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INTERRELATIONSHIPS BETWEEN RENIN–ANGIOTENSIN–ALDOSTERONE SYSTEM INDICATORS AND ENDOTHELIAL DYSFUNCTION MARKERS IN PATIENTS WITH HYPERTENSION AND PAROXYSMAL ATRIAL FIBRILLATION

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Introduction. Hypertension and paroxysmal atrial fibrillation are among the most prevalent cardiovascular conditions, with their incidence steadily increasing with age. The comorbidity of these two diseases is commonly observed in clinical practice, suggesting the presence of shared pathophysiological mechanisms and interconnected risk factors. Understanding these interrelations is important for improving diagnostic and therapeutic strategies. Objectives: To investigate potential associations between indicators of the renin–angiotensin–aldosterone system (RAAS) and markers of endothelial dysfunction in patients diagnosed with hypertension in combination with paroxysmal atrial fibrillation. Materials and Methods. This study is based on a comprehensive examination and dynamic observation of 136 patients with hypertensive disease. Among them, 100 patients had hypertension combined with paroxysmal atrial fibrillation, while 36 patients had hypertension without atrial fibrillation. Additionally, a control group of 33 clinically healthy volunteers was examined on an outpatient basis at the Regional Medical and Physical Culture Dispensary, Zaporizhzhia. All participants provided written informed consent by signing the Informed Consent Form for Participation in the Study. Results. In patients with hypertension and paroxysmal atrial fibrillation, the aldosterone level was 172.42 (142.06; 193.15) pg/ml, significantly higher than in both the hypertensive patients without atrial fibrillation and the healthy control group ($p < 0.05$). The level of NO_2 (nitrite) was found to be lowest in the group with combined hypertension and atrial fibrillation, measured at 6.14 (5.62; 6.66) μmol/l. This represents a 9.31% reduction compared to hypertensive patients without atrial fibrillation and a 22.47% reduction compared to the control group ($p < 0.05$). These findings confirm a significant inverse correlation between aldosterone and NO_2 levels ($R = -0.26$, $p = 0.01$). Additional statistically significant correlations were also identified between other components of the RAAS and nitric oxide metabolites. Conclusion. A significant inverse relationship was observed between RAAS activity and nitric oxide metabolites in patients with hypertension combined with paroxysmal atrial fibrillation. This may play a crucial role in the pathogenesis, progression, and recurrence of atrial fibrillation, highlighting the importance of endothelial function and RAAS modulation in disease management.

Key words: hypertension, atrial fibrillation, renin-angiotensin-aldosterone system, nitric oxide metabolites, correlation.

This research is a part of the research project "Peculiarities of diagnosis and treatment for resistant arterial hypertension in the practice of a family doctor" (state registration number 0118U004282) of the Department of General Practice – Family Medicine and Psychiatry, State Institution "Zaporizhzhia Medical Academy of Postgraduate Education of the Ministry of Health of Ukraine". Within the framework of this topic, the authors determined the interrelationships between indicators of the renin-angiotensin-aldosterone system and markers of endothelial dysfunction among patients with hypertensive disease combined with paroxysmal atrial fibrillation.

Introduction

Hypertension (HT) and paroxysmal atrial fibrillation (AF) are serious cardiovascular diseases whose prevalence constantly increases with patient age. The combination of hypertensive disease and paroxysmal AF is frequently observed, indicating potential common pathophysiological mechanisms and interrelated risk factors. Increased blood pressure in patients with hypertensive disease is usually combined with endothelial dysfunction, where the imbalance between vasodilating and vasoconstricting systems worsens the course of arterial hypertension. Furthermore, increased activity of free radical oxidation processes contributes to the progression of HT, and excessive concentration of peroxides accelerates the breakdown of NO, reducing its concentration in the blood, which ultimately reduces the vasodilating properties of the vascular endothelium. According to modern pathophysiological theories, the vascular endothelium is an active dynamic structure involved in the formation of vasoactive substances and controls the release of disaggregants and fibrinolysis [1, 2].

