Comparative evaluation of the influence of diabetic retinopathy progression factors on indices of lipid metabolism in metabolic syndrome

**Abstract.** Background. The search and study of new risk factors for the development and progression of diabetic retinopathy (DRP) and their modifying influence on the components of metabolic syndrome in type 2 diabetes mellitus (T2DM) remain relevant. The purpose was to conduct a comparative evaluation of the impact of certain DRP development factors on indices of lipid metabolism in metabolic syndrome. **Materials and methods.** The research was carried out in 64 patients (95 eyes) with T2DM, metabolic syndrome and DRP (males and females, average age 61.55 ± 2.37 years, average duration of diabetes 11.23 ± 2.11 years, average level of HbA1c 9.89 ± 0.78 %, average body mass index 34.55 ± 3.75 kg/m²), who were divided into 3 groups depending on the stage of DRP. **Results.** Results had showed that the following factors have modifying influence on the level of total cholesterol in the blood of patients with T2DM and DRP: age of patients (under 60 years), duration of diabetes (less than 10 years), decompensation of carbohydrates metabolism — for the 3rd stage of DRP, features of therapy for T2DM (oral hypoglycemic drugs) — for the 2nd stage of DRP; on the level of low-density lipoprotein cholesterol: younger age of patients, decompensation of diabetes — for the 3rd stage of DRP, features of hypoglycemic therapy (insulin therapy), shorter duration of diabetes — for the 2nd stage of DRP; on the level of triglycerides: age of patients (under 60 years), duration of diabetes (less than 10 years) and insulin therapy — for the 1st and 3rd stages of DRP. **Conclusions.** It is concluded that features of hypoglycemic therapy can be a new modifying factor for the risk of DRP progression. **Keywords:** diabetic retinopathy; metabolic syndrome

**Introduction.** Clinical and epidemiological studies which were carried out in Ukraine and abroad demonstrated the influence of hyperglycemia, arterial hypertension (AH) and dyslipidemia and to a lesser degree a high body mass index as well as a low level of physical activity and insulin-resistance on frequency of occurrence and development of diabetic retinopathy (DRP) [1, 14, 15]. However the level of glycated hemoglobin (HbA1c) is the most essential risk factor for development and progression of DRP, it represents only 11 % of risk for retinopathy [6]. Similar to HbA1c, AH and level of general cholesterol in blood serum together make up from 9 to 10 % of risk for development of DRP [8]. Thus prophylaxis of complication of diabetes mellitus (DM) should include further examination of other modifying or non-modifying risk factors. Contemporary references also testify to the importance of other factors including obstructive sleep apnea, non-alcoholic fatty liver disease, level of prolactin, homocysteine and hormones of adipose tissue of blood serum [1, 2, 9–12, 16, 17], genetic factors and endothelial dysfunction in development of DRP [5, 13]. Considering the fact that the relative contribution of different factors to the risk of developing retinopathy remains uncertain, the search and study for new risk factors of development and progression of DRP and their modifying influence on components of the metabolic syndrome (MS) at T2DM remain actual. **Purpose.** To conduct a comparative evaluation of influence of certain DRP development factors on indices of lipid metabolism at MS.
Materials and methods

The research was carried out on 64 patients (95 eyes) with T2DM, metabolic syndrome and DRP (males and females, average age 61.55 ± 2.37 years old, average duration of diabetes 11.23 ± 2.11 years, average level of HbA1c 9.89 ± 0.78 %, average BMI 34.55 ± 3.75 kg/m²), who were divided into 3 groups depending on the stage of DRP. The research was conducted according to World Medical Association Declaration of Helsinki (2008) and literary recommendations for inclusion criteria into the research of patients with obesity and T2DM [18]. MS, parameters of T2DM and dyslipidemia were estimated according to the criteria accepted by the WHO experts from National Health Institute of the USA (Adult Treatment Panel III, ATP III, 2001), recommendations of International Diabetes Federation (IDF), American Diabetes Association (ADA) (2013, 2015), European Society of Cardiology (ESC), European Atherosclerosis Society (EAS), Ukrainian Association of Cardiology (2011).

