UDC: 616.441-008.64-06:616 **DOI: https://doi.org/10.20998/BMPP.2024.01.05**

V. Nemtsova, P. Poteiko, N. Ryndina, V. Berezniakov, H. Korchevska, S. Kravchuk
Educational and Scientific Medical Institute of the National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine.

THE IMPACT OF SUBCLINICAL HYPOTHYROIDISM ON MARKERS OF ENDOTHELIAL DYSFUNCTION IN PATIENTS WITH ARTERIAL HYPERTENSION AND ENDOCRINE COMORBIDITIES

Summary

Introduction. Hypertension (HTN), despite the considerable progress in recent decades, remains a major public health problem and burden worldwide.

Purpose of the study to investigate the influence of subclinical hypothyroidism (STH) on the endothelial state in the patients with a comorbid course of HTN and type 2 diabetes mellitus (T2DM).

Materials and methods. 240 patients with stage II HTN were divided into 3 groups: group 1 (n = 40) – with isolated HTN, group 2 (n = 120) – with a combined course of HTN and T2DM; group 3 (n = 80) – with comorbidity of HTN, T2DM and SHT. Blood pressure, carbohydrate, lipid and thyroid metabolism, vascular endothelial growth factor (VEGF-A) plasma levels, desquamated circulating endothelial cells (DCEC) were investigated.

The results. Patients in all groups experienced dyslipidemia, more pronounced in group 3, but significant difference was shown only for triglycerides ($p < 0.05$). Blood fasting glucose was significantly higher in group 2 than in group 3 ($p < 0.05$). The highest levels of VEGF-A were found in the patients with HTN, T2DM and SHT, in the patients with HTN and T2DM, VEGF-A levels were lower than in the patients with isolated HTN. Endothelial morphological changes were the lowest in the group 3 (DCEC levels were 12.06 ± 0.61 cells/100 μl group 1, 11.97 ± 0.31cells/100 μl group 2, 10.07 ± 0.26 cells/100 μl group 3, $p_{1-3} = 0.001$ and $p_{2-3} = 0.001$, respectively).

Conclusions. The impact of subclinical hypothyroidism on the endothelium is characterised by a progression of impaired vasodilation, but not by morphological damage of the endothelium. Even minor changes in thyroid status contribute to the progression of endothelial dysfunction in patients with comorbid pathology.

Keywords: *hypertension, type 2 diabetes mellitus, endothelial dysfunction, vascular endothelial growth factor, desquamated circulating endothelial cells.*

В. Д. Немцова, П. І. Потейко, Н. Г. Риндіна, В. І. Березняков, Г. І. Корчевська, С. Л. Кравчук
Навчально-науковий медичний інститут Національного технічного університету «Харківський політехнічний інститут», Харків, Україна

УДК: 616.441-008.64-06:616

ПОСТТРАВМАТИЧНИЙ СТРЕСОВИЙ РОЗЛАД ТА ПРИЧИНИ ЙОГО ВИНИКНЕННЯ СЕРЕД ОСІБ, ЯКІ МАЮТЬ ДОСВІД УЧАСТІ В БОЙОВИХ ДІЯХ

Аннотація

Вступ. Артеріальна гіпертензія, незважаючи на значний прогрес за останні десятиліття, залишається основною проблемою охорони здоров'я та тягарем у всьому світі.

Мета. Дослідити вплив субклінічного гіпотиреозу (СГТ) на стан ендотелію у хворих на коморбідний перебіг гіпертонічної хвороби (ГБ) та цукрового діабету 2 типу (ЦД 2 типу).

Матеріали та методи. 240 хворих на ГБ II стадії були розподілені на 3 групи: 1 група (n = 40) – з ізольованою ГБ, 2 група (n = 120) – з поєднаним перебігом ГБ і ЦД 2 типу; 3 група (n = 80) – з коморбідністю ГБ, ЦД 2 типу та СГТ. Досліджували показники вуглеводного, ліпідного і тиреоїдного метаболізму, рівень васкулоендотеліального фактора росту (ВЕФР) у плазмі крові, кількістьдесквамованих циркулюючих ендотеліальних клітин (ДЦЕК).