Anticoagulant therapy plays a crucial role in preventing thromboembolic events, especially stroke, in patients with AF, regardless of its form. The choice of anticoagulant should be individualized, considering the risk of stroke and bleeding, comorbidities, genetic characteristics of the patient, and their lifestyle. The high prevalence and significant risks associated with AF underscore the importance of using effective anticoagulation strategies [3, 4].

In AF, complex thromboembolic mechanisms are activated, involving the interaction of risk factors associated with endothelial dysfunction. Recognized markers of endothelial dysfunction include endothelin-1 (ET-1) and nitric oxides (NO_2 and NO_3). Under physiological conditions, nitric oxide (NO) acts as an antagonist to endothelin, a vasodilator, and also inhibits platelet aggregation and the secretion of adhesion molecules, provides antiproliferative, anti-apoptotic, and antithrombotic effects, and suppresses the formation of complexes of oxidized cholesterol with low-density lipoproteins. However, excessive production of nitric oxide poses a threat of forming toxic substances such as per-

oxynitrite and hydroxyl radical, which cause a decrease in the energy potential of cells and their death [5, 6].

The renin-angiotensin-aldosterone system (RAAS) is one of the key neurohumoral mechanisms in the development and progression of cardiovascular diseases and one of the most important regulatory systems in the human body. Its main tasks are maintaining water-salt homeostasis, controlling blood pressure levels, and being responsible for the body's adaptive responses, including correcting central hemodynamics indicators during acute disturbances. Although these manifestations of RAAS activity were initially regarded as temporary functional changes, it has become increasingly evident that chronic RAAS activation leads to significant structural alterations in all components of the cardiovascular system [7, 8, 9].

Angiotensin II (AT II) is a stable, biologically active octapeptide with a potent vasoconstrictive effect. RAAS activation and subsequent renin secretion are regulated by several key mechanisms: renal arterial pressure, sympathetic nervous system activity, sodium balance, and a negative feedback loop involving AT II, which suppresses nitric oxide (NO) production.

The pro-fibrillatory effects of aldosterone are linked to fibrosis, hypertrophy, inflammation, and remodeling of the extracellular matrix within atrial cardiomyocytes. Aldosterone also contributes to electrophysiological alterations in cardiomyocytes, creating a substrate that sustains atrial fibrillation (AF). A growing body of evidence supports the role of RAAS in the pathogenesis of AF, indicating that its contribution extends beyond being a marker of comorbid conditions. Rather, RAAS appears to be directly involved in the initiation and progression of the arrhythmia. This understanding underpins the rationale for investigating the interrelationships between RAAS indicators and markers of endothelial dysfunction, in order to elucidate potential mechanistic links in patients with hypertension and paroxysmal AF [10, 11, 12].

Objective

The aim of this study is to determine the interrelationships between indicators of the renin-angiotensin-aldosterone system and markers of endothelial dysfunction in patients with hypertensive disease and paroxysmal atrial fibrillation.

Participants and Methods

A prospective, open-label comparative study was conducted at the Municipal Non-Enterprise City Hospital No. 10, Zaporizhzhia. Patient recruitment was carried out from 2018 to November 2019. The study included a comprehensive examination and dynamic follow-up of 136 patients with hypertensive disease (HT), among whom 100 patients had HT in combination with paroxysmal atrial fibrillation (AF), and 36 patients had HT without AF.

A control group of 33 clinically healthy volunteers was examined on an outpatient basis at the Municipal Institution "Regional Medical and Physical Culture Dispensary", Zaporizhzhia.

All participants provided written informed consent by signing the Informed Consent Form for Participation in the Study.

Inclusion criteria were as follows: male and female patients aged 46 to 65 years; recurrent paroxysmal atrial fibrillation; verified stage II hypertensive disease; disease duration >1 year and patient consent for observation.

Exclusion criteria were as follows: atrioventricular block II-III degree; ventricular arrhythmias; circulatory failure greater than NYHA class II; oncological diseases; thyroid dysfunction; diabetes mellitus; hemodynamically significant heart defects; drug addiction; alcohol dependence; presence of mental disorders and patient refusal of observation during the follow-up period.

