RESEARCH ARTICLE

Novel atherogenic indices and risk of cardiovascular complications in patients of hypertension

Emina Dervišević[1], Lejla Čolak[2], Amela Dervišević[3], Zurifa Ajanović[4], Ekrema Mujarić[5], Aida Bešić[6*], Ferid Krupić[7], Edina Lazović[8], Hajrudin Spahović[9], Nedim Šuta[10], Almir Fajkić[11]

[1]Department of Forensic Medicine, Faculty of Medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
[2]Department of Pediatrics, Primary Health Care Centre in Zenica, Zenica, Bosnia and Herzegovina
[3]Department of Human Physiology, Faculty of Medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
[4]Department of Anatomy, Faculty of Medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
[5]Department of Internal Diseases, Cantonal Hospital Zenica, Zenica, Bosnia and Herzegovina
[6]Department of Clinical Sciences Veterinary Medicine, Veterinary Faculty, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
[7]Department of Anaesthesiology, Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[8]Department of Pathology, Faculty of Medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
[9]Urology Clinic, Clinical Center, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
[10]Department of Biology, Faculty of Science, University of Sarajevo, Sarajevo, Bosnia and Herzegovina
[11]Department of Pathophysiology, Faculty of Medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

[*]**Corresponding author:** Aida Bešić, DVM
Address: Zmaja od Bosne 90 71000 Sarajevo, Bosnia and Herzegovina
Phone: +38733729155
ORCID: 0000-0001-9157-6942
E-mail: katicaaida1@gmail.com

Original Submission: 15 October 2025
Revised Submission: 06 November 2025
Accepted: 20 November 2025

How to cite this article: Dervišević E, Čolak L, Dervišević A, Ajanović Z, Mujarić E, Bešić A, Krupić F, Lazović E, Spahović H, Šuta N, Fajkić A. 2025. Novel atherogenic indices and risk of cardiovascular complications in patients of hypertension. Veterinaria, 74(3), 249-57.

ABSTRACT

The study was aimed to evaluate the lipid panel parameters in *Hypertension* (HTA) patients along with gender-dependent comparison and *Cardiovascular Disease* (CVD) risk estimated based on Atherogenic Index of Plasma (AIP) values. This study aims to emphasize the importance of the lipid profile in blood in cardiovascular patients with hypertension. Total number of 136 adult HTA patients (85 female/51 male: ≤ 55 years (male:13, female:19); 56 - 70 years (male:23, female:47); > 70 years (male:15, female:19)) were included in this retrospective study. According to CVD risk estimated based on AIP values (Table 2), patients were classified into two groups: HTA patients with low/moderate CVD risk - AIP ≤ 0.21 (n=51) and HTA patients with high CVD risk - AIP >0.21 (n=85). Triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), non-high-density lipoprotein cholesterol (nHDL-C), total cholesterol (TC), atherogenic coefficient (AC), TG/HDL-C ratio, LDL-C/HDL-C ratio and TC/HDL-C ratio were used for comparison between the groups. Routine lipid parameters were analyzed by standard biochemical methods. For calculation of composite lipid indices, we used reference formulas. HTA patients with high CVD risk had significantly higher levels of TC (p=0.02), TG/HDL-C ratio, TG, AIP, LDL-C/HDL-C ratio, nHDL-cholesterol, TC/HDL-C ratio, and atherogenic coefficient, and significantly lower HDL-C compared to HTA patients with low/moderate CV risk (p<0.001, respectively). Our findings underscore the importance of considering various lipid profile parameters in risk stratification among patients with HTA.

Keywords: Atherogenic dyslipidemia, cardiovascular risk, hypertension

INTRODUCTION

Cardiovascular diseases (CVD) account for above 33% of deaths all around the world and is ranked as a leading cause of mortality. The prevalence of CVD is expected to rise rapidly because of the growing exposure to CVD contributing factors (Niroumand et al., 2015).

Significant predisposing factors for CVD include hypertension and hyperlipidemia. Recent study suggests that lipid profiles analysis commonly

reported by laboratories may not show significant differences between patients with CVD and healthy individuals. Instead, focusing on the testing of subfractions or subpopulations of individual lipoproteins appears to be more significant and helpful (Chandra and Rohatgi, 2014).

Lipoprotein transport between the periphery and the liver is crucial for lipid metabolism homeostasis. Low-density lipoprotein (LDL) represents a class of lipoproteins that carries the most cholesterol and has the primary function of transporting cholesterol from the liver to peripheral cells. On the other hand, very low-density lipoprotein (VLDL) delivers to periphery, and cholesterol is carried to the liver from peripheral cells by high-density lipoprotein (HDL) (Zanoni et al., 2018; Karathanasis et al., 2017).