Отримані результати. У пацієнтів всіх груп спостерігалася дисліпідемія, що була більш виражена в групі 3, але достовірні відмінності були знайдені лише для тригліцеридів ($p < 0,05$). Рівень глюкози в крові натще був значно вищим у групі 2, ніж у групі 3 ($p < 0,05$). Найвищі рівні ВЕФР були виявлені у хворих на ГБ, ЦД 2 типу та СГТ, у хворих на ГБ та ЦД 2 типу рівень ВЕФР був нижчим, ніж у пацієнтів із ізольованою ГБ. Морфологічні зміни ендотелію були найнижчими в групі 3 (рівень ДЦЕК становив 12,06 ± 0,61 клітин/100 мкл у групі 1, 11,97 ± 0,31 клітин/100 мкл у групі 2, 10,07 ± 0,26 клітин/100 мкл у групі 3, $p_{1-3} = 0,001$ і $p_{2-3} = 0,001$ відповідно).

Висновки. Вплив субклінічного гіпотиреозу на судинний ендотелій характеризується прогресуванням порушення вазодилатації, а не морфологічним пошкодженням ендотелію. Навіть незначні зміни тиреоїдного статусу сприяють прогресуванню ендотеліальної дисфункції у пацієнтів із коморбідною патологією.

Ключові слова: *артеріальна гіпертензія, цукровий діабет 2 типу, ендотеліальна дисфункція, васкулоендотеліальний фактор росту, десквамовані циркулюючі ендотеліальні клітини.*

Introduction. Hypertension (HTN), despite the considerable progress in recent decades, remains a major public health problem and burden worldwide. As reported by the NCD Risk Factor Collaboration (NCD-RisC), the number of people with hypertension globally in 2019 was over 1 billion and this number has doubled since 1990 [1] and continue to increase worldwide [2]. Ukraine is no exception: according to the Global epidemiology study, provided by Bin Zhou and colleagues, Ukraine is among the countries with a high age-standardized prevalence of raised blood pressure (BP) [3].

From the other hand, thyroid dysfunction, including subclinical, and type 2 diabetes mellitus (T2DM) are two of the most frequent chronic endocrine disorders with variable prevalence among different populations [4]. Subclinical hypothyroidism (SHT) can be asymptomatic and, therefore, undiagnosed and untreated, leading to important adverse events. T2DM and thyroid diseases are two closely related conditions that can have bidirectional influence upon each other [5, 6].

Endothelial dysfunction (ED) is a complex of multi-stage balance disorders that leads to a decrease in the ability of blood vessels to relax and dilate, resulting in impaired blood flow, increased BP, and a higher risk of cardiovascular diseases. ED can pay a leading role in the development of many diseases, including HTN and T2DM, independently predicts cardiovascular risk [7, 8]. Vascular endothelial growth factor-A (VEGF-A) is considered to be one of the earliest blood serum marker of ED, which changes appear even ahead of active intravascular inflammation [9]. Serious attention has also been paid to the study of the molecular and cellular mechanisms of the ED. The vessels endothelium damage is accompanied by desquamation of endothelial cells with their entry into the bloodstream. Therefore, the determination of the number of desquamated circulating endothelial cells (DCEC) in the blood is recognized by many researchers as a direct cellular marker of endothelial dysfunction [10].

Thus, the comorbid course of HTN and T2DM greatly increases the risk of cardiovascular complications, but in cases of SHT-associated comorbidities many questions remain unclear. It is known that the thyroid system, actively interacting with other neurohormonal factors, also affects the processes of vascular regulation. Till today the data on the impact of thyroid dysfunction, developing on the background of SHT, on the state of endothelium and ED formation are very diverse and remain not fully clear [11].

Purpose of the study. The purpose of the study was to investigate the influence of thyroid subclinical hypofunction on the state of endothelium in the patients with a comorbid course of hypertension and type 2 diabetes mellitus.