HbA1c was estimated by the analyzer D-10 (Bio-Rad, France/USA) by liquid ion exchange chromatography with high pressure using sets made by Bio-Rad (France/USA), triglycerides (TG), total cholesterol and its fractions — by the automatic biochemical analyzer Olympus AU400 (Beckman Coulter (USA)) using the method of spectrum photometry with reagents Olympus AU400. All patients underwent complex ophthalmological examination: autorefractometry, visometry, tonometry, perimetry, biomicroscopy, fundus photography and fluorescein fundus angiography. Diagnosis of diabetic retinopathy was established according to Order of Ministry of Health of Ukraine as of 22 May 2009 N 356 (in the edition of Order of Ministry of Health of Ukraine as of 05 August 2009 N 574), in which it is recommended to use 3 main stages for diabetic retinopathy in ophthalmological work: non-proliferative, pre-proliferative and proliferative.

Results

Main biochemical clusters of MS in patients with T2DM depending on the stage of DRP and considering such factors as progression, age of patients, duration of T2DM, degree of compensation and applied hypoglycemic therapy have been represented in tables 1–4.

At the age below 60 years old the highest average level of total cholesterol was diagnosed in patients at the 3rd stage of DRP, at the age over 60 — at the 2nd stage of DRP. The worst level of total cholesterol in those comparison groups was observed in patients at the age below 60 at the 3rd stage of DRP (6.68 mmol/l, by CI — 7.99 mmol/l). Patients with the duration of diabetes less than 10 years and more than 10 years — the worst average level of total cholesterol was at the 3rd stage of DRP. The worst average level of total cholesterol in those comparison groups was observed in patients with the duration of diabetes less than 10 years at the 3rd stage of DRP (6.36 mmol/l, by CI — 7.51 mmol/l). Patients with subcompensation and decompensation of carbohydrates metabolism — the highest average level of total cholesterol was at the 3rd stage of DRP.

Table 1. Average statistical data of concentration of total cholesterol in blood at different stages of diabetic retinopathy depending on risk factors for progression (n, M ± m; 95% CI)

| Comparison groups                  | Diabetic retinopathy | 1st stage | 2nd stage | 3rd stage |
|------------------------------------|----------------------|-----------|-----------|-----------|
|                                    |                      | n         | M ± m     | n         | M ± m     | n         | M ± m     |
| Age of patients ≤ 60 years old     |                      | 25        | 5.68 ± 0.25 | 6         | 5.05 ± 0.75 | 5         | 6.68 ± 0.64 |
|                                    |                      |           | 5.16–6.21  |           | 3.54–6.55  |           | 5.38–7.99  |
| Age of patients > 60 years old     |                      | 17        | 5.45 ± 0.31 | 6         | 5.71 ± 0.53 | 5         | 5.33 ± 0.64 |
|                                    |                      |           | 4.82–6.08  |           | 4.65–6.78  |           | 4.03–6.64  |
| Duration of diabetes ≤ 10 years    |                      | 31        | 5.73 ± 0.22 | 5         | 6.06 ± 0.64 | 6         | 6.36 ± 0.57 |
|                                    |                      |           | 5.27–6.19  |           | 4.76–7.35  |           | 5.20–7.51  |
| Duration of diabetes over 10 years |                      | 11        | 5.19 ± 0.38 | 7         | 5.04 ± 0.57 | 4         | 5.43 ± 0.74 |
|                                    |                      |           | 4.42–5.96  |           | 3.88–6.19  |           | 3.93–6.92  |
| Subcompensation of diabetes        |                      | 14        | 5.30 ± 0.35 | 5         | 5.18 ± 0.92 | 4         | 5.50 ± 0.75 |
|                                    |                      |           | 4.59–6.00  |           | 3.31–7.04  |           | 3.97–7.02  |
| Decompensation of diabetes         |                      | 27        | 5.78 ± 0.25 | 7         | 5.58 ± 0.49 | 6         | 6.32 ± 0.58 |
|                                    |                      |           | 5.27–6.28  |           | 4.58–6.58  |           | 5.14–7.49  |
| OHGD                               |                      | 26        | 5.56 ± 0.24 | 5         | 7.11 ± 0.88 | 4         | 4.96 ± 0.72 |
|                                    |                      |           | 5.07–6.06  |           | 5.34–8.87  |           | 3.52–6.41  |
| Insulin therapy                    |                      | 16        | 5.63 ± 0.31 | 7         | 5.03 ± 0.47 | 6         | 6.64 ± 0.55 |
|                                    |                      |           | 5.01–6.26  |           | 4.08–5.97  |           | 5.52–7.75  |

