The relationship between blood pressure changes and the efficacy of treatment in patients with primary glomerulonephritis with special regard to kidney size

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Abstract

Introduction. Blood pressure plays a modulating role in the progression of glomerulonephritis. Kidney size could also constitute a factor influencing the efficacy of treatment.
The study sought to determine renal length and the influence of blood pressure changes and renal length on the efficacy of treatment.
Material and methods. This study included 53 adult patients (25 female and 28 male), aged 17 to 63. At the beginning of the observation period, the following tests were performed: percutaneous renal biopsy, anthropometric measurements, renal length in abdominal ultrasound scan. At the beginning of the observation period and after 24 months the following tests were performed: SBP, DBP, MAP, PP, serum creatinine level, GFR MDRD, DPL. Absolute renal length (D) was related to anthropometric parameters and values of relative renal length D/H, D/BSA, D/BMI were calculated.
Results. D value ranged from 93.5 mm to 135.5 mm. Mean values of parameters were: D/H 0.67 ± 0.07 mm/cm, D/BSA 61.8 ± 8.7 mm/m^2, D/BMI 4.67 ± 0.79 mm/kg/m^2. No correlations were found of DPL changes and GFR MDRD changes with arterial pressure. A correlation was found between DPL changes and D. In patients whose DPL values decreased by at least 50%, mean values of D, D/H and D/BSA were higher. No correlations were found of GFR MDRD changes with D, D/H, D/BSA or D/BMI.
Conclusions. No influence of arterial blood pressure on the efficacy of treatment was discovered. Renal length is not a prognostic factor for changes in glomerular filtration rate; however, it can be a prognostic factor for proteinuria changes.
Key words: blood pressure, body mass index, body surface area, glomerular filtration rate, glomerulonephritis, height, proteinuria, renal length.

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Abbreviations: ACEI — angiotensin-converting enzyme inhibitors; ARB — angiotensin receptor blockers; b.w. — body weight; BMI — body mass index; BSA — body surface area; CKD — chronic kidney disease; D — absolute renal length; DBP — diastolic blood pressure; DPL — daily protein loss in urine; GFR MDRD — glomerular filtration rate according to MDRD formula; H — height; MAP — mean arterial pressure; NPG — non-proliferative glomerulonephritis; PG — proliferative glomerulonephritis; PP — pulse pressure; RAA — renin-angiotensin-aldosterone system; SBP — systolic blood pressure

Background

In patients with primary, chronic glomerulopathies, immune processes causing damage to the glomerular filtration barrier manifest themselves in proteinuria and glomerular filtration defect, and induce the development of secondary, renal parenchymal hypertension [1–3].

Apart from the underlying, causal immune process, proteinuria and glomerular filtration defect are also affected by intraglomerular pressure and hemodynamic conditions within the renal glomeruli affected by, among other things, systemic arterial pressure [2].

The progressive decrease in the number of active nephrons further propels the vicious cycle by worsening hemodynamic disorders in the remaining, normally-functioning nephrons, leading to the aggravation of proteinuria and its negative consequences, i.e. further progression of glomerular filtration defect. An important modulatory role in this process is played by arterial blood pressure [4, 5].

The progressive loss of active nephrons ultimately results in reduced kidney size and altered kidney structure [6, 7]. One of kidney size parameters is renal length, that is the measurement of its longitudinal axis obtained by measuring the longest straight line between two visible poles of the kidney [8]. Renal length constitutes an indicator of the progression of histopathological changes and chronicity of the disease process, as well as renal functional status and reserve [9–11].

Calculating relative renal length by relating absolute renal length to such anthropometric parameters as height, body surface area (BSA) and body mass index (BMI) serves as an attempt to determine nomograms and standardize kidney size, which would allow for the objectivization of the progression of structural changes.

It could be assumed that renal length could constitute a prognostic factor, modifying the extent of the influence of arterial pressure changes on the efficacy of treatment.

It thus seems reasonable to carry out an investigation aiming at:

1. Determining the absolute and relative renal length.
2. Assessing the influence of blood pressure changes and absolute and relative renal length on the efficacy of treatment.
3. Determining whether renal length modifies the influence of blood pressure changes on treatment efficacy.
4. Determining whether the type of glomerulonephritis has any bearing on the influence of blood pressure and renal length on treatment efficacy.

The study analyzed two indicators of the efficacy of treatment in a two-year period of observation: reduction of proteinuria and decline of renal excretory function.