All patients underwent physical examination and standard clinical laboratory and instrumental diagnostics: complete blood count, urinalysis, 12-lead ECG. Biochemical blood tests included glucose, total protein, creatinine, total bilirubin, alanine and aspartate transaminases, and lipid levels. Diagnosis HT was verified according to the 2018 ESH/ESC guidelines. Paroxysmal AF diagnosis was established according to the 2020 ESC guidelines [13, 14].

AF presence was determined by ECG changes during examination. Patients were divided into groups based on inclusion/exclusion criteria and the presence of comorbid AF:

Group 1 included 100 patients with HD combined with AF (median age 60.00 [54.00; 63.00] years);

Group 2 included 36 patients with HD without AF (median age 57.00 [54.00; 61.00] years);

Group 3 comprised 33 practically healthy volunteers (median age 56.00 [55.00; 59.00] years).

All 169 examined individuals were comparable in terms of age, social status, and sex. The number of patients with hypertensive disease combined with paroxysmal AF was 100 individuals: 49 men and 51 women. The mean body mass index (BMI) in the group of patients with hypertension (HT) and paroxysmal atrial fibrillation (AF) was 28.41 ± 0.33 kg/m². The mean duration of hypertension in this group was 7.86 ± 0.54 years, and the mean duration of AF was 4.06 ± 0.40 years. The group of patients with hypertension without AF consisted of 36 individuals (16 men and 20 women), with a mean BMI of 26.92 ± 0.50 kg/m² and a mean hypertension duration of 10.30 ± 1.05 years. The control group included 33 clinically healthy individuals (16 men and 17 women); the mean BMI in this group was 23.12 ± 0.23 kg/m².

Plasma levels of angiotensin-II and aldosterone were determined using the enzyme-linked immunosorbent assay (ELISA) method with the commercial Human Ang-II (Angiotensin II) ELISA Kit (Elabscience, USA) and the ALDOSTERONE

ELISA kit (Diagnostics Biochem Canada Inc., Canada), according to the manufacturers' instructions. Plasma concentrations of angiotensin-II and aldosterone were expressed in pg/mL.

Stable end metabolites of nitric oxide in blood were determined using a method based on the reduction of nitrate to nitrite, followed by the determination of nitrite using the Griess reaction. Nitrite concentrations were calculated using a calibration curve constructed with sodium nitrite standards. The study yielded three results: nitrite ion (NO_2) concentration (μmol/l), nitrate ion (NO_3) concentration (μmol/l), and the total concentration of nitrite and nitrate ions ($NO_2 + NO_3$) (μmol/l).

Statistical analysis of the obtained data was performed using a personal computer with the PSPP software package (version 1.2.0, GNU Project, 1998-2018, GNU GPL license). The distribution of each studied parameter was analyzed, and the data were presented as median (Me) and interquartile range (Q25;Q75). The relationship between variables was assessed using correlation analysis; depending on the data distribution, Pearson's (r) or Spearman's (R) correlation coefficient was evaluated.

Results

Patients with HT combined with AF reported palpitations, heart rhythm interruptions, and shortness of breath more frequently than patients with HT without AF ($p < 0.05$). Patients with HT without AF reported headaches more frequently ($p < 0.05$).

In accordance with the aims and objectives of this study, plasma levels of aldosterone and angiotensin II were first analyzed in all patients who provided informed consent to participate in the research. A comparison was then made based on the presence of Atrial Fibrillation in the examined patients. The results are presented in Table 1.