Recent studies analyzed blood levels of triglycerides (TG) derived from TG-rich lipoproteins (TRL), including VLDL and chylomicrons (Karathanasiset al., 2017; Mudhaffar, 2013; Parinita, 2012). Large molecules of VLDL and chylomicrons cannot pass through the endothelium of the blood vessel and enter the arterial wall, and in physiological conditions cholesterol is not produced from them. In metabolic disorders, small TRL molecules called residual lipoproteins are synthesized and can pass through the arterial wall. Elevated levels of small dense LDL (sdLDL) are caused by higher concentrations of TG. It is caused by cholesterol ester transfer protein and hepatic lipase activity, which contribute to the formation of sdLDL. The produced sdLDL oxidizes very easily and forms a very harmful abnormal lipoprotein, oxidized LDL cholesterol (oxLDL-C), which is considered a marker of oxidative stress (Kanthe et al., 2012; Borén and Taskinen, 2021).

A number of confirmed etiological factors can disrupt lipid homeostasis, leading to abnormal accumulation of lipids in the peripheral circulation and in the liver. The accumulation of lipid deposits, especially oxLDL-C, on the endothelium of blood vessels leads to the activation of foam cells and the development of atherosclerotic-fatty streaks and systemic inflammation with consequent cardiovascular events.

Disorder of serum lipid concentration is crucial in endothelial dysfunction development, a significant factor in the pathogenesis of conditions such as thrombosis, insulin resistance and hypertension. Various studies have shown that hyperlipidemia and hypertension may have a synergistic effect in atherosclerosis (Albucher et al., 2000).

Hypertension causes the walls of blood vessels to thicken. This occurs as a result of smooth muscle proliferation along with collagen in the central layer of the wall. Consequently, the lumen of blood vessels becomes narrower (Martinez-Quinones et al., 2018). In addition, the high concentration of lipids in the bloodstream makes it difficult to remove them, which results in their deposition within the walls of blood vessels. This deposition eventually leads to the formation of atherosclerotic plaques. Post-mortem studies of human coronary arteries and aortas from different regions of the world have led to the conclusion that atherosclerosis is extensively severe and prevalent in people with hypertension in comparison to those with normal blood pressure (Nasri et al., 2014).

Numerous clinical studies are currently underway in search of a more effective biomarker to assess lipoprotein metabolism, one that can accurately predict CV risk and assess the effectiveness of treatment response (Niroumand et al., 2015; Pirillo et al., 2021; Lopez and Adair, 2019; Fu et al., 2021).

In recent years, lipid indices have been studied for their prognostic values in various metabolic disorders and CVD (Niroumand et al., 2015). Previous studies have proved that to predict the risk of coronary heart disease and atherosclerosis, atherogenic index of plasma (AIP) is a vital biomarker (Carroll et al., 2019; Friedewald et al., 1972), and it is important to use it in combination with other risk markers. For the risk of cardiovascular events, the predictive value of AIP has been demonstrated in T2DM patients. A retrospective study performed on diabetic patients with high risk for CVD indicated an association between AIP and glucose and lipid metabolism abnormality. In addition, the role of AIP as a significant predictor of long-term prognosis in T2DM patients was established (Fu et al., 2021).

This study was destined to evaluate lipid profile parameters in hypertensive patients and compare them in association to gender and CVD risk estimated based on AIP values.

MATERIAL AND METHODS

This single centre study was conducted with the electronic records of 136 patients with hypertension admitted to Primary Health Care Centre in Zenica (Bosnia and Herzegovina) from January to August.

Participants were categorized as hypertensive, who showed systolic blood pressure (SBP) of 140 mmHg or higher, or a diastolic blood pressure (DBP) of 90 mmHg or higher.

Participants were split into two groups: HTA patients with less/moderate CVD - AIP ≤ 0.21 (n=51) and the second group of HTA patients with the high CV risk AIP >0.21 (n=85). Subjects with hypertension who had hematological diseases, malignant diseases or pregnant women were not included in this evaluation.

Sample selection

Demographic, clinical, and laboratory data were collected. We followed these parameters: age, sex, nHDL-C, AC, TC (mmol/L), HDL-cholesterol (mmol/L), triglycerides (mmol/L), LDL-cholesterol (mmol/L), LDL-C/HDL-C ratio, TG/HDL-C ratio, and TC/HDL-C ratio.

Lipid measurements were performed using an XT 1800i hematology autoanalyzer (Sysmex Corporation, Kobe, Japan) and an Olympus AU 480 chemistry analyzer (Beckman Coulter, USA).

Calculation of LDL-C levels was completed using Friedewald formula (Friedewald et al., 1972; Tseng et al., 2023).

HDL-C was subtracted from TC to calculate Non-HDL-C (Zaciragic et al., 2022).

TG was divided by HDL-C, TC by HDL-C, and LDL-C by HDL-C, to calculate TG/HDL-C ratio, TC/HDL-C ratio, and LDL-C/HDL-C ratio, respectively. Ratio of non-HDL-C/HDL-C gave AC values (Namitha et al., 2022).