Material and methods

The study was conducted retrospectively by analyzing medical records of patients with primary, chronic glomerulonephritis, diagnosed and treated at the Department of Nephrology, Hypertension and Internal Diseases and at the Outpatient Clinic of Nephrology of the Antoni Jurasz University Hospital in Bydgoszcz, in the years 2000–2006.

The study protocol was approved by The Bioethics Committee at Collegium Medicum in Bydgoszcz (KB/81/2007).

The study included patients over 17 years of age with complete clinical records, from whom representative material for histopathological testing was obtained, that is no less than 5 glomeruli in kidney specimens collected for analysis under an optical and immunofluorescence microscope, and whose two-year period of observation following renal biopsy was completed.

Initial analysis was performed in all patients who underwent renal biopsy in the years 2000–2004 (180 patients in total). After the analysis of the clinical course of kidney disease and kidney biopsy results, patients with the following conditions were excluded from further study:

— diabetes (irrespective of histopathological test results),
— secondary glomerulopathies in the course of collagenosis, including SLE, systemic vascular inflammation, neoplastic diseases, chronic inflammatory states,

— glomerulopathies in the course of diabetes, amyloidosis,
— hypertensive nephropathy,
— acute and rapidly progressive glomerulopathies.

Ultimately, 53 patients were involved in the study, including 25 women and 28 men. The patients were aged 17 to 63; mean age was 37.6 ± 12.9.

Analysis of medical reports pertained to the period of two weeks before and two weeks after renal biopsy, which was taken as the beginning of observation („0"), and at twenty-four months („24") following renal biopsy.

At the beginning of observation („0"), the following procedures were performed: percutaneous renal biopsy, measurement of body weight (b.w.) and height (H) and subsequent calculation of BSA and BMI, and determination of right and left kidney length performed upon revealing the longitudinal cross-section and axis of the kidneys in abdominal ultrasound examination. For each patient, absolute renal length (D) was calculated as the arithmetic mean of right and left kidney length.

$$BSA\ (m^2) = 0.007184 \times b.w.^{0.425} \times H^{0.725}\ [12]$$

$$BMI\ (kg/m^2) = b.w./H^2$$

where:

b.w. — body weight [kg],

H — height [m].

Absolute renal length (D) was related to anthropometric parameters by calculating the measurements of relative renal length D/H, D/BSA, D/BMI.

Based on renal biopsy, PG was diagnosed in 32 (60.4%) patients, and NPG in 21 (39.6%) patients (Figure 1).

At „0" and at „24", the following parameters were measured: SBP and DBP, which were the basis for calculation of MAP and PP, and serum creatinine level, which was the basis for calculation of GFR MDRD and DPL.

$$MAP\ (mmHg) = DBP + 1/3 \times (SBP–DBP)$$

$$PP\ (mmHg) = SBP–DBP$$

$$GFR\ MDRD\ (mL/min/1.73\ m^2) = 186 \times (serum\ creatinine)^{-1.154} \times (age)^{-0.203} \times C$$

where:

C — constant value: for men — 1; for women — 0.742; for African Americans — 1.21 [13].

Arterial hypertension was diagnosed in 37 (69.8%) out of 53 patients: 20 (71.4%) out of 28 men and 17 (68.0%) out of 25 women; 23 (71.9%) out of 32 patients with PG and 14 (66.7%) out of 21 patients with NPG. The differences were statistically insignificant.

During the two-year observation period, the patients were treated with immunosuppressive and antihypertensive drugs, in accordance with recommended treatment protocols. Target values of arterial pressure were the lowest ones, well tolerated by the patients. During the observation period, ACEI drugs were administered to 46 (86.8%), ARB drugs — to 16 (30.2%), and ACEI and ARB simultaneously — to 14 (26.4%) out of 53 patients. Despite no prior hypertension diagnosis, 14 (87.5%) out of 16 patients took RAA system blockers.

Statistics

The normality of variable distributions was analyzed using the Shapiro-Wilk test. Homogeneity