Table 1.
Plasma levels of aldosterone and angiotensin II in the examined individuals (Me (Q25;Q75), n = 169)

Variable	Group of participants		
	HT combined with AF (n=100)	HT without AF (n=36)	Healthy individuals (n=33)
Aldosterone, pg/mL	172,42 (142,06; 193,15)	171,41 (129,53; 194,35)	124,95 (115,99; 134,23)
P-value	$p_{1-2} = 0,99$	$p_{2-3} < 0,001$	$p_{1-3} < 0,001$
Angiotensin II, pg/mL	532,56 (438,76; 673,87)	495,90 (393,22; 579,81)	312,58 (274,65; 335,46)
P-value	$p_{1-2} = 0,25$	$p_{2-3} < 0,001$	$p_{1-3} < 0,001$

Table 2.
Nitric oxide metabolite levels in the blood plasma of the examined individuals (Me (25; 75), n = 169)

Variables	Group of participants		
	HT combined with AF (n=100)	HT without AF (n=36)	Healthy individuals (n=33)
NO_2, μmol/l	6,14 (5,62; 6,66)	6,77 (6,34; 7,12)	7,92 (7,25; 8,26)
P-value	$p_{1-2} = 0,01$	$p_{2-3}<0,001$	$p_{1-3}<0,001$
NO_3, μmol/l	11,10 (10,28; 11,76)	11,30 (10,10; 12,33)	14,24 (13,08; 15,04)
P-value	$p_{1-2} = 0,97$	$p_{2-3}<0,001$	$p_{1-3}<0,001$
NO_2+NO_3, μmol/l	17,24 (15,96; 18,11)	18,10 (16,63; 19,19)	21,58 (20,88; 22,79)
P-value	$p_{1-2} = 0,21$	$p_{2-3}<0,001$	$p_{1-3}<0,001$

The aldosterone level in patients with hypertension combined with atrial fibrillation was 172.42 (142.06; 193.15) pg/mL and was significantly higher compared to both 171.41 (129.53; 194.35) pg/mL in the group HT without AF ($p<0.05$) and compared to healthy individuals, where it was 124.95 (115.99; 134.23) pg/mL ($p<0.05$). There was no significant difference in this indicator between the groups HT with and without AF ($p>0.05$).

No significant differences were found in such a RAAS parameter as angiotensin II between the groups HT, whereas, in comparison with the healthy control group, where this indicator was 312.58 (274.65; 335.46) pg/mL, it was significantly higher in the group HT combined with AF by 1.7 times, and in the group HT without AF by 1.58 times ($p<0.05$). At the same time, there were no differences in this indicator between the patient groups with HT ($p>0.05$).

The next stage of this study was the determination of nitric oxide metabolite levels in the blood plasma of the examined individuals. The distribution of values depending on the study groups is presented in Table 2.

The NO_2 level was lowest in the group of patients with hypertension combined with AF, at 6.14 (5.62; 6.66) μmol/L, and was significantly lower by 9.31% compared to the group HT without AF - 6.77 (6.34; 7.12) μmol/L, as well as by 22.47% compared to the value of 7.92 (7.25; 8.26) μmol/L in practically healthy individuals ($p<0.05$). The NO_2 level was also 14.52% lower in the group HT without AF, 6.77 (6.34; 7.12) μmol/L, compared to 7.92 (7.25; 8.26) μmol/L in practically healthy individuals ($p<0.05$).

There were no significant differences in NO_3 values between the group HT combined with AF, 11.10 (10.28; 11.76) μmol/L, and the group HT without AF - 11.30 (10.10; 12.33) μmol/L ($p>0.05$).

The NO_3 level in practically healthy individuals was 14.24 (13.08; 15.04) μmol/L, which was highly significantly higher by 22.05% and 20.65% compared to the group HT combined with AF and the group HT without AF, respectively ($p<0.05$).

The median of the NO_2+NO_3 metabolites in the group HT combined with AF was 17.24 (15.96; 18.11) μmol/L and did not show a significant difference compared to the median of this indicator in the group HT without AF - 18.10 (16.63; 19.19) μmol/L ($p>0.05$). In comparison with the practically healthy group, where this indicator was 21.58 (20.88; 22.79) μmol/L, patients with both groups HT with and without AF showed a significant decrease of 20.11% and 16.13%, respectively ($p<0.05$).