Materials and methods. 240 patients (164 women) aged 40 to 75 years (mean age 58.2 ± 5.6 years) with stage II HTN were observed. Depending on comorbid pathology all patients were divided into 3 groups: Group 1 (n = 40) – with isolated HTN (comparison group); Group 2 (n = 120) - with a combined course of HTN and T2DM; Group 3 (n = 80) – with comorbidity of H, T2DM and SHT as a result of autoimmune thyroiditis (AIT). Criteria of non-inclusion were symptomatic HTN, diabetes type 1 and other endocrine disorders, clinical signs of coronary heart disease or severe concomitant chronic diseases, pregnancy. Patients with diagnosed manifested hypothyroidism or with treated SHT, after surgical treatment of thyroid gland were not included. Use of such therapy: iodine preparations, glucocorticoids, amiodarone, lithium medicines, estrogens – was also exclusion criteria. Against the background of dietary recommendations, all patients received basic antihypertensive and antidiabetic therapy in individually selected doses in accordance with international and national Guidelines [2, 12, 13].

The survey program included a single list of laboratory and instrumental studies. BP levels were assessed by means of BP obtained

from three measurements at 2-minute intervals in a sitting position. Assessment of carbohydrate, thyroid and lipid metabolism was provided by standard methods. Ultrasound examination of the thyroid gland was performed according to the standard procedure on the device «LOGIQ5». The level of VEGF-A in blood plasma was studied by an immunoassay (ELISA) kit IBL International Gmbh (Germany) on a semi-automatic immunoassay microplate analyzer «ImmunoChem-2100», HighTechnology, Inc. (USA).The state of the vascular endothelium and the degree of its damage were studied by determining the number of DCEC in the blood according to the method of Hladovec J. (1978) as modified by Rajec J. et al. (2007) using phase contrast microscopy techniques [14].

Statistical data processing was carried out using the computer software SPSS 21.0. Qualitative data were presented as percentages; quantitative – in the form of the mean and standard error (M ± m). The Student criterion was used to estimate the differences between groups in the distribution close to normal. The differences were considered statistically significant at $p < 0.05$.

The study was performed in compliance with the basic provisions of the World Medical Association (WMA) Declaration of Helsinki on ethical principles for medical research involving human subjects (1964–2000) and MOH of Ukraine Order No. 690 dated September 23, 2009. The study was approved by the Bioethics Commission of Kharkiv National Medical University in accordance with the principles set forth in the Helsinki Declaration. All the patients signed the inform consent.

Results and discussion. To objectify the study all selected patients had controlled HTN stage 2 with stable antihypertensive therapy at least 3 months before randomization. The demographic and metabolic data for the patients participating in this study are presented in Table 1.

Table 1. General characteristics, parameters of lipid, thyroid and carbohydrate metabolism in study groups (M ± m)

Index	Group 1 (isolated HTN)	Group 2 (HTN + DM2T)	Group 3 (HTN + DM2T + SHT)
Age, yrs	61.37 ± 0.59	63.18 ± 0.72	61.59 ± 0.80
SBP, mmHg	139.23 ± 4.65	145.70 ± 3.36	150.11 ± 5.86
DBP, mmHg	88.16 ± 5.06	94.08 ± 4.21	96.19 ± 5.72
BMI, kg/m^2	26.32 ± 1.26	29.37 ± 1,09*	33.06 ± 2.01*,**
TSH, mIU/L	2.3 ± 0.54	2.41 ± 0.82	6.73 ± 2.04*,**
TC, mmol/l	5.31 ± 0.52	5.69 ± 0.83	5.97 ± 0.88
LDL-cholesterol, mmol/l	2.90 ± 0.47	3.05 ± 0.17	3.57 ± 0.69
HDL-cholesterol, mmol/l	1.27 ± 0.05	1.18 ± 0.13	1.14 ± 0.08
TG, mmol/l	1.66 ± 0.11	1.79 ± 0.23	2.40 ± 0.34*,**
Blood fasting glucose, mmol/l	5.32 ± 0.19	8.11 ± 0.57*	6.39 ± 0.48$^{*, **}$
HbA1c (%)	5.59 ± 0.32	7.59 ± 0,11*	7.19 ± 0.12*,**

