

# MAIN CLINICAL AND LABORATORY CHARACTERISTICS OF PATIENTS WITH TYPE 1 DIABETES AND DIABETIC NEPHROPATHY IN TERMS OF RISK GROUP PERSPECTIVES EVALUATION

Ihor V. Kovalchuk, Ievgeniia A. Burlaka, Inga O. Mityuryayeva-Kornijko

Bogomolets National Medical University, Kyiv, Ukraine

## *Abstract*

**Introduction.** Diabetes mellitus is the most common metabolic disease in children, the prevalence of which has increased markedly worldwide in recent decades. Children and adolescents with type 1 diabetes are at increased risk of developing microvascular complications, including diabetic nephropathy. The critical impact of childhood diabetes on morbidity and mortality in the future requires us to rationally use all available tools and resources for the intensive development of new diagnostic mechanisms.

**Aim.** To study the basic anamnestic, clinical, laboratory, instrumental, and functional characteristics of pediatric patients with type 1 diabetes and diabetic nephropathy in order to identify potential risk factors for diabetic nephropathy for further studies, taking into account specific markers.

**Materials and methods.** A comprehensive examination was conducted, which is basic for all patients: 150 children with type 1 diabetes, diabetic nephropathy, and a control group aged from 3 to 18 years in the endocrinology department of Children's Clinical Hospital № 6. Statistical analysis and data processing were performed using GraphPad Prism 10.0 for Windows (USA, San Diego, California).

**Results.** Data on physical development, hematological, and biochemical parameters of patients with diabetes mellitus and diabetic nephropathy were analyzed. Renal dysfunction in the early stage of diabetic nephropathy shows a higher degree of microalbuminuria and an increased glomerular filtration rate compared with the group of patients with type 1 diabetes mellitus.

**Conclusions.** An analysis of basic clinical, laboratory, and anamnestic data in children with type 1 diabetes and diabetic nephropathy was conducted, which is the basis for further studies to identify potential risk factors for the formation of diabetic nephropathy through a comprehensive analysis of basic and specific molecular markers.

**Keywords:** diabetes mellitus, diabetic nephropathy, statistics, data, medical history, children, risk groups, perspectives

## INTRODUCTION

Diabetes mellitus (DM) is recognized as a non-communicable epidemic of the 21st century and is one of the most important problems in clinical medicine, due to its wide distribution, clinical polymorphism, and severity of complications. There is a rapid growth in and prevalence of diabetes mellitus worldwide. According to WHO, 422 million people worldwide suffer from the disease, and 1.5 million deaths each year are directly related to it. The number of cases and prevalence of DM have been increasing over the past few decades. It is estimated that type 1 DM manifests annually in around 110 thousand children under the age of 14 [1]. By the age of 20, this annual incidence rises to 130 thousand newly

diagnosed cases, indicating a significant prevalence of the pathology among the young population, which can subsequently lead to the development of chronic diabetic complications and reduce the quality of life of patients with DM. According to scientists, more than 1.1 million children and adolescents worldwide have type 1 diabetes, more than half of whom (54%) are under the age of 15 [2].

Diabetic nephropathy is one of the most severe microvascular complications of type 1 diabetes, which can lead to early disability in patients. The incidence of DN in type 1 diabetes is 5-6% in people under 10 years of age and 25-40% in people under 20 years of age. DN usually develops 4-5 years after the diagnosis of diabetes [3]. The population of kidney cells is very heterogeneous.

Morphological abnormalities occur in various cells: podocytes, endothelial and mesangial cells, the glomerular basement membrane, tubular epithelium, interstitial fibroblasts, and vascular epithelium. Microalbuminuria is the main early objective indicator of diabetic nephropathy. The criteria for microalbuminuria are as follows: urinary albumin excretion of 30-300 mg/day; albumin/creatinine ratio in a single urine sample of 30-300 mg/g. Albumin excretion rate is the best noninvasive predictor of diabetic nephropathy and is measured according to established guidelines [4].

Risk factors associated with the increased prevalence of DN among children and adolescents include high blood pressure, poor glycemic control, low birth weight, obesity, and dyslipidemia. It is clinically important to identify patients with type 1 diabetes at high risk of developing DN. This study presents an analysis of baseline clinical and laboratory parameters in patients with type 1 diabetes and DN [5].

### AIM

To study the basic anamnestic, clinical, laboratory, instrumental, and functional characteristics of pediatric patients with type 1 diabetes and diabetic nephropathy in order to identify potential risk factors for diabetic nephropathy for further studies, taking into account specific markers.

### MATERIALS AND METHODS

A survey of 150 children with type 1 diabetes, DN, and a control group aged from 3 to 18 years (48 boys, 102 girls) was conducted in the endocrinology department of Children's Clinical Hospital № 6 (Kyiv, Ukraine). Informed consent was obtained from all patients and their families. The study was approved by the local hospital ethics committee. All informed consent forms were signed by children (from the age of 12) themselves and/or by their parents and were stored in medical records.

Inclusion criteria: children aged 3 to 18 years; patients with established diagnoses of type 1 diabetes mellitus and diabetic nephropathy. Exclusion criteria: patients with conditions unrelated to diabetes mellitus, diabetic nephropathy, or kidney pathology.

The study was conducted at Children's Clinical Hospital № 6, where the clinical base of the Department of Pediatrics No. 4 of the Bogomolets National Medical University is located. All patient data were documented, including a detailed medical history and a systematic clinical analysis.

A comprehensive examination was performed, including physical examination, blood pressure measurement, blood tests, lipid profile, ECG, ultrasound examinations, etc., which are basic for all patients. Urinary microalbumin excretion was measured in 24-hour urine collection samples using the traditional method established at Children's Clinical Hospital № 6.