Correlations between the parameters of the renin-angiotensin-aldosterone system and endothelial dysfunction in the blood plasma of patients with hypertension combined with paroxysmal atrial fibrillation are presented in Table 3.

Table 3.
Correlations between aldosterone and angiotensin II levels and nitric oxide metabolites in the blood plasma of patients with HT combined with AF (n=100)

Variable	Aldosterone, pg/mL	Angiotensin II, pg/mL
NO_2, μmol/l	R = -0,26	r =- 0,14
P-value	p = 0,01	p = 0,18
NO_3, μmol/l	R =- 0,23	R = -0,21
P-value	p = 0,02	p = 0,04
NO_2+NO_3, μmol/l	R = - 0,24	R = - 0,16
P-value	p = 0,01	p = 0,11

As evident from the data in Table 3, the comparative evaluation of aldosterone and angiotensin II levels and nitric oxide metabolites in blood plasma using correlation analysis among patients with HT combined with AF revealed significant moderate correlations between the levels of: aldosterone and NO_2 in blood plasma ($R = -0.26$, $p=0.01$); aldosterone and NO_3 in blood plasma ($R = -0.23$, $p=0.02$); aldosterone and NO_2+NO_3 ($R = -0.24$, $p=0.01$); and angiotensin II and NO_3 in patients with HT combined with AF ($R = -0.21$, $p=0.04$). Correlation analysis between angiotensin II levels and such indicators as NO_2 and NO_2+NO_3 in patients with HT combined with AF did not show significant associations ($p>0.05$).

Discussion

Dysregulation of the RAAS is involved in the pathogenesis of hypertension and other cardiovascular disorders, acting as a central regulator of the cardiovascular system, and this may be a key link in the comorbidity of paroxysmal AF. If the RAAS is excessively activated in HT, it also promotes atrial remodeling, leading to AF; thus, this system may be a common pathway through which one condition influences the other [15].

Overall, our data are consistent with the results of other researchers. Hypertension and atrial fibrillation frequently coexist, and both conditions are independently associated with endothelial dysfunction. Hypertension exacerbates endothelial dysfunction in patients with atrial fibrillation. RAAS activation, characteristic of hypertension, can contribute to endothelial dysfunction through increased oxidative stress and reduced NO bioavailability. Angiotensin II stimulates the production of ET-1, further promoting vasoconstriction and endothelial dysfunction. In patients with HTN and paroxysmal AF, the RAAS is likely a central link that not only contributes to elevated blood pressure but also enhances endothelial dysfunction, potentially creating a vicious cycle that promotes arrhythmia recurrence. Historically, the role of endothelial dysfunction in the development of AF was considered to be due to an indirect effect on atrial thromboembolism; however, evidence has supported the assertion that endothelial dysfunction contributes to and maintains the atrial arrhythmogenic effect and provokes the development of adverse events associated with AF. Data obtained in the study by T. Komatsu et al. confirm the association between endothelial dysfunction and the progression and frequency of recurrence of atrial fibrillation episodes [16, 17].

Thus, considering the individual roles of RAAS and endothelial dysfunction in HT and AF, studying their interaction in patients with both conditions is crucial for a comprehensive understanding of the underlying pathophysiology. Understanding this relationship may further identify potential therapeutic targets for the management of these patients.

Conclusions

Comparable elevations in RAAS indicators were observed in patients with hypertension both with and without paroxysmal atrial fibrillation. The level of NO_2 was significantly lower in patients with HT and AF compared to those with HT without arrhythmia. A significant inverse correlation was identified between RAAS indicators and nitric oxide metabolites in patients with hypertension and paroxysmal AF.

Prospects for further research

The comorbidity of hypertension and paroxysmal AF worsens endothelial dysfunction, potentially creating a vicious cycle. This could be a negative factor regarding AF recurrence. Understanding the complex relationship between RAAS and endothelial dysfunction in these patients is crucial for developing effective treatment strategies. Combined therapies aimed at improving endothelial function, such as including statins, may be beneficial. Further research is required to assess the direct impact of treatment on RAAS

indicators and endothelial dysfunction markers in patients with HT combined with paroxysmal AF. Future evaluation of the identified relationships after treatment with ACE inhibitors is required. Further research will aim to determine the significance of RAAS and endothelial dysfunction indicators as predictors of AF recurrence.