Notes: TC – total cholesterol, LDL-cholesterol – low-density lipoprotein cholesterol, HDL-cholesterol – high-density lipoprotein cholesterol, TG – triglycerides, SBP – systolic blood pressure, DBP – diastolic blood pressure, BMI – body mass index, TSH – hyroid stimulating hormone, HbA1c – glycosylated hemoglobin, * – $p < 0.05$ vs. the 1st group; ** – $p < 0.05$ vs. the 2nd group.

There were no significant differences between the groups in the mean values of both systolic BP (SBP) and diastolic BP (DBP), despite different comorbidities. Patients in all groups experienced dyslipidemia, more pronounced in the presence of a combined course of HTN and T2DM than in patients with isolated HTN. The presence of SHT to HTN and T2DM was accompanied by the emergence of a tendency for the growth of all investigative indexes of lipid metabolism (see Table1). The presence of more expressed dyslipidemia in patients of group 3 coincides with the results of the HUNT study, which showed a direct relationship between thyroid-stimulating hormone (TSH) levels and blood lipids and again confirm the existing data on the presence of atherogenic dyslipidemia on the background of incomplete compensation of thyroid metabolism, including with comorbid pathology, as a risk factor for the progression of atherosclerosis and, accordingly, the risk of its complications [15].

In this study the fasting glucose levels in the group with isolated HTN was significantly lower than in groups with comorbid pathology, despite the antidiabetic therapy. The presence of SHT in patients with HTN and T2DM was characterized by significantly lower levels of fasting glucose ($p = 0.001$), glycated hemoglobin ($p = 0.011$) compared to patients with comorbidity of HTN and T2DM with euthyroid. A univariate variance analysis revealed a significant effect of TSH level on fasting glucose level ($p = 0.001$) in patients with a combined course of HTN, T2DM and SHT. These data are consistent with the results of recent years, which indicate a decrease in glucose levels with elevated TSH levels due to stimulation of gluconeogenesis and sympathetic stimulation of the liver [16].

Analysis of markers of ED found a significantly lower VEGF levels in patients with the combined course of HTN and T2DM compared to the patients with isolated HTN (317.43 ± 11.10 pg/ml and 369.12 ± 22.07 pg/ml, respectively, $p = 0.049$, see Table 2.), which can be explained by taking metformin, which was one of the inclusion criteria in this study.

Table 2. Markers of endothelial dysfunction

Index	Group 1 (isolated HTN)	Group 2 (HTN + DM2T)	Group 3 (HTN + DM2T + SHT)	Significance, p
VEGF-A, pg/ml	369.12 ± 22.07	317.43 ± 11.10	476.61 ± 24.82	$p_{1-2} = 0.049$ $p_{1-3} = 0.001$ $p_{2-3} = 0.001$
CDEC, cells/100 µl	12.06 ± 0.61	11.97 ± 0.31	10.07 ± 0.26	$p_{1-2} > 0.05$ $p_{1-3} = 0.001$ $p_{2-3} = 0.001$

Notes: VEGF-A – vascular endothelial growth factor-A, CDEC- the amount of circulating desquamated epithelial cells.

Emerging numerous evidence, including those obtained in randomized studies, suggests the beneficial effect of metformin on endothelial function [17, 18]. Thus, Wu S et al (2014) demonstrated a significant improvement in endothelial function with the use of metformin for 12 months [18].

The presence of T2DM in group 2 practically not reflected on the the amount of CDEK ($p = 0.967$) when compared with the group 1. This data also indicates the positive effect of metformin on ED. In patients with a combined course of HTN, T2DM and SHT, the level of VEGF was significantly higher than in other groups in this study (476.61 ± 24.82 pg/ml, $p = 0.001$ for all comparison groups), but the amount of DCEK was the lowest and significantly differed from the other studied groups ($p = 0.001$ when comparing groups 1 and 2).