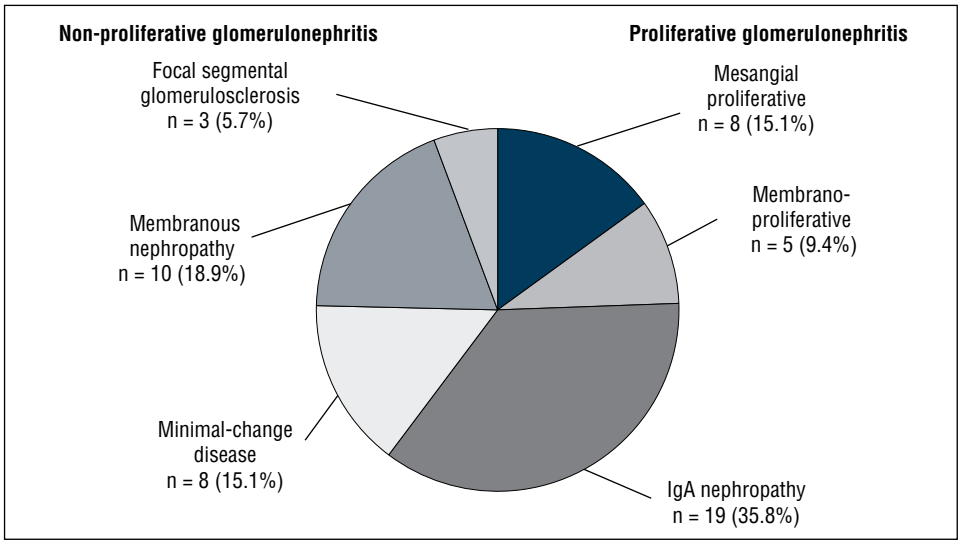

Figure 1. Histopathological findings based on the renal biopsy

Table I. Right and left kidney length (N = 53)

	N	Mean ± SD	Minimum	Maximum
Right kidney length [mm]	53	111.4[a] ± 12.2	87.0	141.0
Left kidney length [mm]	53	115.4[b] ± 10.0	98.0	138.0

[a,b]p = 0.0043

Table II. Absolute renal length and relative renal length indicators (N = 53)

	Mean ± SD	Minimum	Maximum
D [mm]	113.4 ± 10.0	93.5	135.5
D/H [mm/cm]	0.67 ± 0.07	0.52	0.83
D/BSA [mm/m^2]	61.8 ±8.7	47.2	90.6
D/BMI [mm/kg/m^2]	4.67 ± 0.79	3.30	6.58

of variance was analyzed using the Levene test. For variables with approximately normal distributions, results were presented as means and standard deviations (SDs), and the means were compared using the Student's t-test for independent and dependent variables. For variables whose distribution deviated from normal, results were presented as medians and ranges, and significant differences between groups were determined using the Mann-Whitney U test and Wilcoxon test. Group proportions were analyzed using the chi-square test (χ^2). Correlations between variables were determined using the Pearson's correlation coefficient for normally distributed variables and the Spearman's correlation coefficient for non-normally distributed variables.

To find the best parameters and optimal cut-off values for treatment efficacy indicators, receiver operating curves (ROCs) were plotted, and areas under curve (AUC) were calculated. To determine the prognostic value of the obtained cut-off values, the sensitivity, specificity, positive and negative predictive values, accuracy and likelihood ratio (LR) were calculated.

Multiple regression model was used to analyze the simultaneous influence of several variables on the dependent variable.

The significance level was set at p = 0.05. All calculations were performed using STATISTICA v.10.0 PL (StatSoft, Inc.).

Results

Ultrasound examination yielded renal length results ranging from 87 mm to 141 mm. The mean length of the left kidney was statistically significantly greater than that of the right kidney (p = 0.0043) (Table I). Further analysis focused on the D value, i.e. the arithmetic mean of the values of right and left kidney length. The values of D and relative renal length ratios D/H, D/BSA, D/BMI for the study population are presented in Table II. In the study population, no statistically significant correlations were found between D and age, H, BSA, or BMI. Mean values of right and left kidney length, D and D/H were lower in patients with PG (Table III).

In the study population, stage 1–2 CKD was diagnosed in 45 (84.9%) patients at „0", and in 38 (71.7%) patients at „24" (Figure 2). At „0", patients with PG were found to have a higher median of creatinine levels and a lower mean value of GFR MDRD, while patients with NPG were found to have a higher median of DPL values. No differences were found in the mean values of arterial pressure (Table IV).

In the study population, positive correlations were found of DPL „0" with D and D/H (Figure 3). No statistically significant correlations were found of DPL „0" with D/BSA or D/BMI. In patients with PG, positive correlations were found of DPL „0" with D and D/H, which were not observed in patients with NPG (Figures 4, 5).

At „0", positive correlations were found of DPL with SBP (R = 0.53; p = 0.0142) and MAP (R = 0.48; p = 0.0268) in patients with NPG; such correlations were not found in patients with PG.

During observation, a decrease in the median of DPL values was found in patients from both NPG and PG groups. A decrease in mean SBP, DBP and MAP values was found only in patients with NPG (Tables V, VI).