Logarithm of the ratio between high-density lipoprotein cholesterol and triglycerides was taken to calculate AIP. It is then classified into different CVD risk categories. AIP values below 0.1 were considered low risk, values between 0.1 and 0.24 were considered medium risk, and values equal to or above 0.24 were considered high risk (Lumu et al., 2023).

Statistical analysis

Kolmogorov-Smirnov test was used to test dissemination of quantifiable variables. Standard deviation (SD) and Mean for normally distributed variables was used to express the descriptive statistics for continuous variables. Meanwhile, skewedly distributed variables were expressed as median and interquartile range. Evaluation of significance of mean differences between two groups was performed by independent two-sample Student's t-test. Difference in values of parameters revealed non-normal dispersal pattern when analysed by Mann-Whitney U-test. Chi-square was used to assess the differences between categorical variables. Statistically significant results were considered if the P values less than 0.05.

RESULTS

The initial and clinical characteristics of HTA patients included in the analysis according to gender are shown in Table 1. Overall, 85 (62.5%) of subjects were women. The mean age of the patients was 63.3 ± 10.2 years, with females having an average age of 63.2 ± 8.9 years and males 63.5 ± 12.2 years. No statistically significant variations were observed between the female HTA patients and male HTA patients when comparing age, the prevalence among different age groups, diabetes mellitus type 2 status, cardiovascular events status, or AIP/CVD risk status.

Table 1 Baseline and medical characteristics of HTA patients categorized by gender

	Total	Female	Male	p
n (%)	136 (100)	85 (62.5)	51 (37.5)	
Age (years)	63.3 ± 10.2	63.2 ± 8.9	63.5 ± 12.2	0.855
Age groups, n (%)				
≤ 55 years	32 (23.5)	19 (22.4)	13 (25.5)	0.449
56 - 70 years	70 (51.5)	47 (55.3)	23 (45.1)	
> 70 years	34 (25.0)	19 (22.4)	15 (29.4)	

	Total	Female	Male	p
Diabetes mellitus type 2, n (%)				
Yes	45 (33.1)	29 (34.1)	16 (31.4)	0.742
No	91 (66.9)	56 (65.9)	35 (68.6)	
Cardiovascular event, n (%)				
Yes	54 (39.7)	34 (40.0)	20 (39.2)	0.928
No	82 (60.3)	51 (60.0)	31 (60.8)	
AIP/CVD risk, n (%)				
< 0.1/Low	30 (22.1)	19 (22.4)	11 (21.6)	0.859
0.1-0.21/ Moderate	21 (15.4)	12 (14.1)	9 (17.6)	
> 0.21/High	85 (62.5)	54 (63.5)	31 (60.8)	

Analysis of lipid profile parameters revealed that triglycerides, HDL-cholesterol, serum TC, AIP, TG/HDL-C ratio, LDL-cholesterol, TC/HDL-C ratio, nHDL-C, LDL-C/HDL-C ratio, and AC did not differ significantly between the female and male HTA patients (Table 2).

Table 2 Lipid profile parameters of HTA patients according to gender

	Total (n=136)	Female (n=85)	Male (n=51)	p
Total cholesterol (mmol/L)	6.6 (5.8-7.4)	6.6 (5.9 – 7.3)	6.5 (5.8 – 7.5)	0.919
Triglycerides (mmol/L)	2.2 (1.6-2.8)	2.1 (1.6 – 2.95)	2.2 (1.6 – 2.8)	0.577
HDL-cholesterol (mmol/L)	1.2 (1.0-1.3)	1.1 (1.0 – 1.3)	1.2 (1.1 – 1.3)	0.129
LDL-cholesterol (mmol/L)	4.2 (3.5-5.0)	4.2 (3.4 – 4.85)	4.3 (3.6 – 5.1)	0.412
AIP	0.28 (0.12-0.45)	0.3 (0.12-0.46)	0.26 (0.14-0.43)	0.454
TG/HDL-C ratio	1.9 (1.3-2.8)	2.0 (1.32 – 2.86)	1.83 (1.38 – 2.67)	0.439
LDL-C/HDL-C ratio	3.5 (2.9-4.3)	3.6 (2.96 – 4.23)	3.3 (2.86 – 4.36)	0.770
TC/HDL-C ratio	5.5 (4.8-6.8)	5.75 (4.96 – 6.83)	5.2 (4.57 – 6.82)	0.251
nHDL-C	5.4 (4.6 – 6.2)	5.5 (4.7 – 6.2)	5.3 (4.5 – 6.4)	0.863
AC	4.5 (3.8 – 5.8)	4.8 (4.0 – 5.8)	4.2 (3.6 – 5.8)	0.251

HTA patients with high CVD risk exhibited notably elevated levels of total cholesterol (p=0.02), triglycerides, AIP, AC, TG/HDL-C ratio, LDL-C/HDL-C ratio, TC/HDL-C ratio, nHDL-cholesterol, and significantly lower HDL-C compared to HTA patients with low/moderate CV risk (p<0.001, respectively). However, values of LDL-C reported higher in HTA patients with high CVD risk compared to the HTA patients with low/moderate CV risk, but the change was statistically non-significant (p=0.169) (Table 3).