Glomerular filtration rate was used to assess renal function, calculated by the Schwartz formula for children and adolescents aged 1 to 18 years:  $eGFR = 0.413 \times \text{height} / \text{Scr}$  (height in cm, Scr – standardized serum creatinine in mg/dl).

Statistical analysis. The descriptive statistics method was used, including calculation of the mean, standard deviation (SD), and assessment of the reliability of the mean using the standard error of the mean (SEM). The ANOVA test with post hoc analysis (Kruskal-Wallis and Dunn's Multiple Comparisons Test) and the non-parametric Mann-Whitney test were used to calculate p-values and assess the significance of differences. The Chi-square test and Fisher's exact test were used to analyze relationships between categorical variables. Data were processed using GraphPad Prism 10.0 software for Windows (USA, San Diego, California). P values less than 0.05 were considered statistically significant.

### RESULTS

The study was designed as a case-control study, covering the period from 2023 to 2025, including children with type 1 diabetes and DN in the endocrinology department of Children's Clinical Hospital № 6 (Kyiv, Ukraine). All patients were examined and consulted once every three months, and all of them (except the control group) were on flexible dosing intervals of insulin treatment. Age, duration of diabetes, weight, height, body mass index (BMI), blood pressure, HbA1c, fasting glucose, biochemical blood parameters (total protein, cholesterol, ALT, AST, bilirubin, creatinine, urea), complete blood count, urinalysis, and markers of kidney function were recorded at each periodic hospital visit.

Features of demographic and clinical indicators of the study population.

The group of patients with type 1 diabetes (n = 50) had a mean disease duration of 6.8 years with a standard error of the mean (SEM)  $\pm$  0.39. In this group, the majority of patients had a diabetes duration of 5-10 years (70%), 22% had diabetes for less than 5 years, and 8% for more than 10 years. The proportion of patients with diabetes manifestation at the age under 3 years, 3-5 years, and older than 5 years was uniform (28%, 36%, 36%).

The group of children with diabetic nephropathy (n = 50) had a mean disease duration of 9.4 years with a standard error of the mean  $\pm$  0.38; patients with DN had a longer history of diabetes. Seventy-four percent of patients were aged 10-15 years. Significantly fewer were younger than 10 years (4%) and older than 15 years (22%). The largest number of patients (48%) had manifestation of DM at the age of 3-5 years. Fewer patients had manifestation under 3 years (28%) and older than 5 years (24%). The group of children with DN was observed for one year after the first documented episode of albuminuria (Table 1).

## Clinic characteristics of patients

Parameter (Mean±SEM)	T1DM (n=50)	DN (50)	p
Age	11.84±0.49	13.58±0.3	<0.05
Gender	15/35	12/38	>0.05
Weight, kg	34.87±1.8	34.8±1.8	>0.05
Height, cm	140.7±2.7	144.9±1.3	>0.05
DM duration, years	6.86±0.39	9.4±0.39	<0,0001
BMI	17.03±0.45	19.71±0.39	<0,0001
Pulse, bpm	82.3±1.4	79.56±1.2	>0.05
BP, sys	106±2.8	102.9±2.7	>0.05
BP, dia	67.5±2.9	67±2.2	>0.05
RBC	4.3±0.09	4.35±0.09	>0.05
Hb	134.8±2.1	134.5±2.1	>0.05
PLT	253.1±7.6	254.2±6.3	>0.05
WBC	4.9±0.18	4.5±0.09	>0.05
ESR	5±0.35	4.8±0.36	>0.05
Total Blood Protein, g/l	63.84±0.54	63.23±0.53	>0.05
Cholesterol, μmol/l	3.9±0.08	3.9±0.08	>0.05
ALT, U/L	15.98±0.63	15.65±0.56	>0.05
AST, U/L	25.12±0.75	18.2±1.2	<0.001
Bilirubin	7.6±0.28	9.1±0.37	<0.01
Creatinine, μmol/l	68.22±1.5	55.7±1.9	<0,0001
Urea, mmol/l	3.6±0.13	3.7±0.13	>0.05
Blood glucose	10.9±0.3	10.9±0.33	>0.05
Hb1Ac	8.5±0.28	8±0.23	>0.05
MAU	14.89±1.6	74±2.6	<0,0001
GFR	73.9±1.7	110.5±1.2	<0,0001

The gender distribution of patients in the type 1 DM group was 15 boys and 35 girls, while in the DN group it was 12 boys and 38 girls, respectively (Fig. 1). The gender distribution in the control group was more balanced, with a slight predominance of girls – 29 girls and 21 boys. The average age of children in the type 1 DM group was  $11.84 \pm 0.49$  years; in the DN group,  $13.58 \pm 0.3$  years; and in the control group,  $13.44 \pm 0.54$  years. In the T1DM group, age differed significantly from the control group ( $p < 0.01$ ), while no statistically significant differences were found between the DN and control groups, as well as between the DN and T1DM groups ( $p > 0.05$ ).

Body mass index (BMI) was analyzed in all children included in the study. BMI in the DN group ( $19.71 \pm 0.39$  kg/m<sup>2</sup>) was significantly higher than in the T1DM group ( $17.03 \pm 0.45$  kg/m<sup>2</sup>) ( $p < 0.0001$ ), while a slight difference was found between the control and T1DM groups ( $p < 0.05$ ), and there was no difference between the control and DN groups ( $p > 0.05$ ).