Personal contribution of the author

Lytvynenko V.V.: a) concept and design; b) data collection and analysis; c) analysis and interpretation of the results; d) writing the article; e) editing the manuscript.

Sid' E.V.: a) concept and design; e) editing the manuscript; f) final approval of the manuscript.

Conflicts of interest

Authors have no conflict of interest to declare

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Реферат

ВЗАЄМОЗВ'ЯЗКИ ПОКАЗНИКІВ РЕНІН-АНГІОТЕНЗИН-АЛЬДОСТЕРОНОВОЇ СИСТЕМИ З МАРКЕРАМИ ЕНДОТЕЛІАЛЬНОЇ ДИСФУНКЦІЇ У ХВОРИХ НА ГІПЕРТОНІЧНУ ХВОРОБУ В ПОЄДНАННІ З ПАРОКСИЗМАЛЬНОЮ ФІБРИЛЯЦІЄЮ ПЕРЕДСЕРДЬ

Литвиненко В.В., Сідь Є.В.

Ключові слова: гіпертонічна хвороба, фібриляція передсердь, ренін-ангіотензин-альдостеронова система, метаболіти оксиду азоту, кореляція.

Вступ. Гіпертонія та пароксизмальна фібриляція передсердь є значними серцево-судинними захворюваннями, поширеність яких постійно зростає з віком пацієнтів. Поєднання гіпертонічної хвороби та пароксизмальної фібриляції передсердь часто спостерігається, що вказує на потенційні спільні патофізіологічні механізми та взаємопов'язані фактори ризику.

Резюме. Метою роботи було визначення можливих взаємозв'язків між показниками ренін-ангіотензин-альдостеронової системи з маркерами ендотеліальної дисфункції у хворих на гіпертонічну хворобу в поєднанні з пароксизмальною фібриляцією передсердь.

Об'єкт та методи. Результати дослідження ґрунтуються на комплексному обстеженні та динамічному спостереженні за 136 пацієнтами з гіпертонічною хворобою, зокрема 100 пацієнтами з гіпертонічною хворобою у поєднанні з пароксизмальною формою фібриляції передсердь та 36 пацієнтами з гіпертонічною хворобою без фібриляції передсердь. Також амбулаторно було обстежено 33 практично здорових добровольці у КНП «Обласний диспансер спортивної медицини» Запорізької обласної ради. Пацієнти підписали «Інформовану згоду на участь у дослідженні».

Результати. На даний час гіпертонічна хвороба залишається одним з основних модифікуючих факторів розвитку серцево-судинних захворювань, в тому числі й фібриляції передсердь. Не зважаючи на сучасний підхід до лікування з урахуванням рівня доказовості фібриляція передсердь залишається однією з найбільш актуальних проблем сучасної аритмології, що обумовлено збільшенням розповсюдження цього порушення ритму з віком пацієнтів, необхідністю частих госпіталізацій та постійно-

го амбулаторного спостереження.

Рівень альдостерону у хворих на гіпертонічну хворобу в поєднанні з фібриляцією передсердь склав 172,42 (142,06; 193,15) пг/мл і був достовірно вищим проти рівня у групі хворих на гіпертонічну хворобу без фібриляції передсердь та проти групи здорових осіб. Рівень NO_2 мав найнижче значення в групі хворих на ГХ в поєднанні з ФП 6,14 (5,62; 6,66) мкмоль/л і достовірно був нижче на 9,31 % у порівнянні з групою хворих на гіпертоніну хворобу без фібриляції передсердь та на 22,47 % у порівнянні із значенням у практично здорових осіб, ($p < 0,05$), що підтверджує наявність зворотного зв'язку між цими показниками ($R = -0,26$, $p = 0,01$). Також нами були виявлені й інші достовірні взаємозв'язки між показниками ренін-ангіотензин-альдостеронової системи та метаболітами оксиду азоту.