Table 3 Lipid profile parameters in HTA patients with low/moderate and high CVD risk

Variables	HTA patients with low/moderate CVD risk AIP ≤ 0.21 (n=51)	HTA patients with high CV risk AIP > 0.21 (n=85)	p
Total cholesterol (mmol/L)	6.2 (5.8 – 7.0)	7.0 (5.8 – 7.6)	**0.02**
Triglycerides (mmol/L)	1.5 (1.3 – 1.7)	2.5 (2.2 – 3.2)	**< 0.001**

Variables	HTA patients with low/moderate CVD risk AIP ≤ 0.21 (n=51)	HTA patients with high CV risk AIP > 0.21 (n=85)	p
HDL-C (mmol/L)	1.3 (1.2 – 1.4)	1.1 (1.0 – 1.2)	**< 0.001**
LDL-C (mmol/L)	4.0 (3.4 – 4.6)	4.3 (3.6 – 5.1)	0.169
AIP	0.1 (0.03-0.14)	0.38 (0.29-0.51)	**< 0.001**
AC	3.9 (3.4 – 4.5)	5.1 (4.2 – 6.2)	**< 0.001**
TG/HDL-C Ratio	1.25 (1.08 – 1.38)	2.42 (1.96 – 3.2)	**< 0.001**
LDL-C/HDL-C Ratio	3.23 (2.71 – 3.7)	3.9 (3.24 – 4.67)	**< 0.001**
TC/HDL-C Ratio	4.92 (4.43 – 5.45)	6.08 (5.2 – 7.2)	**< 0.001**
nHDL-cholesterol	4.9 (4.4 – 5.7)	5.9 (5.0 – 6.5)	**< 0.001**

DISCUSSION AND CONCLUSION

Dyslipidaemia hypertension is a very often used term to describe the coexistence of dyslipidaemia and hypertension, which are recognized as two of the majorly significant global CVD risk determinants. This label makes it easier to identify people who have both conditions. The combined impacts of high BP and elevated lipids level in serum are multiple. These metabolic abnormalities are regarded as one of the most crucial determinants for the onset of ischemic heart disease (IHD) or cardiovascular disease (CVD) (Kannel et al., 1971; Dalal et al., 2012; Karadimas TL and Meier HCS, 2024; Omidi et al., 2024).

This study presented differences in routine lipid profile and composite lipid parameters in HTA patients divided into two groups according to CVD risk estimated by AIP values: HTA patients with low/moderate CVD risk and HTA patients with high CV risk.

Results of the study revealed that significantly higher level of total cholesterol (p=0.02), triglycerides, nHDL-cholesterol, and significantly lower level of HDL-C compared to HTA patients with low/moderate CV risk (p<0.001, respectively) were present in HTA participants with greater CVD risk. However, the values of LDL-C were higher in HTA patients with high CVD risk compared to the HTA patients with low/moderate CV risk, but the variation was statistically non-significant (p=0.169).

This finding aligns with the criteria set by the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) according to which the highly common disorder in serum lipid profile among HTA patients was noted to be an abnormally high level of LDL-C, followed by high levels of TC and TG. On the other hand, low HDL-C has been found to be the rarest lipid abnormality in HTA patients. It is worth noting that these lipid abnormalities often coexist and do not occur in isolation (Lipsy, 2003).

The findings of the current study appear to be consistent with those of Xie and colleagues who conducted a prospective cohort analysis that included non-hypertensive participants (n=2116). The main objective of the study was to develop a lipid risk score to evaluate the predictive impact of combined lipid profile components on HTA development. The authors concluded that an integrated lipid risk score, which combined LDL-C, non-HDL-C, TC and TG, independently of traditional risk factors, predicted the risk of HTA in people under the age of 55 years (Xie et al., 2022).