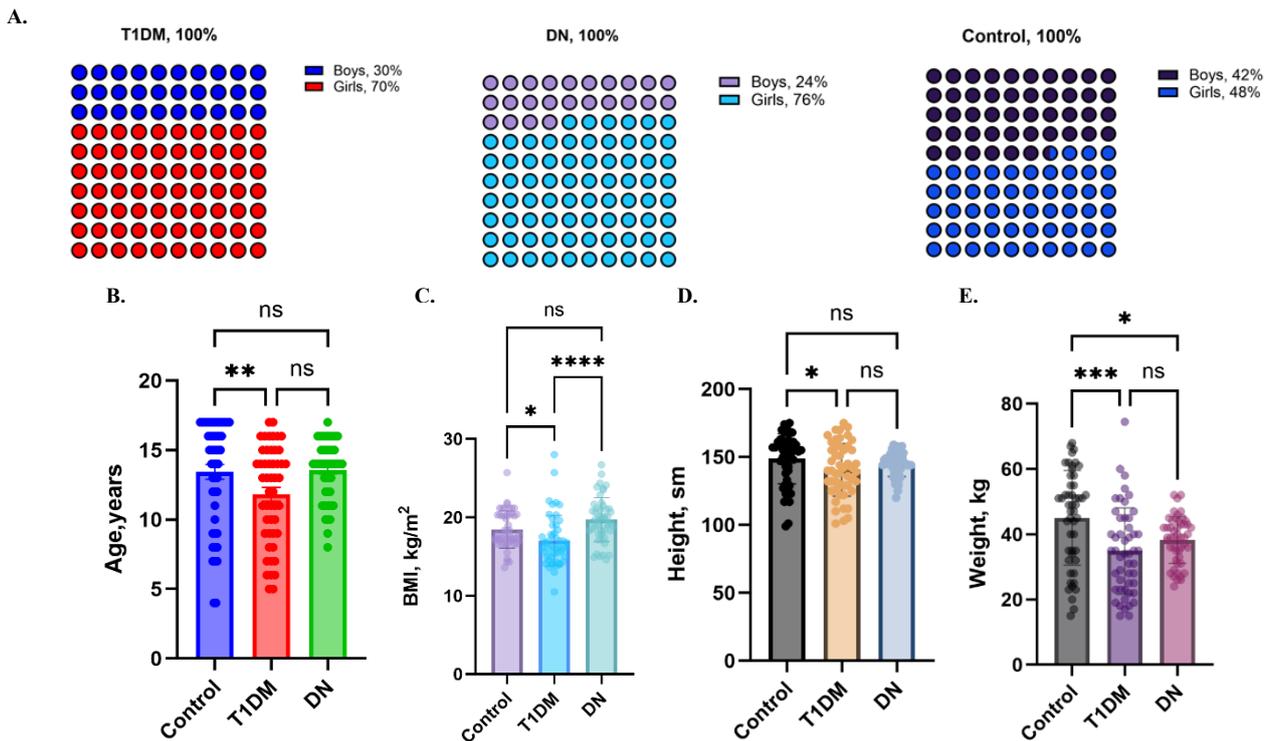
Weight by patient groups was as follows: type 1 DM,  $34.87 \pm 1.8$  kg; DN,  $38.28 \pm 1.8$  kg; control group,  $45.06 \pm 2.0$  kg. Weight in the T1DM ( $p < 0.001$ ) and DN ( $p < 0.05$ ) groups was significantly lower than in the control group, while there was no statistically significant difference between the T1DM and DN groups ( $p > 0.05$ ).

The average height was  $140.7 \pm 2.74$  cm in the type 1 diabetes group,  $144.9 \pm 1.3$  cm in the DN group, and  $148.7 \pm 2.6$  cm in the control group ( $p < 0.05$ ). Height

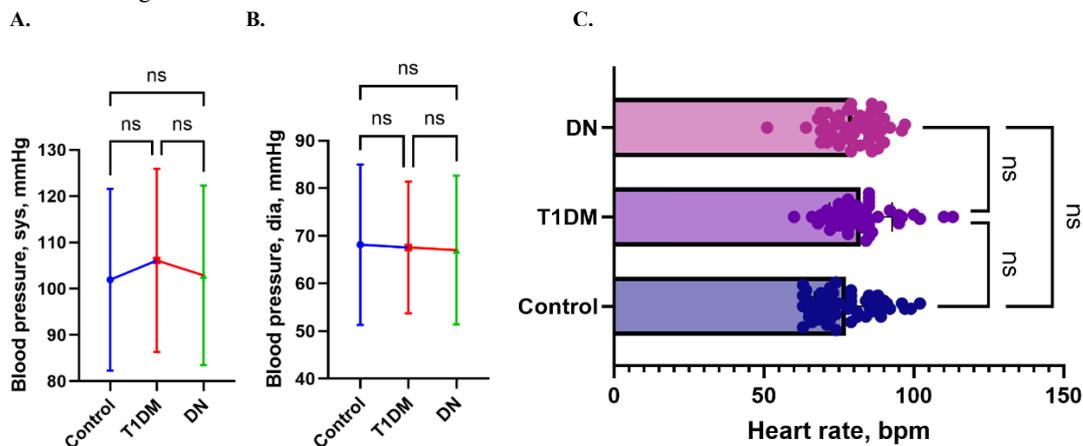
in the T1DM group was significantly different from the control group ( $p < 0.05$ ), while no statistically significant differences were found between the control and DN groups, as well as between the T1DM and DN groups ( $p > 0.05$ ).