Notes: here and in the tables 2–4: n — number of the studied patients, CI — confidence interval, OHGD — oral hypoglycemic drugs.
total cholesterol was observed in patients at the 3rd stage of DRP. The worst average level of total cholesterol in those comparison groups was observed in patients with HbA1c > 8% at the 3rd stage of DRP (4.07 mmol/l, and by CI — 4.95 mmol/l). In case of therapy by oral hypoglycemic drugs (OHGD) the highest average level of total cholesterol was observed in patients at the 2nd stage of DRP, in case of insulin therapy — at the 3rd stage of DRP. The worst average level of total cholesterol in the presented comparison groups was observed at the 2nd stage of DRP in patients who were prescribed OHGD (7.11 mmol/l, by CI — 8.87 mmol/l) (table 1).

At the age of over 60 years old the best average level of cholesterol HDLP was observed in patients at the 2nd stage of DRP. The worst total indicator of cholesterol HDLP among those comparison groups was revealed in patients with the duration of diabetes less than 10 years at the 2nd stage of DRP, in case of insulin therapy — at the 3rd stage of DRP. The worst average level of cholesterol HDLP in the comparison groups was determined in patients with the level of HbA1c > 8% at the 3rd stage of DRP (4.17 mmol/l, and by CI — 5.05 mmol/l). In patients with the duration of diabetes over 10 years, the highest average level of cholesterol HDLP was revealed at the 3rd stage of DRP and in patients with the duration of diabetes over 10 years — at the 1st and 3rd stages of DRP. The worst average level of cholesterol LDLp in the comparison groups was revealed in patients with the duration of diabetes less than 10 years at the 2nd stage of DRP (4.17 mmol/l, and by CI — 5.05 mmol/l). In patients with the level of HbA1c ≤ 8% the highest average level of cholesterol LDLp was determined in patients at the 1st and 2nd stages of DRP, and at HbA1c more than 8% — at the 3rd stage of DRP. The worst total index of cholesterol LDLp among the comparison groups was revealed in patients with HbA1c > 8% at the 3rd stage of DRP (4.29 mmol/l, and by CI — 5.07 mmol/l). In case of therapy by OHGD the highest average level of cholesterol LDLp was determined in patients at the 2nd stage of DRP, in case of insulin therapy — at the 3rd stage of DRP.

Table 2. Average statistical data of concentration of cholesterol of high density lipoproteins in blood at different stages of diabetic retinopathy depending on risk factors for progression (n, M ± m; 95% CI)