The association between high HTA risk and abnormal lipid profiles can be attributed to several pathophysiological mechanisms. One of these mechanisms involves the dysfunction of the vascular endothelium. Abnormal lipid profiles including elevated oxidation of LDL under hypercholesterolemic state, may result in declined production of endothelial nitric oxide synthase (eNOS). Meanwhile, HDL particles may enhance NO production by eNOS reactivity. This endothelial dysfunction characterized by impaired NO production and increased production of vasoconstrictors contributes to increased vascular tone and reduced vasodilation, finally leading to elevated blood pressure (Kawashima et al., 2004; Dąbrowska E and Narkiewicz K., 2023). Dyslipidemia, especially elevated levels of LDL-C, can stimulate the renin-angiotensin-aldosterone

system (RAAS). This leads to increased production of angiotensin II, a potent vasoconstrictor. Angiotensin II acts on the smooth muscle cells of blood vessels, causing them to constrict and resulting in an increase in peripheral vascular resistance, ultimately leading to elevated blood pressure. Angiotensin II also promotes sodium and water retention, and oxidative stress, which ultimately affect the maintenance and development of HTA (Ni et al., 2013). Resistance to insulin is another key factor linking abnormal lipid profiles and HTA. Dyslipidaemia, particularly high triglycerides levels and low HDL-C levels, is often linked to insulin resistance. Resistance to insulin impairs the insulin capability to regulate the levels of blood glucose and promotes the inflammatory mediators release (adipokines and cytokines), leading to dysfunction of endothelium and vascular tone elevation, which are potential contributor to HTA (Tsuruta et al., 1996; Alidu et al., 2023). All these physiological mechanisms illustrate the complex interplay between abnormal lipid profiles and HTA, underscoring the significance of effectively managing dyslipidaemia as a potential approach to prevent or control HTA.

The outcomes of our evaluation revealed that values of lipid indices, AIP, AC, LDL-C/HDL-C ratio, TG/HDL-C ratio, and TC/HDL-C ratio were significantly different between HTA patients with high CVD risk and HTA patients with less/moderate CV susceptibility. Namely, the levels of TG/HDL-C ratio, LDL-C/HDL-C ratio, TC/HDL-C ratio, AIP and AC were markedly elevated in HTA patients with a high CVD risk compared to those with low or moderate CV risk ($p<0.001$, respectively).

The AIP and AC have been widely used as predictors of arteriosclerosis in CVD screening and risk stratification. However, the studies focusing on the hypertensive population in relation to these markers are not enough. The results of a study based on 211,833 Chinese adults showed that AIP and AC were elevated in HTA patients in comparison with the normotensive participants, suggesting that a higher proportion of dyslipidaemia has relatedness with HTA. The study indicates the incidence of HTA especially in women, can be readily predicted by AC values (Cheng et al., 2022).

A higher AIP is found to have a positive and crucial association with the risk of hypertension or prehypertension in normoglycemic individuals in Gifu, Japan. This association is predominantly expressed among women, especially those between the ages of 40 and 60 (Tan et al., 2023).

Relationship between TG/HDL-C ratio and HAT was not consistent with the results obtained in the research. A cohort study on men was conducted in Spain, which elaborated that HTA and TG/HDL-C ratio had positive association. The study followed participants for an average of 8.49 years and five equal categories were developed for TG/HDL-C ratio. The risk of HTA was increased up to 90% in the patients with the highest TG/HDL-C ratio compared to the patients with the lowest ratio of TG/HDL-C (Sánchez-Íñigo et al., 2016).

Wu et al. explained in a prospective study that in hypertensive population, arterial stiffness progression had significant association with TG/HDL-C ratio. This was observed during a median follow-up of 4.71 years, but this link was not found in prehypertensive population (Wu et al., 2021).

In the current study, women with HTA were observed to have higher TC, AIP, AC, nHDL-C, LDL/HDL-C, TC/HDL-C, and TG/HDL-C compared to men. However, it is important to note that these differences were not statistically significant. Recent study has shown that non-elderly patients are more likely to have dyslipidaemia compared to the elderly. In comparison to males, higher levels of LDL-C, TG and TC were also observed in female hypertensive patients. Conclusively, authors of the study recommend that the healthcare professionals pay more attention to the lipid profile of HTA patients, especially those who are younger and female (Wu et al., 2022). The variations in hormone levels between men and women contribute to differences in lipid metabolism. Sex hormone concentrations have been found to affect lipoprotein levels, with estrogen playing a significant role in regulating lipid metabolism (Palmisano et al., 2018). In addition, follicle-stimulating hormone (FSH) levels are associated with serum cholesterol levels. However, the influence of progesterone and androgens only partially explains the disparities in serum lipid levels and further research is needed to fully understand their role in lipid metabolism (Wang et al., 2011). Sex differences in the onset and progression of HTA in humans may be attributed to variations in sympathetic nerve activity (SNA) and specific brain regions that express different estrogen receptor subtypes (Sabbatini and Kararigas al., 2020). Gaining insight into the mechanisms by which estrogen affects SNA regulation in key brain regions is important for the development of new, gender-specific treatment for HTA (Hay, 2016).

This investigation has certain constraints that must be recognized. Firstly, the broader applicability of these

findings to a wider population is limited because a single centre with a small sample size was used to perform this retrospective study. In addition, detailed patient history and medication use were not ensured, making it difficult to establish a clear association between traditional risk factors (family history, smoking, physical activity, menopause, obesity) and the development of dyslipidaemia and HTA.