These advances are consistent with the results of studies demonstrating impaired secretion of endothelium-dependent dilation factors in hypothyroidism and are consistent with the data show that ED during SHT is not accompanied by morphological damage of endothelium [11, 19, 20].

The presence of correlations between indexes of thyroid metabolism and indexes characterized ED in group 2 (VEGF – thyroid stimulating hormone (TSH) r = -0.299, p = 0.001, CDEC – T4frei r = -0.168, p = 0.036, CDEC – T3frei r = 0.162, p = 0.043), and the correlation between VEGF and TSH in group 3 (r = 0.434, p = 0.001) indicates a significant influence of thyroid hormones on the functional state of the endothelium even within normal TSH values and worsens as the TSH level increases. The results of univariate variance analysis showed a significant effect of VEGF on TSH levels in patients of both group 2 (p = 0.001) and group 3 (p = 0.001) in this study.

Conclusions.

1. Endothelial dysfunction is more expressed with a combination of hypertension, type 2 diabetes, and thyroid dysfunction. Even minor changes in thyroid status contribute to the progression of endothelial dysfunction in patients with comorbid pathology.

2. The impact of subclinical hypothyroidism on endothelial dysfunction is characterised by the progression of impaired vasodilation, but not associated with an influence on morphological damage of the endothelium.

3. Metformin may have a protective effect on the endothelium in patients with comorbid pathology, including subclinical hypothyroidism.

4. It is important that ED develops already in the early stages of pathological processes and is ahead of the clinical manifestations of the disease. Therefore, the early detection of ED in the patients with a combination of hypertension, type 2 diabetes mellitus and subclinical hypothyroidism has a great diagnostic and prognostic significance.

Funding and conflict of interest. There is no conflict of interest.

Funding source: authors' own funds.

Publication ethics. Patients were included in the study after obtaining informed consent. The study complied with international ethical standards for biometric research.

REFERENCES

1. Nguyen T. N, Chow C K. Global and national high blood pressure burden and control. *Lancet*. 2021. Vol. 398 (10304). P. 932–933. doi: https://doi.org/10.1016/S0140-6736(21)01688-3

2. 2023 ESH Guidelines for the management of arterial hypertension The Task Force for the management of arterial hypertension of the European Society of Hypertension: Endorsed by the International Society of Hypertension (ISH) and the European Renal Association (ERA) / G. Mancia rt al. *J Hypertens*. 2023. Vol. 41 (12). P. 1874–2071. doi: https://doi.org/10.1097/HJH.0000000000003480

3. Global epidemiology, health burden and effective interventions for elevated blood pressure and hypertension / B. Zhou, P. Perel, G. A. Mensah, M. Ezzati. *Nat Rev Cardiol*. 2021. Vol. 18 (11). P. 785–802. doi: https://doi.org/10.1038/s41569-021-00559-8

4. Biondi B., Kahaly G. J., Robertson R. P. Thyroid Dysfunction and Diabetes Mellitus : Two Closely Associated Disorders. *Endocr Rev*. 2019. Vol. 40 (3). P. 789–824. doi: https://doi.org/10.1210/er.2018-00163

5. Association between thyroid dysfunction and type 2 diabetes: a meta-analysis of prospective observational studies / F. Rong et al. *BMC Med*. 2021. Vol. 19 (1). P. 257. doi:

https://doi.org/10.1186/s12916-021-02121-2

6. Serum TSH, T(4), and thyroid antibodies in the United States population (1988 to 1994): National Health and Nutrition Examination Survey (NHANES III) / J. G. Hollowell et al. *J Clin Endocrinol Metab*. 2002. Vol. 87 (2). P. 489–499. doi: https://doi.org/10.1210/jcem.87.2.8182

7. Endothelial Dysfunction in Diabetes Mellitus: New Insights / M. Dubsky et al. *Int J Mol Sci*. 2023. Vol. 24 (13). P. 10705. doi: https://doi.org/10.3390/ijms241310705

8. Konukoglu D., Uzun H. Endothelial Dysfunction and Hypertension. *Adv Exp Med Biol*. 2017. Vol. 956. P. 511–540. doi: https://doi.org/10.1007/5584_2016_90

9. Nemtsova V., Vischer A. S., Burkard T. Hypertensive Heart Disease: A Narrative Review Series—Part 3: Vasculature, Biomarkers and the Matrix of Hypertensive Heart Disease. *J Clin Med*. 2024. Vol. 13 (2). P. 505. doi: https://doi.org/10.3390

10. Circulating endothelial cells in coronary artery disease / M. Lampka et al. *Kardiol Pol*. 2015. Vol. 68 (10). P. 1100–1105.