| Comparison groups | Diabetic retinopathy |
|-------------------|----------------------|
|                   | 1st stage | 2nd stage | 3rd stage |
| Age of patients ≤ 60 years old |          |           |           |
| 25                | 1.11 ± 0.06 | 1.46 ± 0.17 | 1.07 ± 0.14 |
| 0.99-1.23        | 1.12-1.81  | 0.77-1.37  |
| Age of patients over 60 years old |          |           |           |
| 17                | 1.10 ± 0.07 | 1.33 ± 0.12 | 1.30 ± 0.14 |
| 0.95-1.24        | 1.09-1.57  | 1.00-1.59  |
| Duration of diabetes ≤ 10 years |          |           |           |
| 30                | 1.09 ± 0.05 | 1.32 ± 0.14 | 1.06 ± 0.13 |
| 0.98-1.20        | 1.03-1.61  | 0.79-1.32  |
| Duration of diabetes over 10 years |          |           |           |
| 11                | 1.14 ± 0.08 | 1.42 ± 0.13 | 1.40 ± 0.16 |
| 0.96-1.32        | 1.15-1.68  | 1.06-1.73  |
| Subcompensation of diabetes |          |           |           |
| 14                | 1.17 ± 0.07 | 1.45 ± 0.21 | 1.33 ± 0.17 |
| 1.02-1.33        | 1.03-1.86  | 0.99-1.67  |
| Decompensation of diabetes |          |           |           |
| 26                | 1.06 ± 0.05 | 1.35 ± 0.11 | 1.10 ± 0.13 |
| 0.95-1.18        | 1.13-1.56  | 0.83-1.36  |
| OHGD              | 25         | 1.10 ± 0.05 | 1.35 ± 0.21 |
| 0.98-1.21        | 0.92-1.77  | 0.98-1.67  |
| Insulin therapy   | 16         | 1.12 ± 0.07 | 1.38 ± 0.11 |
| 0.97-1.27        | 1.16-1.61  | 0.83-1.36  |
DRP. The worst average level of cholesterol LDLP in the comparison groups was observed at the 3rd stage of DRP in patients who received insulin therapy (4.53 mmol/l, and by CI — 5.27 mmol/l) (table 3).

At the age of 60 years old the highest average level of TG was revealed in patients at the 1st stage of DRP and at the age over 60 years old — at the 1st and 2nd stages of DRP. The worst level of TG in age comparison groups was determined in patients at the age of 60 years old at the 1st stage of DRP (2.95 mmol/l, and by CI at the 3rd stage — 4.19 mmol/l). In patients with the duration of diabetes less than 10 years the highest average level of TG was revealed at the 1st stage of DRP, and in patients with duration of diabetes over 10 years — the same as at the 1st stage of DRP. The worst average level of TG in comparison groups by the duration of diabetes was determined in patients with the duration of diabetes less than 10 years at the 1st stage of DRP (2.57 mmol/l, and by CI at the 3rd stage — 3.72 mmol/l). In case of OHGD therapy the highest average level of TG was revealed at the 1st stage of DRP, in case of insulin therapy — the same as at the 1st stage of DRP. The worst average level of TG in comparison groups by the type of hypoglycemic therapy was determined at the 1st stage of DRP in patients who received insulin therapy (2.62 mmol/l and by CI — at the 2nd stage if OHGD is used — 4.26 mmol/l) (table 4).

**Discussion**

As the results of the statistical analysis showed, average indices of total cholesterol in blood in all comparison groups of patients with T2DM mainly exceeded the upper level of reference indices for patients without the risk for development of cardiovascular events and T2DM (less than 5—5.18 mmol/l) and mainly for patients with T2DM (less than 4.5 mmol/l); average indices of cholesterol HDLP in blood were not lower than those of the recommended boundary value level in blood serum (less than 1.0 mmol/l) and were within normal values (1.03—1.55 mmol/l), average indices of cholesterol LDLP were higher than the norm (reference values for healthy people 2.6—3.3 mmol/l) and exceeded the higher reference value level, determined for patients with T2DM (less than 2.5 mmol/l), in 23 groups of patients (95.8 %), average indices of TG in blood of patients with DRP were higher than the norm (reference data for healthy people — 1.7 mmol/l) in 13 out of 24 comparison groups (54.1 %).

According to the results of comparative estimation for the influence of progression factors of DRP on indices of lipid metabolism in patients with T2DM and DRP we can notice that the most significant hypercholesterolemia was observed at the 3rd stage of DRP in patients who received insulin therapy (4.53 mmol/l, and by CI at the 3rd stage — 5.27 mmol/l). In patients with the duration of diabetes less than 10 years the highest average level of TG was revealed at the 1st stage of DRP, and in patients with duration of diabetes over 10 years — the same as at the 1st stage of DRP. The worst average level of TG in comparison groups by the type of hypoglycemic therapy was determined at the 1st stage of DRP in patients who received insulin therapy (2.62 mmol/l and by CI — at the 2nd stage if OHGD is used — 4.26 mmol/l) (table 4).