However, our findings underscore the importance of considering various lipid profile parameters, including routine parameters and composite lipid indices, in risk stratification among hypertensive patients. The observed differences in lipid profiles between different risk groups highlight the potential utility of these parameters as valuable indicators for cardiovascular risk assessment in this patient population.

Extensive research and advanced studies on a large-scale may be necessary to elaborate the clinical implications of these distinctions and their role in guiding therapeutic interventions for hypertensive patients, at varying levels of CVD risk.

CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

CONTRIBUTION

Conception: ED, LČ, ZA, EM, AB, HS; Design: LČ, EM, AB, FK, HS, AF; Supervision: ED, AD, ZA, FK, EL, NŠ AF; Materials: ED, AD, AB, AF; Data Collection and/or Processing: LČ, ZA, FK, EL, HS; Analysis and/or Interpretation: ZA, EM, FK, EL; Literature Search: ED, AD, ZA, EL, NŠ, HS; Writing – Original Draft: ED, LČ. AF; Critical Review: AD, AB, AF.

REFERENCES

Albucher JF, Ferrieres J, Ruidavets JB, Guiraud-Chaumeil B, Perret BP, Chollet F. 2000. Serum lipids in young patients with ischaemic stroke: a case-control study. J Neurol Neurosurg Psychiatry, 69, 29–33. doi:10.1136/jnnp.69.1.29.

Alidu H, Dapare PPM, Quaye L, Amidu N, Bani SB, Banyeh M. 2023. Insulin Resistance in relation to Hypertension and Dyslipidaemia among Men Clinically Diagnosed with Type 2 Diabetes. Biomed Res Int, 2023, 8873226. doi: 10.1155/2023/8873226.

Borén J and Taskinen MR. 2021. In von Eckardstein A, Binder CJ, Prevention and Treatment of Atherosclerosis: Improving State-of-the-Art Management and Search for Novel Targets [Internet].:Metabolism of Triglyceride-Rich Lipoproteins. Cham (CH), Springer. doi: 10.1007/164_2021_520

Carroll MD, Kruszon-Moran D, Tolliver E. 2019. Trends in apolipoprotein B, non-high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol for adults aged 20 and over, 2005–2016. Natl Health Stat Rep, 127, 1–16.

Chandra A, Rohatgi A. 2014. The role of advanced lipid testing in the prediction of cardiovascular disease. CurrAtheroscler Rep, 16(3), 394. doi:10.1007/s11883-013-0394-9.

Cheng W, Wang L, Chen S. 2022. Differences in Lipid Profiles and Atherogenic Indices Between Hypertensive and Normotensive Populations: A Cross-Sectional Study of 11 Chinese Cities. Front Cardiovasc Med, 9, 887067. doi: 10.3389/fcvm.2022.887067.

Dąbrowska E, Narkiewicz K. 2023. Hypertension and Dyslipidemia: the Two Partners in Endothelium-Related Crime. CurrAtheroscler Rep, 25(9), 605-12. doi: 10.1007/s11883-023-01132-z

Dalal JJ, Padmanabhan TN, Jain P, Patil S, Vasnawala H, Gulati A. 2012. LIPITENSION: Interplay between dyslipidemia and hypertension. Indian J Endocrinol Metab, 16(2), 240-5. doi: 10.4103/2230-8210.93742.

Friedewald WT, Levy RI, Fredrickson DS. 1972. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem, 18(6), 499–502.

Fu L, Zhou Y, Sun J, Zhu Z, Xing Z, Zhou S, et al. 2021. Atherogenic index of plasma is associated with major adverse cardiovascular events in patients with type 2 diabetes mellitus. Cardiovasc Diabetol, 20(1), 201.doi: 10.1186/s12933-021-01393-5

Hay M. 2016. Sex, the brain and hypertension: brain oestrogen receptors and high blood pressure risk factors. Clin Sci (Lond), 130(1), 9-18. doi: 10.1042/CS20150654.

Kannel WB, Castelli WP, Gordon T, McNamara PM. 1971. Serum cholesterol, lipoproteins, and the risk of coronary heart disease. The Framingham study. Ann Intern Med, 74(1), 1-12. doi: 10.7326/0003-4819-74-1-1

Kanthe PS, Patil BS, BagaliSh, Deshpande A, Shaikh G, Aithala M. 2012. Atherogenic Index as a Predictor of Cardiovascular Risk among Women with Different Grades of Obesity. IJCRIMPH, 4(10), 1767–74.

Karadimas T, Meier HCS. 2024. Association between

coexisting hypertension, dyslipidaemia and elevated C reactive protein with cardiovascular disease and mortality: a cross-sectional and longitudinal analysis in a representative cohort of older US adults. BMJ Public Health, 2(2), e000455. doi: 10.1136/bmjph-2023-000455.