11. Mechanism of subclinical hypothyroidism accelerating endothelial dysfunction (Review) / Lu. Ming, Bo Yang Chong, Gao. Ling, Zhao. Jia-Jun. *Exp Ther Med*. 2015. Vol. 9 (1). P. 3–10. doi: https://doi.org/10.3892/etm.2014.2037

12. 2013 ETA Guideline: Management of Subclinical Hypothyroidism / S. H. Pearce et al. *Eur Thyroid J*. 2013. Vol. 2 (4). P. 215–228. doi: https://doi.org/10.1159/000356507

13. Quattrocchi E., Goldberg T., Marzella N. Management of type 2 diabetes: consensus of diabetes organizations. *Drugs Context*. 2020. Vol. 9. P. 212607. doi: https://doi.org/10.7573/dic.212607

14. Endothelaemia-a marker of vascular damage / J. Rajec et al. *Bratisl Lek Listy*. 2007. Vol. 108 (9). P. 403–405.

15. The association between TSH within the reference range and serum lipid concentrations in a population-based study. The HUNT Study / B. O. Asvold, L. J. Vatten, T. I. Nilsen, T. Bjøro. *Eur J Endocrinol*. 2007. Vol. 156 (2). P. 181–186. doi: https://doi.org/10.1530/eje.1.02333

16. High TSH Level within Normal Range Is Associated with Obesity, Dyslipidemia, Hypertension, Inflammation, Hypercoagulability, and the Metabolic Syndrome: A Novel Cardiometabolic Marker / Y. C. Chang et al. *J. of Clinical Medicine*. 2019. Vol. 8 (6). P. 817. doi: https://doi.org/10.3390/jcm8060817

17. Metformin in cardiovascular diabetology: a focused review of its impact on endothelial function / Y. Ding et al. *Theranostics*. 2021. Vol. 11 (19). P. 9376–9396. doi: https://doi.org/10.7150/thno.64706

18. Wu S., Li X., Zhang H. Effects of metformin on endothelial function in type 2 diabetes. *Exp Ther Med*. 2014. Vol. 7 (5). P. 1349–1453. doi: https://doi.org/10.3892/etm.2014.1582

19. Endothelial dysfunction and low-grade chronic inflammation in subclinical hypothyroidism due to autoimmune thyroiditis / E. E. Türemen et al. *Endocr J*. 2011. Vol. 58 (5). P. 349–354. doi: https://doi.org/10.1507/endocrj.k10e-333

20. Hypothyroidism and Cardiovascular Disease: A Review / D. Zúñiga et al. *Cureus*. 2024. Vol. 16 (1). P. e52512. doi: https://doi.org/10.7759/cureus.52512

Надійшла до редакції 22.02.2024

Прийнята до опублікування 29.03.2024

Інформація про авторів (Information about the authors)

Nemtsova Valeriya, Doctor of Medical sciences, Professor, Educational and Scientific Medical Institute of the National Technical University "Kharkiv Polytechnic Institute", Professor of the Department of "Family medicine and internal diseases"; Kharkiv, Ukraine.

Немцова Валерія Данилівна, докторка медичних наук, професорка, Навчально-науковий медичний інститут Національного технічного університету «Харківський політехнічний інститут», професорка кафедри сімейної медицина та внутрішніх хвороб; Харків, Україна.