**Table 3. Average statistical data on concentration of cholesterol of low density lipoproteins in blood at different stages of diabetic retinopathy depending on risk factors for progression (n, M ± m; 95% CI)**

| Comparison groups                   | Diabetic retinopathy |
|-------------------------------------|----------------------|
|                                     | 1st stage            | 2nd stage            | 3rd stage            |
| Age of patients ≤ 60 years old      | 25                   | 5                    | 5                    |
|                                     | 3.44 ± 0.17          | 3.06 ± 0.51          | 4.07 ± 0.44          |
|                                     | 3.03–3.80            | 2.04–4.08            | 3.19–4.95            |
| Age of patients over 60 years old   | 17                   | 7                    | 5                    |
|                                     | 3.21 ± 0.21          | 3.90 ± 0.36          | 3.49 ± 0.44          |
|                                     | 2.78–3.64            | 3.17–4.62            | 2.6–4.37             |
| Duration of diabetes ≤ 10 years     | 31                   | 5                    | 6                    |
|                                     | 3.35 ± 0.15          | 4.17 ± 0.43          | 4.07 ± 0.39          |
|                                     | 3.04–3.67            | 3.29–5.05            | 3.28–4.85            |
| Duration of diabetes is over 10 years| 11                  | 7                    | 4                    |
|                                     | 3.34 ± 0.26          | 3.18 ± 0.39          | 3.3 ± 0.5            |
|                                     | 2.81–3.87            | 2.39 – 3.96          | 2.28–4.31            |
| Subcompensation of diabetes         | 14                   | 5                    | 4                    |
|                                     | 3.20 ± 0.23          | 3.20 ± 0.61          | 2.93 ± 0.50          |
|                                     | 2.73–3.66            | 1.96–4.43            | 1.92–3.93            |
| Decompensation of diabetes          | 27                   | 7                    | 6                    |
|                                     | 3.45 ± 0.16          | 3.74 ± 0.32          | 4.29 ± 0.38          |
|                                     | 3.11–3.78            | 3.08–4.40            | 3.51–5.07            |
| OHGD                                | 26                   | 5                    | 4                    |
|                                     | 3.34 ± 0.16          | 4.05 ± 0.58          | 2.53 ± 0.47          |
|                                     | 3.01–3.66            | 2.88–5.21            | 1.58–3.48            |
| Insulin therapy                     | 16                   | 7                    | 6                    |
|                                     | 3.37 ± 0.20          | 3.50 ± 0.31          | 4.53 ± 0.36          |
|                                     | 2.96–3.78            | 2.87–4.12            | 3.79–5.27 p < 0.001* |

*Note: * — in comparison with OHGD.
rolemia (the worst level) is observed at the age of patients under 60 years old — at the 3rd stage of DRP (exceeding target values by 48%), with the duration of diabetes less than 10 years — at the 3rd stage of DRP (exceeding target values by 41%), in patients with decompensation of carbohydrate metabolism (HbA1c > 8%) — at the 3rd stage of DRP (exceeding target values by 41%), in case of administration of OHGD — at the 2nd stage of DRP (exceeding target values by 58%).

Most clinically significant increase in levels of cholesterol LDLP were determined at the age of patients under 60 years old — at the 3rd stage of DRP (exceeding target values by 62%), with the duration of diabetes less than 10 years — at the 2nd stage of DRP (exceeding target values by 67%), in patients with decompensation of T2DM (HbA1c > 8%) — at the 3rd stage of DRP (exceeding target values by 71%), in case of insulin therapy — at the 3rd stage of DRP (exceeding target values by 80%). The obtained results were supported by publications on interrelation between duration of diabetes and the level of HbA1c > 8% with cholesterol LDLP [11].

Moreover by cholesterol HDLP the clinically significant decrease in its concentration in blood can be determined only by the confidence interval at the 3rd stage of DRP at the age of patients under 60 years old (decrease by 23%), with the duration of diabetes less than 10 years (decrease by 21%), at decompensation of carbohydrate metabolism (decrease by 17%) and if insulin therapy was administered (decrease by 17%). On the whole average levels of cholesterol HDLP remain relatively unfavorable without the influence on it from factors of DRP progression, which indicates probably their minimal contribution to the formation of endothelial dysfunction typical for diabetes.