Karathanasis SK, Freeman LA, Gordon SM, Remaley AT. 2017. The Changing Face of HDL and the Best Way to Measure It. Clin Chem, 63, 196–210. doi: https://doi.org/10.1373/clinchem.2016.257725.

Kawashima S, Yokoyama M. 2004. Dysfunction of endothelial nitric oxide synthase and atherosclerosis. ArteriosclerThrombVascBiol, 24(6), 998-1005.doi: 10.1161/01.ATV.0000125114.88079.96.

Lipsy RJ. 2003. The National Cholesterol Education Program Adult Treatment Panel III guidelines. J Manag Care Pharm, 9(1), 2-5. doi: 10.18553/jmcp.2003.9.s1.2

Lopez AD, Adair T. 2019. Is the long-term decline in cardiovascular-disease mortality in high-income countries over? Evidence from national vital statistics. Int J Epidemiol, 48, 1815–23.doi: 10.1093/ije/dyz143

Lumu W, Bahendeka S, Wesonga R, Kibirige D, Kasoma RM, Ssendikwanawa E. 2023. Atherogenic index of plasma and its cardiovascular risk factor correlates among patients with type 2 diabetes in Uganda. Afr Health Sci, 23(1), 515-27.doi: 10.4314/ahs.v23i1.54.

Martinez-Quinones P, McCarthy CG, Watts SW, Klee NS, Komic A, Calmasini FB, et al. 2018. Hypertension Induced Morphological and Physiological Changes in Cells of the Arterial Wall. Am J Hypertens, 31(10), 1067-1078. doi: 10.1093/ajh/hpy083.

Mudhaffar SK. 2013. Atherogenic Index of Plasma (AIP) As a Parameter in Predicting Cardiovascular Risk in Males Compared To the Conventional Dyslipidemic Indices (Cholesterol Ratios). Karbala J Med, 6(1), 1506–13.

Namitha D, Nusrath A, Asha Rani N, Dhananjaya SY, Lokanathan TH, Kruthi BN, et al. 2022. Role of Lipid Indices in the Assessment of Microvascular Risk in Type 2 Diabetic Retinopathy Patients. Cureus, 14(3), e23395. doi: 10.7759/cureus.23395

Nasri H, Behradmanesh S, Ahmadi A, Baradaran A, Nasri P, Rafieian-Kopaei M. 2014. Association of serum lipids with level of blood pressure in type 2 diabetic patients. J Renal InjPrev, 3(2), 43–6.doi: 10.12861/jrip.2014.15

Ni J, Ma KL, Wang CX, Liu J, Zhang Y, Lv LL, et al. 2013. Activation of renin-angiotensin system is involved in dyslipidemia-mediated renal injuries in apolipoprotein E knockout mice and HK-2 cells. Lipids Health Dis, 12, 49. doi: 10.1186/1476-511X-12-49.

Niroumand S, Khajedaluee M, Khadem-Rezaiyan M, Abrishmani M, Juya M, Khodaee G, et al. 2015. Atherogenic Index of Plasma (AIP): A marker of cardiovascular disease. Med J Islam Repub Iran, 29, 240.

Omidi F, Nasiri MJ, Sadeghi S. 2024. Impact of hypertension and lipid profile on cardiac function in an Iranian teaching hospital: A cross-sectional analysis. Global Cardiology Science and Practice, 2024, 29. doi: https://doi.org/10.21542/gcsp.2024.29

Palmisano BT, Zhu L, Eckel RH, Stafford JM. 2018. Sex differences in lipid and lipoprotein metabolism. Mol Metab, 15, 45-55. doi: 10.1016/j.molmet.2018.05.008.

Parinita K. 2012. Study of serum lipid profile in individuals residing in and around Nalgonda. Int J Pharm Bio Sci, 2, 110–16.

Pirillo A, Casula M, Olmastroni E, Norata GD, Catapano AL. 2021. Global epidemiology of dyslipidaemias. Nat Rev Cardiol, 18(10), 689–700.doi: 10.1038/s41569-021-00541-4.

Sabbatini AR, Kararigas G. 2020. Estrogen-related mechanisms in sex differences of hypertension and target organ damage. Biol Sex Differ, 11(1), 31. doi: 10.1186/s13293-020-00306-7.

Sánchez-Íñigo L, Navarro-González D, Pastrana-Delgado J, Fernández-Montero A, Martínez JA. 2016. Association of triglycerides and new lipid markers with the incidence of hypertension in a Spanish cohort. J Hypertens, 34(7), 1257–65.doi: 10.1097/HJH.0000000000000941.