Heart rate and blood pressure values were included in the study, heart rate values in the T1DM group were  $82.32 \pm 1.48$  beats per minute, in the DN group were  $79.56 \pm 1.2$  beats per minute, in the control group were  $77.36 \pm 1.49$  beats per minute ( $p > 0.05$ ). Type I DM – systolic blood pressure  $106.1 \pm 2.79$ , DN –  $102 \pm 2.74$ , control –  $101.9 \pm 2.79$  ( $p > 0.05$ ). Diastolic blood pressure in the type I DM group was  $67 \pm 1.95$  mmHg, DN –  $67 \pm 2.2$ , in the control group –  $68 \pm 2.3$  mmHg, respectively ( $p > 0.05$ ). The wide standard deviations indicate significant individual variability within each group (Fig. 2).

Complete blood count was performed in all patients. RBC, WBC, PLT, Hb, and ESR data were analyzed and compared. The values of erythrocytes in the type 1 DM and DN groups did not show any difference –  $4.33 \pm 0.09 \times 10^{12}$ ,  $4.35 \pm 0.09 \times 10^{12}$ , and  $4.28 \pm 0.09 \times 10^{12}$  respectively ( $p > 0.05$ ). There was no difference in the number of leukocytes: in the type 1 DM group,  $4.9 \pm 0.18 \times 10^9/l$ ; in the DN group,  $4.5 \pm 0.09 \times 10^9/l$ ; and in the control group,  $4.5 \pm 0.09 \times 10^9/l$  ( $p > 0.05$ ). The number of platelets (PLT) was  $253.1 \pm 7.6 \times 10^9/l$  overall; in the type 1 diabetes group,  $254 \pm 6.3 \times 10^9/l$ ; in the DN group,  $260.4 \pm 7.0 \times 10^9/l$ ; and in the control group ( $p > 0.05$ ).



**Figure 1. Gender distribution of patients and their physical development in children with T1D and DN.**  
 Note: A – gender distribution, B – age, C – BMI, D – Height, E – Weight. \* –  $p < 0,05$ , \*\* –  $p < 0,01$ , \*\*\* –  $p < 0,001$ , \*\*\*\* –  $p < 0,0001$ , ns – difference is not significant.



**Figure 2. Functional indicators of the cardiovascular system in children with T1D and DN.**  
 Note: A – systolic blood pressure, B – diastolic blood pressure, C – Heart rate. NS – difference isn't significant. NS – difference isn't significant.

No differences were found in hemoglobin levels. In type 1 diabetes, DN, and the control group, respectively, hemoglobin was  $134.8 \pm 2.1$  g/l,  $134.5 \pm 2.15$  g/l, and  $133.6 \pm 1.87$  g/l ( $p > 0.05$ ). The average ESR values were also almost the same: type 1 diabetes, DN, control – respectively  $5.0 \pm 0.35$  mm/h,  $4.8 \pm 0.36$  mm/h, and  $5.2 \pm 0.36$  mm/h ( $p > 0.05$ ). In patients with type 1 diabetes and DN, the complete blood count levels did not differ from those of the control group, suggesting that anemia or iron deficiency is probably not significant in these groups.

Parameters of glucose metabolism were included in the study. Fasting blood glucose levels obtained from all

patients in the type 1 diabetes and DN groups during each control visit showed no differences:  $10.9 \pm 0.3$  mmol/l and  $10.9 \pm 0.33$  mmol/l, respectively. The absence of a statistically significant difference in HbA1c levels –  $8.5 \pm 0.28$  in type 1 diabetes and  $8.0 \pm 0.23$  in DN – indicates a comparable level of glycated hemoglobin and similar glycemic control in both groups. The level of total protein in the blood did not differ statistically significantly between any of the groups: type 1 DM  $63.84 \pm 0.54$  g/l and DN  $63.23 \pm 0.53$  g/l. Total protein is a stable parameter and does not reflect functional or pathological changes associated with diabetes or its complications in these groups.

We analyzed blood cholesterol levels in all patients included in the study. In all three groups, cholesterol levels were approximately the same, around 4 mmol/l ( $p > 0.05$ ). The levels of the enzyme aspartate aminotransferase (AST, U/L) were also analyzed. In the control group, the AST level was the lowest. In the type 1 DM group, AST was  $25.12 \pm 0.75$  U/L, and in the DN group,  $18.2 \pm 1.2$  U/L ( $p < 0.01$ ); these values were increased compared to the controls but similar to each other, possibly indicating metabolic changes associated with diabetes. Alanine aminotransferase (ALT) levels in type 1 DM ( $15.98 \pm 0.63$  U/L) and DN ( $15.65 \pm 0.56$  U/L) were very close, with no significant increase or decrease in either group ( $p > 0.05$ ).

Changes in bilirubin levels were observed: in the type 1 DM group, bilirubin was significantly reduced at  $7.6 \pm 0.28$  mmol/L compared to the control group

( $p < 0.01$ ); in the DN group, bilirubin was also reduced to  $9.1 \pm 0.37$  mmol/L, but less pronounced ( $p < 0.05$ ). The difference between the type 1 DM and DN groups was not statistically significant ( $p > 0.5$ ).

Levels of urea, creatinine in serum, microalbuminuria, and GFR were measured to assess kidney function in all children. All three groups had similar urea levels, approximately 4 mmol/l (type 1 DM  $3.6 \pm 0.13$  mmol/l, DN  $3.7 \pm 0.13$  mmol/l), with no statistically significant differences ( $p > 0.05$ ). Creatinine levels were as follows: type 1 DM –  $68.22 \pm 1.5$   $\mu$ mol/l, DN –  $55.7 \pm 1.9$   $\mu$ mol/l, control –  $65.62 \pm 1.2$   $\mu$ mol/l. Creatinine levels were significantly reduced in the DN group compared to the control and T1DM groups ( $p < 0.0001$ ), while no statistically significant difference was found between the control and T1DM groups ( $p > 0.05$ ) (Fig. 3).