Clinically significant hypertriglyceridemia was determined mainly only at the 1st stage of DRP (exceeding target values maximally — up to 73%), and notably at the action of all the factors of DRP progression presented by us, with the exception of the age of patients under 60 years old, the factor of duration of diabetes less than 10 years and the factor of insulin therapy, when hypertriglyceridemia was revealed also at the 3rd stage of DRP (exceeding target values by 32–48%).

Previous examination of clusters of MS in patients with T2DM and DRP showed that patients with DRP possess phenotypic and clinical-biochemical signs of MS: obesity (83.4 % patients) with the increased waist regardless of gender, AH (71.4 % patients), dyslipidemia (47.6 % patients), hypercholesterolemia (61.9 % patients) and hypertriglyceridemia (52.3 % patients). The authors suggest that hypertriglyceridemia is one of the trigger pathogenetic mechanisms for development of DRP [18]. In the world literature it has been shown that the severity of DRP is connected with the increased concentration of TG and inversely proportional to the level of cholesterol HDLP; it was also shown that fenofibrate decreased by 31 % the

| Comparison groups | Diabetic retinopathy |
|-------------------|----------------------|
|                   | 1st stage | 2nd stage | 3rd stage |
| **Age of patients ≤ 60 years old** |          |           |           |
| 24                | 2.95 ± 0.33 | 5         | 2.52 ± 0.83 |
|                   | 2.27–3.62 | −0.75–3.09 | 0.85–4.19 |
| **Age of patients over 60 years old** |          |           |           |
| 17                | 1.85 ± 0.40 | 7         | 1.45 ± 0.83 |
|                   | 1.05–2.65 | 1.80 ± 0.67 | −0.21–3.12 |
| **Duration of diabetes ≤ 10 years** |          |           |           |
| 30                | 2.61 ± 0.31 | 6         | 2.25 ± 0.77 |
|                   | 1.97–2.94 | 1.66 ± 0.86 | 0.70–3.81 |
| **Duration of diabetes is over 10 years** |          |           |           |
| 11                | 2.18 ± 0.52 | 6         | 1.54 ± 1.00 |
|                   | 1.13–3.23 | 1.53 ± 0.77 | 0.06–3.55 |
| **Subcompensation of diabetes** |          |           |           |
| 13                | 2.45 ± 0.47 | 5         | 1.64 ± 1.01 |
|                   | 1.50–3.41 | 1.25 ± 1.23 | 0.37–3.65 |
| **Decompensation of diabetes** |          |           |           |
| 27                | 2.57 ± 0.32 | 7         | 1.10 ± 0.13 |
|                   | 1.91–3.23 | 1.68 ± 0.65 | 0.83–1.36 |
| **OHGD** |          |           |           |
| 25                | 2.41 ± 0.34 | 5         | 1.19 ± 0.99 |
|                   | 1.71–3.10 | 1.81 ± 1.22 | 0.81–3.19 |
| **Insulin therapy** |          |           |           |
| 16                | 2.62 ± 0.43 | 7         | 2.47 ± 0.77 |
|                   | 1.76–3.49 | 1.52 ± 0.65 | 0.92–4.01 |

Notes: * — in comparison with 3rd stage with DM decompensation, ** — in comparison with 3rd stage with DM decompensation.
necessity for laser treatment of proliferative DRP, threatening eyesight of patients with T2DM [4]. The provided literature data correspond to our results.

We are inclined to consider that at the 1st stage of developing DRP hypertriglyceridemia takes part in the formation of endothelial dysfunction and provides idiosyncratic metabolic “hit” on rheological properties of blood and endothelium of vessels, contributing to the realization of the influence from such markers of endothelial damage and low-graual inflammation as interleukin-8 [5, 13], inhibitor of activator of plasminogen-1 [3], vascular cell adhesion molecule type 1 [7], which are actively produced in the body in case of obesity. Hypercholesterolemia and dyslipidemia (by cholesterol LDLp), seemingly may lead to further progression of endothelial dysfunction by the type of the “second wave” at later stages of DRP. At that the modifying influence on those clusters of MS, as our own results showed, at different stages of DRP can be made by such factors as age of patients with T2DM, duration of the disease, degree of compensation and features of hypoglycemic therapy. It can be suggested that the type of hypoglycemic therapy can be the new factor for progression of DRP.