Tan M, Zhang Y, Jin L, Wang Y, Cui W, Nasifu L, et al. 2023. Association between atherogenic index of plasma and prehypertension or hypertension among normoglycemia subjects in a Japan population: a cross-sectional study. Lipids Health Dis, 22(1), 87. doi: https://doi.org/10.1186/s12944-023-01853-9.

Tseng YW, Jiang JF, Er TK. 2023. Evaluation of Friedewald's Formula for Plasma LDL-Cholesterol Estimation. Clin Lab, 69(4).doi: 10.7754/Clin.Lab.2022.220801

Tsuruta M, Hashimoto R, Adachi H, Imaizumi T, Nomura G. 1996. Hyperinsulinaemia as a predictor of hypertension: An 11-year follow-up study in Japan. J Hypertens, 14(4), 483–8.

Wang X, Magkos F, Mittendorfer B. 2011. Sex differences in lipid and lipoprotein metabolism: it's not just about sex hormones. J Clin Endocrinol Metab, 96(4), 885-93. doi: 10.1210/jc.2010-2061.

Wu H, Yu Z, Huang Q. 2022. Characteristics of serum lipid levels in patients with hypertension: a hospital-based retrospective descriptive study. BMJ Open, 12(6), e054682. doi: 10.1136/bmjopen-2021-054682.

Wu Z, Zhou D, Liu Y, Li Z, Wang J, Han Z, et al. 2021. Association of TyG index and TG/HDL-C ratio with arterial stiffness progression in a non-normotensive population. Cardiovasc Diabetol, 20(1), 134.doi: 10.1186/s12933-021-01330-6.

Xie H, Zhuang Q, Mu J, Sun J, Wei P, Zhao X, et al. 2022. The relationship between lipid risk score and new-onset

hypertension in a prospective cohort study. Front Endocrinol (Lausanne), 13, 916951.doi: 10.3389/fendo.2022.916951

Zaciragic A, Dervisevic A, Valjevac A, Fajkic A, Spahic S, Hasanbegovic I, et al. 2022. Difference in the Standard and Novel Lipid Profile Parameters Between Patients With Alzheimer's Disease and Vascular Dementia Stratified by the Degree of Cognitive Impairment. Mater Sociomed, 34(2), 100-06.doi: 10.5455/msm.2022.34.100-106.

Zanoni P, Velagapudi S, Yalcinkaya M, Rohrer L, von Eckardstein A. 2018. Endocytosis of lipoproteins. Atherosclerosis, 275, 273-95.doi: 10.1016/j.atherosclerosis.2018.06.881.

Novi aterogeni indeksi i rizik kardiovaskularnih komplikacija kod pacijenata sa hipertenzijom

SAŽETAK

Cilj istraživanja je evaluacija parametara lipidnog panela kod pacijenata s *hipertenzijom* (HTA) te usporedba između spolova, kao i *kardiovaskularnog* rizika (CVD) na osnovu vrijednosti aterogenog indeksa plazme (AIP). Ovo istraživanje ima za cilj naglasiti značaj koji lipidni profil krvi ima kod kardiovaskularnih pacijenata s hipertenzijom. U ovu retrospektivnu studiju je uključeno ukupno 136 odraslih pacijenata s HTA (85 žena/51 muškarac: ≤ 55 godina (muškarci:13, žene:19); 56 - 70 godina (muškarci: 23, žene:47); > 70 godina (muškarci:15, žene:19). Pacijenti su prema CVD riziku procijenjenom na osnovu vrijednosti AIP (Tabela 2) podijeljeni u dvije grupe: HTA pacijenti s niskim/umjerenim CVD rizikom - AIP ≤ 0.21 (n=51) i HTA pacijenti s visokim CVD rizikom - AIP >0.21 (n=85). Trigliceridi (TG), lipoprotein niske gustoće s holesterolom (LDL-C), lipoprotein visoke gustoće s holesterolom (HDL-C), lipoprotein ne-visoke gustoće s holesterolom (nHDL-C), ukupni holesterol (TC), aterogeni koeficijent (AC), omjer TG/HDL-C, omjer LDL-C/HDL-C i omjer TC/HDL-C su korišteni za usporedbu između grupa. Rutinski lipidni parametri su analizirani standardnim biohemijskim metodama. Za izračunavanje ukupnih lipidnih indeksa su korištene referentne formule. Pacijenti sa HTA i visokim CVD rizikom su imali znatno više koncentracije TC (p=0.02), omjer TG/HDL-C, TG, AIP, omjer LDL-C/HDL-C, nHDL-holesterol, omjer TC/HDL-C i aterogeni koeficijent, a znatno nižu koncentraciju HDL-C u odnosu na HTA pacijente s niskim/umjerenim KV rizikom (p<0.001). Naši rezultati naglašavaju značaj razmatranja različitih parametara lipidnog profila kod stratifikacije rizika kod pacijenata s HTA.

Ključne riječi: Aterogena dislipidemija, hipertenzija, kardiovaskularni rizik