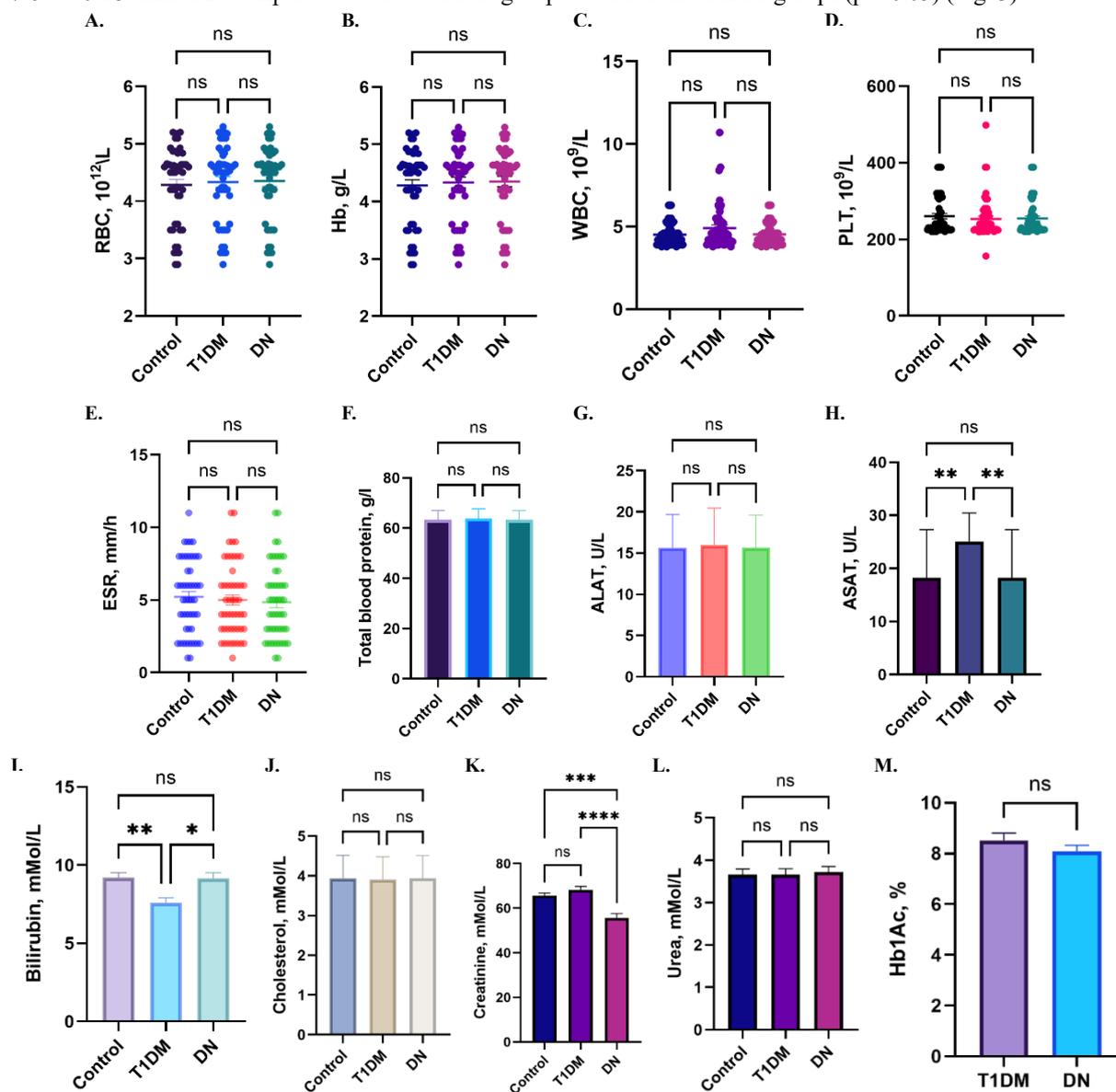


Figure 3. General and biochemical laboratory tests in children with T1D and DN.

Note: A – RBC, B – Hb, C – WBC, D – PLT, E – ESR, F – Total blood protein, G – ALAT, H – AST, I – Bilirubin, J – Cholesterol, K – Creatinine, L – Urea, M – Hb1Ac. \* –  $p < 0.05$ , \*\* –  $p < 0.01$ , \*\*\* –  $p < 0.001$ , \*\*\*\* –  $p < 0.0001$ , ns – difference is not significant.

Microalbuminuria in the type I DM group was  $14.89 \pm 1.5$  mg/g, in the DN group was  $74 \pm 2.6$  mg/g. There was a highly significant difference between the groups, corresponding to  $p < 0.0001$ . The glomerular filtration rate GFR ml/min/1.73m<sup>2</sup> was compared in groups: type I DM was  $73.9 \pm 1.7$ , DN was  $110.5 \pm 1.2$ , control –  $91.7 \pm 1.2$  ( $p < 0.0001$ ). Patients with type I DM had a slight decrease

in GFR, which may indicate impaired renal function even in the early stages of diabetes. The obtained results of GFR in patients with DN confirmed hyperfiltration, which is a characteristic feature of the initial stages of DN. The main indicators of instrumental examinations, anamnestic data in children with type I DM and DN (Fig. 4).