Conclusions

1. The modifying influence on the level of total cholesterol in blood of patients with T2DM and DRP is rendered by: age of patients (under 60 years old), factor of duration of diabetes (less than 10 years), factor of decompensation of carbohydrates metabolism — for the 3rd stage of DRP, features of therapy for T2DM (OHGD) — at the 2nd stage of DRP; on the level of atherogenic cholesterol LDLp, younger age of patients, decompensation of carbohydrates metabolism — for the 3rd stage of duration of diabetes (less than 10 years), factor of decompensation of carbohydrates metabolism — for the 3rd stage of DRP, features of hypoglycemic therapy (insulin therapy), shorter duration of diabetes — for the 2nd stage of DRP; on the level of TG: age of patients (under 60 years old), factor of duration of diabetes (less than 10 years) and factor of insulin therapy — for the 1st and 3rd stages of DRP.

2. Features of hypoglycemic therapy can represent a new modifying factor for the risk of DRP progression.

Conflicts of interests. Authors declare the absence of any conflicts of interests that might be construed to influence the results or interpretation of their manuscript.

References

1. Antonetti DA, Klein R, Gardner TW. Diabetic Retinopathy. N Engl J Med. 2012 Mar 29;366(13):1227-39. doi: 10.1056/NEJMra1005073.

2. Arnold E, Rivera JC, Thebault S, et al. High levels of serum prolactin protect against diabetic retinopathy by increasing ocular vasoanhibins. Diabetes. 2010 Dec;59(12):3192-7. doi: 10.2337/db10-0873.

3. VADT Study Group; Azad N, Agrawal L, Emanuelev NL, et al. Association of PAI-1 and fibrinogen with diabetic retinopathy in the Veterans Affairs Diabetes Trial (VADT). Diabetes Care. 2014 Feb;37(2):501-506. doi: 10.2337/dc13-1193.

4. Ning C, Mitchell P, Wong TY. Diabetic retinopathy. Lancet. 2010 Jul 10;376(9735):124-36. doi: 10.1016/S0140-6736(09)62124-3.

5. Dong L, Bai J, Jiang X, et al. The gene polymorphisms of IL-8(-2517/A) and 1P-10(-1596C/T) are associated with susceptibility and progression of type 2 diabetic retinopathy in northern Chinese population. Eye (Lond). 2017 Apr;31(4):601-607. doi: 10.1038/eye.2016.287.

6. Hirsch IB, Brownlee M. Beyond hemoglobin A1c — need for additional markers of risk for diabetic microvascular complications. JAMA. 2010 Jun 9;303(22):2291-2. doi: 10.1001/jama.2010.785.

7. Hughes JM, Brink A, Wimmer AN, Hanraads-de Riemer M, Klaassen I, Schlingemann RO. Vascular leucocyte adhesion molecules unaltered in the human retina in diabetes. Br J Ophthalmol. 2004 Apr;88(4):566–572. doi: 10.1136/bjo.2003.021204.

8. Klein R. The epidemiology of diabetic retinopathy. In: Duh E, editor. Diabetic retinopathy. Totowa, NJ: Humana; 2008. 67-107 p.

9. Nguyen TT, Albrahim E, Islam FM, et al. Inflammatory, hemostatic, and other novel biomarkers for diabetic retinopathy: the multi-ethnic study of atherosclerosis. Diabetes Care. 2009 Sep;32(9):1704-9. doi: 10.2337/dc09-0102.

10. Targher G, Bertolini L, Chonchol M, et al. Non-alcoholic fatty liver disease is independently associated with an increased prevalence of chronic kidney disease and retinopathy in type 1 diabetic patients. Diabetologia. 2010 Jul;53(7):1341-8. doi: 10.1007/s00125-010-1720-1.