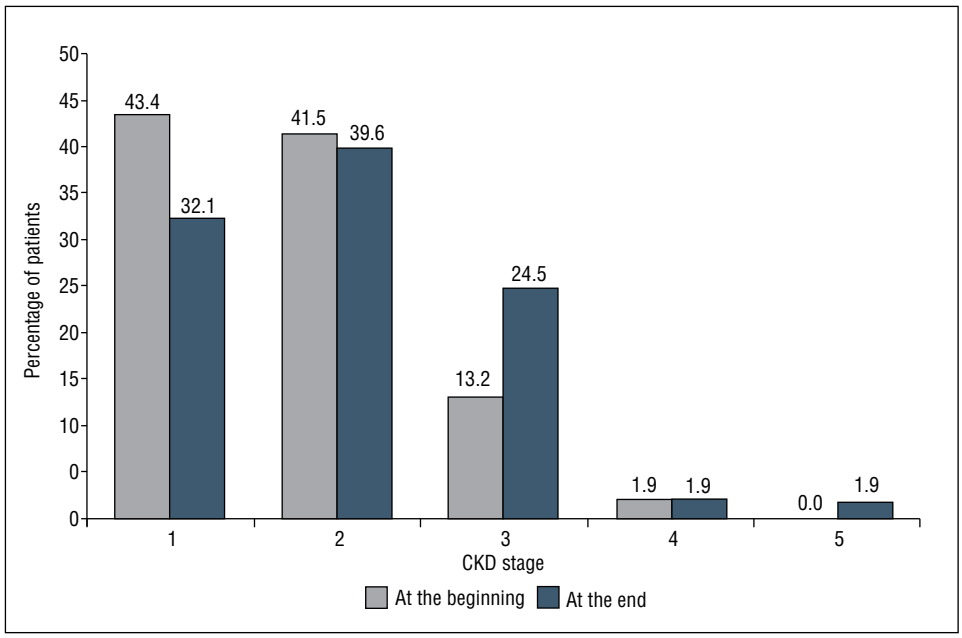

Figure. 2. Percentage of patients in particular CKD stages according to the GFR MDRD at the beginning and at the end of the two-year observation period

Table III. Parameters of the kidneys and relative renal length indicators depending on the type of glomerulonephritis

	PG (N = 32)	NPG (N = 21)	p value
	Mean ± SD	Mean ± SD	
Right kidney length [mm]	107.8 ± 11.6	117.0 ± 11.3	0.0065
Left kidney length [mm]	113.0 ± 9.6	119.1 ± 9.7	0.0272
D [mm]	110.4 ± 9.1	118.0 ± 9.8	0.0056
D/H [mm/cm]	0.65 ± 0.06	0.70 ± 0.07	0.0025
D/BSA [mm/m^2]	59.9 ± 7.2	64.6 ± 10.1	0.0538
D/BMI [mm/kg/m^2]	4.59 ± 0.76	4.77 ± 0.85	0.4179

Table IV. Clinical characteristics at the beginning of observation depending on the type of glomerulonephritis

	PG (N = 32)	NPG (N = 21)	p value
	Mean ± SD Median* (min; max)	Mean ± SD Median* (min; max)	
DPL 0 [g/day]	2.12* (0.15; 11.10)	5.45* (0.32; 19.6)	0.0034
Serum creatinine 0 [mg/dL]	0.99* (0.44; 3.56)	0.84* (0.49; 1.42)	0.0090
GFR MDRD 0 [mL/min/1.73 m^2]	76.3 ± 28.6	95.2 ± 21.2	0.0124
SBP 0 [mmHg]	125.5 ± 11.6	128.9 ± 14.2	0.3438
DBP 0 [mmHg]	78.5 ± 8.3	82.3 ± 12.0	0.1751
MAP 0 [mmHg]	94.1 ± 8.5	97.8 ± 12.0	0.1979
PP 0 [mmHg]	47.0 ± 9.0	46.6 ± 9.0	0.8708