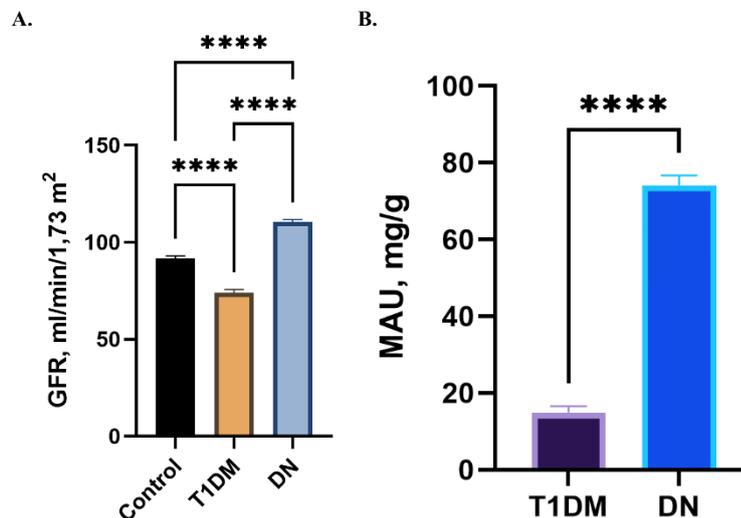


Figure 4. Kidney function assessment in children with T1D and DN. Note: A – GFR, B – MAU. \*\*\*\* –  $p < 0,0001$

Electrocardiogram (ECG) data were analyzed in children from the type 1 diabetes and DN groups. All patients exhibited minor abnormalities in ECG recordings. These included mainly sinus tachycardia, bradycardia, other minor arrhythmias, minor isolated ST/T abnormalities, high R-waves, low ST segment, incomplete (left-sided, right-sided) bundle branch block, minor prolongation of the QT interval, short PR interval, and frequent premature ventricular beats. The percentage of patients with ECG changes in the type 1 diabetes and DN groups was 85% and 84%, respectively ( $p > 0.05$ ).

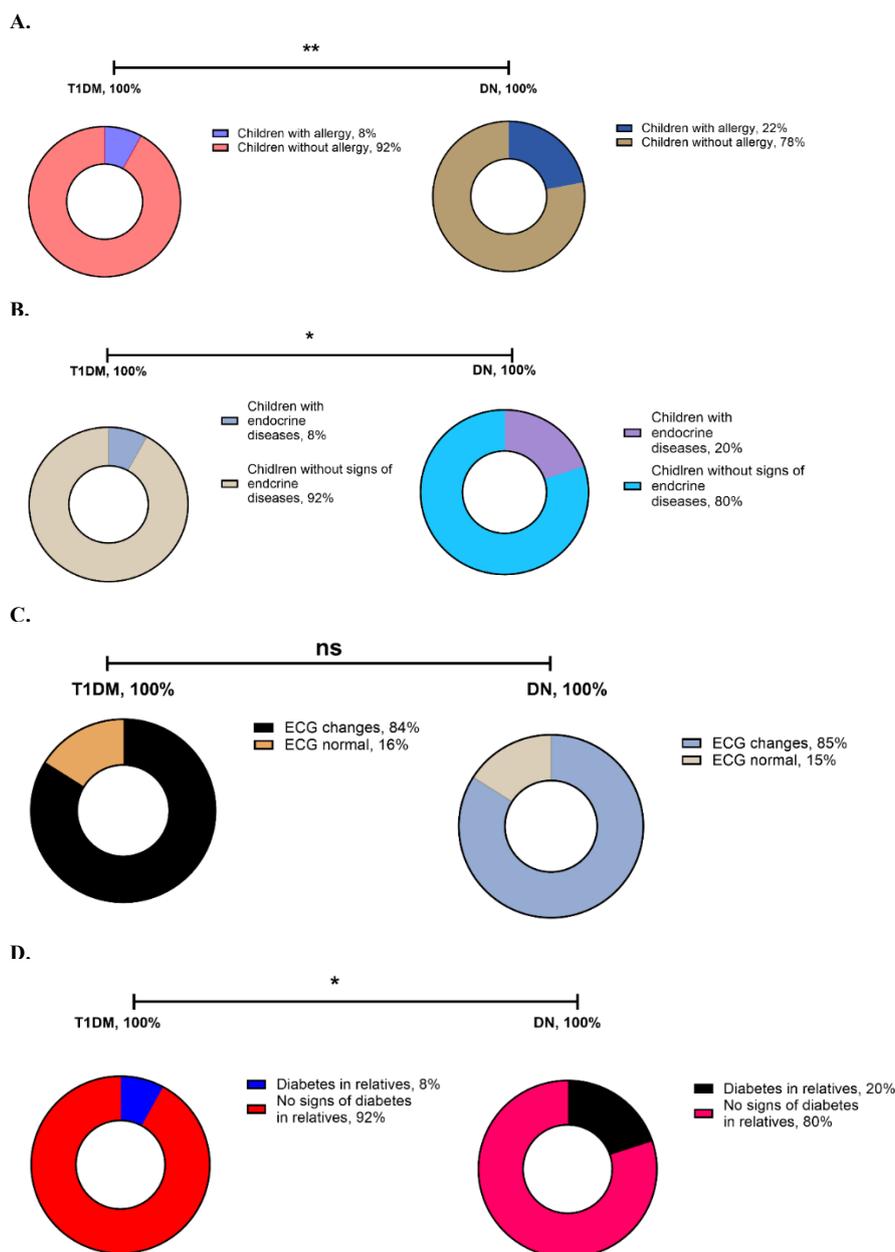
Comorbidities: The frequency of allergies did not show a statistical difference between the groups; in the type 1 diabetes group, 22% of children had allergic manifestations, while in the DN group it was 8% ( $p < 0.01$ ). Endocrine disorders (subclinical hyperthyroidism, hypothyroidism, autoimmune thyroiditis) were present in 20% of children with type 1 diabetes and 8% in the DN group ( $p < 0.05$ ). Retrospective analysis of anamnesis showed the presence of first-degree relatives with diabetes mellitus in 20% of patients with type 1 diabetes and 8% in the DN group ( $p < 0.05$ ) (Fig. 5).