Висновок. Виявлено достовірний зворотній зв'язок між показниками ренін-ангіотензин-альдостеронової системи та метаболітами оксиду азоту у хворих на гіпертонічну хворобу в поєднанні з фібриляцією передсердь, що може мати значення для прогресування та рецидивування фібриляції передсердь.

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ESTIMATED HBA1C AND FASTING GLUCOSE INDICES FOR DIABETES AND PREDIABETES SCREENING QUESTIONNAIRE EVALUATION

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Objective. The aim of this study is to develop new indicators, estimated HbA1c and fasting glucose index, for early detection of diabetes mellitus and prediabetes using questions from various questionnaires based on anamnestic and anthropometric data. Methods and participants. A total of 182 individuals aged 20–79 years (46 men and 136 women) participated in the study. All participants underwent diabetes screening questionnaires, anthropometric measurements, and blood pressure assessments. HbA1c levels were measured using the SDA1c Care analyzer (SD Biosensor, Korea). Fasting and post-load venous plasma glucose levels were determined using the Precision PCx MediSense analyzer (Abbott, USA). A 75 g oral glucose tolerance test (OGTT) was performed for all participants. The following variables were used to calculate the ScrHbA1c and ScrFG indices through multiple linear regression analysis: anamnesis score, age, waist circumference, systolic, and diastolic blood pressure. Chi-square tests were used to compare categorical variables. Diagnostic performance of the ScrHbA1c and ScrFG indices was evaluated using standard measures: sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), overall diagnostic accuracy, and the Youden Index to determine optimal cut-off points. Results. A statistically significant correlation was observed between measured fasting glucose levels and the ScrFG index in both groups: training group: $r = 0.52$, $p < 0.001$, and control group: $r = 0.41$, $p < 0.001$. Similarly, a strong and statistically significant correlation was found between measured HbA1c and the ScrHbA1c index: training group ($n = 91$): $r = 0.5462$, $p < 0.001$, and control group ($n = 91$): $r = 0.51$, $p < 0.001$. Both ScrHbA1c and ScrFG index values were significantly higher in individuals with impaired glucose metabolism (diabetes + prediabetes) than in those with normal glucose metabolism, in both the training and control groups ($p < 0.001$ for both comparisons). No significant differences in ScrHbA1c or ScrFG values were observed between the training and control groups within subgroups of normal or impaired glucose metabolism ($p > 0.05$). Conclusion. The values of the newly proposed indicators, ScrHbA1c and ScrFG, showed significant correlation with measured HbA1c and fasting glucose levels. Using a cut-off point of 125 mg/dL for ScrFG enabled the identification of 100% of diabetes cases, 67.4% of prediabetes cases, and 83% of individuals with normal carbohydrate metabolism. Similarly, applying a cut-off point of 44 mmol/mol for ScrHbA1c allowed for the detection of 100% of diabetes cases, 69.6% of prediabetes cases, while also recommending further examination for 20% of individuals without carbohydrate metabolism disorders. These newly developed indicators ScrHbA1c and ScrFG are intended to facilitate the preliminary selection of individuals who should undergo screening for diabetes and prediabetes.

Key words: estimated value for screening HbA1c and fasting glucose indexes, prediabetes, diabetes mellitus, questionnaires, screening

Introduction

Type 2 diabetes mellitus (DM) is the most prevalent chronic disease worldwide. Numerous cost-effective screening questionnaires are available for the early identification of DM. The diagnostic value of the symptoms included in these questionnaires allows for the timely detection of both type 2 DM diabetes and prediabetes (PD). The aim of this study is to develop novel indicators, namely, estimated HbA1c and a fasting glucose index, for the early detection of diabetes and prediabetes, using data derived from anamnestic and anthropometric parameters incorporated into commonly used screening questionnaires.

The rapid rise in the global prevalence of