11. West SD, Groves DC, Lipinski HJ, et al. The prevalence of retinopathy in men with Type 2 diabetes and obstructive sleep apnoea. Diabet Med. 2010 Apr;27(4):423-30. doi: 10.1111/j.1464-5491.2010.02962.x.

12. Zietz B, Buechler C, Kobuch K, Neumeier M, Sch Imrich J, Sch fller A. Serum levels of adiponectin are associated with diabetic retinopathy and with adiponectin gene mutations in Caucasian patients with diabetes mellitus type 2. Exp Clin Endocrinol Diabetes. 2008 Oct;116(9):532-6. doi: 10.1055/s-2008-1058086.

13. Vytovskaya OP, Axmad TS, Bychkova NG. Violation of the cytokine regulation in patients with diabetic retinopathy. Ukrainian Medical Journal. 2016;8(16):93-95. (in Russian).

14. Malachkova NV, Komaroskova IV, Kiryluk ML. Blood glucose level and insulin resistance in patients with type 2 diabetic mellitus, diabetic retinopathy and obesity. Mezhdunarodnyi Endokrinologicheskii Zhurnal. 2017;13(3):129-134. doi: 10.22141/2224-0722-13.3.2017.104108.

15. Malachkova NV, Kiryluk ML, Komaroskova IV. The features of blood pressure in patients with diabetic retinopathy, type 2 diabetes and adiposity. Arhiv oftalmologii Ukrainy. 2017;5(1(7)):32-37. (in Russian).

16. Malachkova NV, Kiryluk ML, Komaroskova IV. Association between serum resistin level and diabetic retinopathy in obese patients with type 2 diabetes mellitus. Oftalmologicheskii zhurnal. 2017;4(477):9-13. (in Russian).

17. Serdyuk VN, Ishchenko VA. The content of leptin in the blood of patients with type 2 diabetes mellitus at different stages of diabetic retinopathy. Oftalmologija. 2017;1(06):46-54. (in Russian).

18. Serdyuk VN, Ishchenko VA. Morphometric and biochemical clusters of metabolic syndrome in type 2 diabetic patients at different stages of diabetic retinopathy. Mezhdunarodnyi Endokrinologicheskii Zhurnal. 2016;7(79):69-74. doi: 10.22141/2224-0721.7.79.2016.86421.

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Резюме. Актуальность. С учетом того, что относительный вклад различных факторов на риск развития ретинопатии остается неопределенным, являются актуальными поиск и изучение новых факторов риска развития и прогрессирования диабетической ретинопатии (ДРП) и их модифицирующее влияние на компоненты метаболического синдрома (МС) при сахарном диабете (СД) 2-го типа. Цель: выполнить сравнительную оценку влияния некоторых факторов прогрессирования ДРП на показатели липидного обмена при СД 2-го типа. Материалы и методы. Исследования проведены у 64 пациентов (95 глаз) с СД 2-го типа, МС и ДРП (мужчины и женщины, средний возраст — 61,55 ± 2,37 года, средняя длительность диабета — 11,23 ± 2,11 года, средний уровень HbА1с — 9,89 ± 0,78 %, средний индекс массы тела — 34,55 ± 3,75 кг/м²), которых в зависимости от стадии ДРП разделили на 3 группы. Результаты. Модифицирующее влияние на уровень общего холестерина в крови у больных с СД 2-го типа и ДРП оказывают: возраст пациентов (до 60 лет), длительность диабета (до десяти лет), декомпенсация углеводного обмена — для третьей стадии ДРП, особенность терапии СД 2-го типа — для второй стадии ДРП; на уровень холестерина липопротеинов низкой плотности: более молодой возраст больных, декомпенсация диабета — для третьей стадии ДРП, особенностей гипогликемической терапии (инсулинотерапия), меньшая длительность диабета — для второй стадии ДРП; на уровень триглицеридов: возраст пациентов (до 60 лет), длительность диабета (до десяти лет) и инсулинотерапия — для первой и третьей стадий ДРП. Выводы. Особенности сахароснижающей терапии могут служить новым фактором прогрессии ДРП. Ключевые слова: диабетическая ретинопатия; метаболический синдром