## DISCUSSION

Type 1 diabetes is more common in childhood, although severe stages of DN develop over a long period of time and are therefore rarely observed in childhood. Kidney biopsies performed 1.5-5 years after the onset of diabetes reveal structural changes characteristic of DN in

both adults and children. The initial clinical manifestation of DN, increased urinary albumin excretion, usually appears in childhood and adolescence. Effective detection and intervention in the early stages of DN can significantly increase the chances of a successful outcome than in the later stages of the disease. Numerous studies of type 1 diabetes have expanded our understanding of the evolution of diabetes and the risk factors that can be influenced to slow the progression of DN. These studies have also found that the presence of DN identifies a subgroup of diabetics who are at the highest risk of premature mortality, which emphasizes the importance of early detection, prevention, and treatment of DN. Today, there are many laboratory markers of DN, but clinicians are mostly focused on the level of microalbuminuria. The rate of progression of DN in the natural course largely depends on the level of albumin in the urine, in particular, the annual decrease in GFR is 0.3% for normoalbuminuria, 1.5% for microalbuminuria, and 5.7% for macroalbuminuria [6].

This study summarizes and details the clinical, anamnestic, basic laboratory, and instrumental characteristics of children with type 1 diabetes and DN. In patients with DN, the average duration of the disease is 2.6 years longer than in patients with type 1 diabetes, which confirms the development of complications due to the long course of diabetes and insufficient control of blood glucose levels. Low SEMs indicate the accuracy and reliability of the presented data. In the DN group, diabetes manifestation occurs more often at the age of 3-5 years, while in the group with DM1, the age distribution of manifestation is more uniform [7].



**Figure 5. Basic data of anamnesis in children with T1D and DN.**

Note: A – children with T1DM, DN with allergies, B – children with T1DM, DN with endocrine diseases, C – children with T1DM, DN with/without ECG changes, D – children (T1DM, DN) with relatives which have diabetes. \* –  $p < 0,05$ , \*\* –  $p < 0,01$ , ns – difference is not significant.

Both groups have the largest proportion of patients within the age range of 10-15 years, especially in the DN group, but there are almost no children under 10 years in the DN group. In both the type 1 DM and DN groups, a significantly higher percentage of girls is observed compared to boys. This may indicate a certain gender predisposition to the development of DN among girls or the influence of other factors that require additional analysis. Approximately the same average age in the type 1 DM and DN groups indicates that the age factor is not significant for the development of DN among the studied patients. Age should be taken into account when analyzing

the data, but it is probably not the main predictor of the progression of diabetes to nephropathy.

Patients with DN have a significantly higher BMI compared not only to the control group ( $p < 0.05$ ), but also to patients with type 1 diabetes, and this difference is extremely statistically significant ( $p < 0.0001$ ). This indicates that the development of DN may be associated with increased BMI. In patients with type 1 diabetes without nephropathy, BMI is at the level of the control group, which can be interpreted as a possible lack of its effect on body weight without progression of complications.

The weight of patients with type 1 diabetes is significantly lower compared to the control group; at the same time, there is no statistically significant difference between the groups with type 1 diabetes and DN. The development of DN is not accompanied by a significant change in weight compared to the weight of patients with type 1 diabetes. Weight loss may be due to impaired metabolic processes in diabetes and/or DN.

The significant difference in height between the control group and the group with type 1 diabetes indicates the possible influence of endocrine diabetic disorders on growth retardation.

Patients with type 1 diabetes and DN have a similar level of glycemic control, which is reflected in HbA1c. Despite the progression of diabetes to DN, the average HbA1c level remains unchanged, which may indicate that blood glucose levels are only one of the factors contributing to the development of DN. At the same time, HbA1c was the strongest risk factor for albuminuria. This means that among all possible risk factors (e.g., blood pressure, cholesterol levels, etc.), the level of HbA1c (i.e., blood glucose control) was the most significant [8].

The decrease in bilirubin levels in patients with type 1 diabetes and DN may be related to oxidative stress in diabetes, and the almost absence of difference between type 1 diabetes and DN may indicate that bilirubin is not a key factor in the pathogenesis of DN. Bilirubin can potentially be used as a marker of oxidative stress in patients with diabetes.

The lack of significant differences in urea levels may indicate that this indicator is not a sufficiently sensitive or specific marker to detect a difference between these groups. Non-significant results may also be due to the small sample size, which reduces the statistical power of the analysis.

Creatinine levels are lower in the DN group, which may indicate a decrease in glomerular filtration rate due to the progression of DN. The decrease in creatinine levels in the DN group may be related to a decrease in muscle mass due to a long-term chronic condition or impaired creatinine metabolism in DN.

Elevated levels of microalbuminuria in patients with DN indicate a deterioration in kidney function, which is a typical complication of the progression of diabetes mellitus. This study emphasizes the importance of monitoring microalbuminuria for the early detection of DN. The decrease in GFR in the type 1 diabetes group may be a signal for early monitoring of kidney function in patients with diabetes. Hyperfiltration in the DN group may indicate the risk of progression of nephropathy, which requires intensive treatment. GFR control may serve as an important indicator of the stage of kidney damage in patients with diabetes [9].

In children with type 1 diabetes and DN, no significant changes in blood pressure and heart rate were recorded compared to the control group. This may indicate that, at the stage of the study, the cardiovascular system has not yet undergone significant changes or that compensation mechanisms are working effectively. At the same time, a high proportion of children in both groups (type 1 diabetes – 84%, DN – 85%) have changes on the ECG. Since the difference between the groups is insignificant (statistically insignificant), it can be assumed that cardiovascular disorders are equally common in both groups. Blood pressure variability and daily heart rate fluctuations are important.

