C virus replication and liver fibrosis and reduce the effectiveness of antiviral therapy, which determines the relevance of researching the levels of these trace elements in such patients. *The aim.* Evaluate the content of trace elements Zn, Cu and Se in the blood serum of patients with chronic hepatitis C depending on sex, age and body mass index. *Materials and methods.* 62 patients with a verified diagnosis of chronic hepatitis C were under observation, in whom the level of Zn, Cu and Se in blood serum was determined. The control group consisted of 30 healthy people. *Results.* There was no statistically significant difference between the studied groups depending on age ($p=0,16$), sex ($p=0,747$) and body mass index ($p=0,319$), i.e. they were homogeneous. The proportion of patients with chronic hepatitis C in whom the serum Zn level was below normal was 19,4% (12/62). The level of Zn was statistically significantly lower in patients with chronic hepatitis C compared to healthy people (0,649 (0,569; 0,739) mg/l vs. 0,720 (0,645; 0,835) mg/l; $p=0,022$). The detected levels of Cu and Se in the examined persons did not exceed the normal limits, and no statistically significant difference was established between the groups regarding the level of Cu ($p=0,069$) and Se ($p=0,149$). In patients with chronic hepatitis C, the average levels of trace elements in both men and women were almost at the same level and did not differ statistically significantly ($p>0,05$). The levels of the studied trace elements did not depend on the body mass index and did not correlate with age in both groups ($p>0,05$). A weak degree of negative correlation ($p=-0,271$, $p=0,033$) was found between the levels of Zn and Cu in patients with chronic hepatitis C. The average value of the Cu/Zn ratio in the group of patients was statistically significantly higher compared to the healthy people ($p=0,002$). *Conclusions.* The obtained data indicate a probable effect of chronic hepatitis C infection on the level of Zn in blood serum, which creates prerequisites for further research.

Key words: chronic hepatitis C, trace elements, zinc.

ORCID and contributionship:

Sitkar A. D.: 0000-0001-7890-5908 ^{ABCDEF}

Corresponding author
 Sitkar Andrii Dmytrovych
 Uzhhorod national university
 Ukraine, 88000, Uzhhorod, 1 Narodna square
 Tel: +380668586512
 E-mail: siti0095@gmail.com

A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article.

Received 22.03.2022
 Accepted 16.09.2022