E-mail: valeriyan@ukr.net

https://orcid.org/0000-0001-7916-3168 A, B, C, D, E, F

Poteiko Petro, Candidate of Medical sciences, Associate Professor, Educational and Scientific Medical Institute of the National Technical University "Kharkiv Polytechnic Institute", Head of the Department of Family medicine and internal diseases; Kharkiv, Ukraine.

Потейко Петро Іванович, кандидат медичних наук, доцент, Навчально-науковий медичний інститут Національного технічного університету «Харківський політехнічний інститут», завідувач кафедри сімейної медицина та внутрішніх хвороб; Харків, Україна.

E-mail: petro.poteiko@khpi.edu.ua

https://orcid.org/0000-0002-6451-7151 D, E

Ryndina Nataliia, Doctor of Medical sciences, Professor, Educational and Scientific Medical Institute of the National Technical University "Kharkiv Polytechnic Institute", Professor of the Department of "Family medicine and internal diseases"; Kharkiv, Ukraine.

Риндіна Наталія Геннадіївна, докторка медичних наук, професорка, Навчально-науковий медичний інститут Національного технічного університету «Харківський політехнічний інститут», професорка кафедри сімейної медицина та внутрішніх хвороб; Харків, Україна.

E-mail: nryndina81@gmail.com

http://orcid.org/0000-0003-2731-4491 D, E, F

Berezniakov Vladyslav, Candidate of Medical sciences, Associate Professor, Educational and Scientific Medical Institute of the National Technical University "Kharkiv Polytechnic Institute", Associate Professor of the Department of Family medicine and internal diseases; Kharkiv, Ukraine.

Березняков Владислав Ігорович, кандидат медичних наук, доцент, Навчально-науковий медичний інститут Національного технічного університету «Харківський політехнічний інститут», доцент кафедри сімейної медицина та внутрішніх хвороб; Харків, Україна.

E-mail: vladyslav.berezniakov@khpi.edu.ua

https://orcid.org/0000-0001-7818-4864 D, E

Korchevska Hanna, Educational and Scientific Medical Institute of the National Technical University "Kharkiv Polytechnic Institute", Associate Professor of the Department of Family medicine and internal diseases; Kharkiv, Ukraine.

Корчевська Ганна Ігорівна, Навчально-науковий медичний інститут Національного технічного університету «Харківський політехнічний інститут», асистентка кафедри сімейної медицина та внутрішніх хвороб; Харків, Україна.

E-mail: hanna.korchevska@khpi.edu.ua D, E

Kravchuk Stanislav, Educational and Scientific Medical Institute of the National Technical University "Kharkiv Polytechnic Institute", Associate Professor of the department of Family medicine and internal diseases; Kharkiv, Ukraine.

Кравчук Станіслав Леонідович, Навчально-науковий медичний інститут Національного технічного університету «Харківський політехнічний інститут», асистент кафедри сімейної медицина та внутрішніх хвороб; Харків, Україна.

E-mail: stanislav.kravchuk@khpi.edu.ua [D, E]

A	–	Концепція та дизайн роботи (Work concept and design)
B	–	Збір та аналіз даних (Data collection and analysis)
C	–	Відповідальність за статистичний аналіз (Responsibility for statistical analysis)
D	–	Написання статті (Writing the article)
E	–	Критичний огляд статті (Critical review)
F	–	Остаточне затвердження статті (Final approval of the article)

Відповідальний автор:

Немцова Валерія Данилівна, докторка медичних наук, професорка, Навчально-науковий медичний інститут Національного технічного університету «Харківський політехнічний інститут», професорка кафедри сімейної медицина та внутрішніх хвороб.

✉ Україна, 61000, м. Харків, вул. Пушкінська, 79/1.

E-mail: valeriyan@ukr.net

Цитування: Nemtsova V., Poteiko P., Ryndina N., Berezniakov V., Korchevska H., Kravchuk S. The impact of subclinical hypothyroidism on markers of endothelial dysfunction in patients with arterial hypertension and endocrine comorbidities. *Bulletin of medicine, Psychology and Pharmacy*. 2024. No. 1. P. 43–50. doi: https://doi.org/10.20998/BMPP.2024.01.05