The frequency of allergic manifestations did not show a statistically significant difference between the groups. However, allergic diseases are more common among children with type 1 diabetes (22%) compared to the DN group (8%). The frequency of endocrine disorders in children with type 1 diabetes is twice as high as in the DN group, which may indicate an association between type 1 diabetes and other autoimmune diseases. The presence of first-degree relatives with diabetes is more common in the type 1 diabetes group (20%) compared to the DN group (8%), confirming the hereditary predisposition to the development of type 1 diabetes [10].

## CONCLUSIONS

Comparing the average age of children with DN and type 1 DM, the period of puberty can be considered one of the risk factors for DN in adolescence. The duration of diabetes in patients with DN is higher compared to the type 1 DM group, and the age of onset of diabetes is lower in the DN group. In the DN group, the manifestation of clinical signs of diabetes was recorded up to 5 years of age. Therefore, there is a certain relationship between the risk of DN development and the early onset and duration of type 1 DM in children. The most significant laboratory predictors of DN are microalbuminuria (an early important indicator), glycosylated hemoglobin (unstable glycemic control), hyperfiltration, decreased GFR, increased creatinine, and dyslipidemia. Regular screening of these indicators helps to identify the risk of DN in children and adolescents in a timely manner.

**Prospects for further research.** Further improvement in the prediction of DN in children with type 1 diabetes should be based on a comprehensive approach that includes clinical, laboratory and instrumental indicators, as well as anamnestic data. It is important to determine the role of several key risk factors and integrate them into prognostic models to increase the accuracy of diagnosis. This will facilitate the simplification and improvement of the therapeutic application of the acquired knowledge in clinical practice. In addition to traditional markers of kidney damage, such as microalbuminuria and GFR, a study of KIM-1 (Kidney Injury Molecule-1) and xanthine oxidase is being conducted.

## COMPLIANCE WITH ETHICAL REQUIREMENTS

This study was conducted in accordance with the principles outlined in the Declaration of Helsinki, as well as the recommendations established by ethical committee of the Bogomolets National Medical University (No. 4/2024). Prior to the start of the study, all participants received comprehensive information regarding the purpose, methods, potential risks, and benefits of participation. Participation in the study was based on the principle of informed consent, and all respondents signed an appropriate consent form before data collection began. Participants had the right to withdraw from the study at any time without providing a reason.

In the case of research involving minors or individuals with limited legal capacity, informed consent was obtained from their legal representatives.

In accordance with confidentiality standards, all data were collected anonymously and processed in compliance

with the applicable data protection legislation, including the General Data Protection Regulation (GDPR), to ensure the protection of personal information.

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## AUTHOR CONTRIBUTIONS

Kovalchuk I. V.<sup>A, B, C, D</sup>

Burlaka Ie. A.<sup>A, D, E</sup>

Mityuryayeva-Kornijko I. O.<sup>E, F</sup>

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## Резюме

### ОСНОВНА КЛІНІКО-ЛАБОРАТОРНА ХАРАКТЕРИСТИКА ХВОРИХ НА ЦУКРОВИЙ ДІАБЕТ 1 ТИПУ ТА ДІАБЕТИЧНУ НЕФРОПАТІЮ В ПЕРСПЕКТИВІ ОЦІНКИ ГРУП РИЗИКУ

Igor B. Ковальчук, Євгенія А. Бурлака, Інга О. Мітюряєва-Корнійко

Національний медичний університет імені О. О. Богомольця, м. Київ, Україна

**Вступ.** Цукровий діабет є найпоширенішим метаболічним захворюванням у дітей, превалентність якого помітно зросла у світі впродовж останніх десятиліть. Діти та підлітки з цукровим діабетом I типу мають підвищений ризик розвитку мікросудинних ускладнень, включаючи діабетичну нефропатію. Критичний вплив дитячого діабету на захворюваність та смертність у майбутньому вимагає від нас раціонально задіяти всі наявні інструменти та ресурси для інтенсивного розвитку нових діагностичних механізмів.

**Мета.** Вивчити базисні анамнестичні, клініко-лабораторні, інструментальні, функціональні характеристики педіатричних пацієнтів з цукровим діабетом I типу та діабетичною нефропатією з метою виявлення потенційних факторів ризику діабетичної нефропатії з метою подальших досліджень з урахуванням специфічних маркерів.

**Матеріали та методи.** Проведено комплексне обстеження, що є базовим для всіх пацієнтів, 150 дітей з ЦД I типу, діабетичною нефропатією та групою контролю від 3 до 18 років у ендокринологічному відділенні дитячої клінічної лікарні № 6. Статистичний аналіз, обробка даних, за допомогою GraphPad Prism 10.0 для Windows (США, Сан-Дієго, Каліфорнія).

**Результати.** Проаналізовано дані фізичного розвитку, гематологічні, та біохімічні параметри пацієнтів з цукровим діабетом та діабетичною нефропатією. Порушення функції нирок на ранній стадії діабетичної нефропатії показує вищий ступінь мікроальбумінурії, підвищення швидкості клубочкової фільтрації, порівняно з групою хворих на цукровий діабет I типу.

**Висновки.** Проведений аналіз базисних клінічних, лабораторних та анамнестичних даних у дітей з ЦД I типу та ДН, що є підґрунтям для подальших досліджень з визначенням потенційних факторів ризику формування ДН шляхом комплексного аналізу базисних та специфічних молекулярних маркерів.

**Ключові слова:** цукровий діабет, діабетична нефропатія, статистика, дані, анамнез, діти, групи ризику, перспективи

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