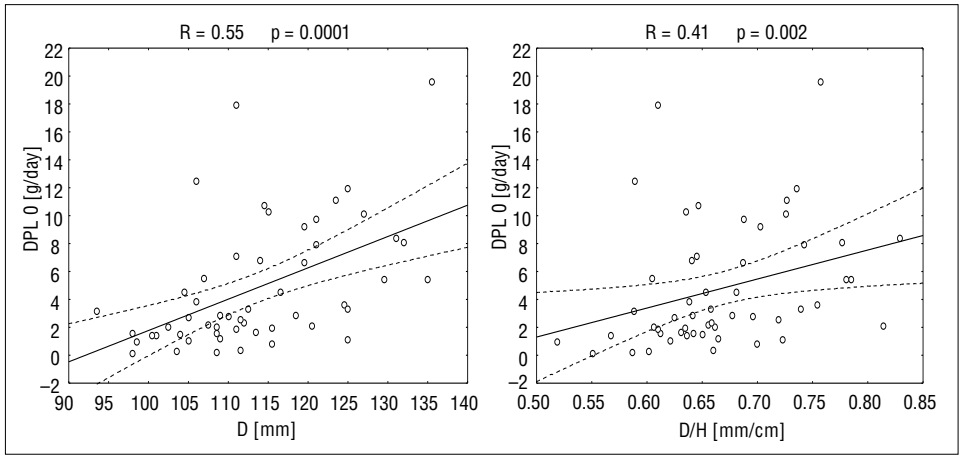

Figure. 3. Correlations between DPL „0" and D and D/H (N = 53)

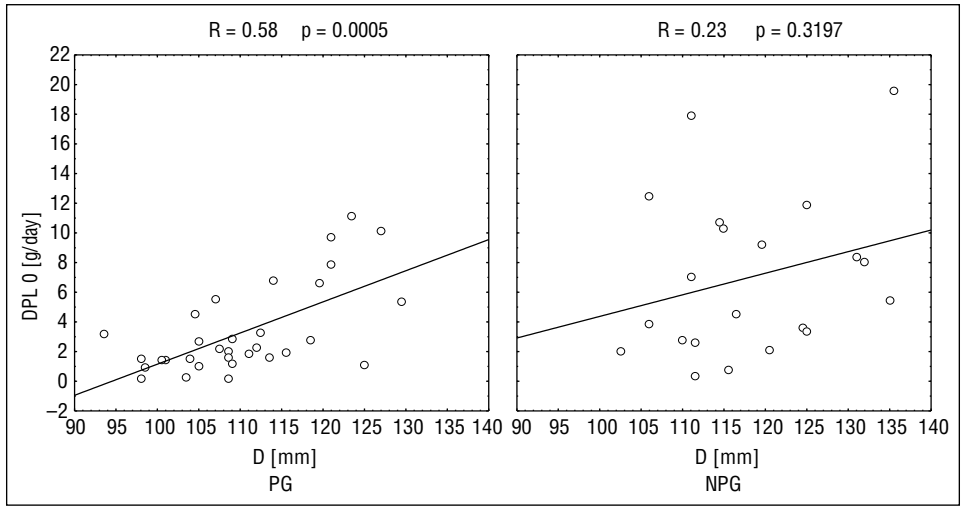

Figure 4. Correlations between DPL „0" and D depending on the type of glomerulonephritis

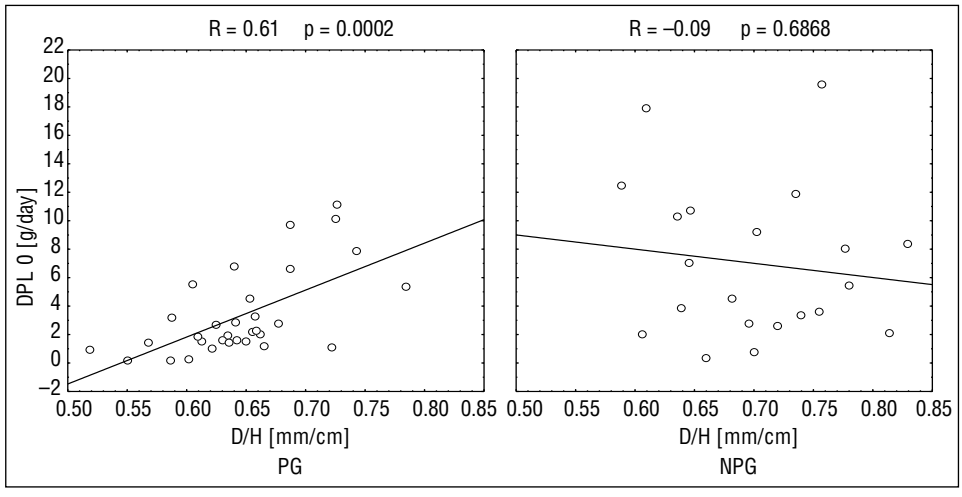

Figure 5. Correlations between DPL „0" and D/H depending on the type of glomerulonephritis

Table V. Clinical characteristics of the patients with PG at the beginning and at the end of observation (N = 32)

	„0"	„24"	p value
	Mean ± SD Median* (min; max)	Mean ± SD Median* (min; max)	
DPL [g/day]	2.12* (0.15; 11.10)	0.98* (0.00; 5.00)	0.0026
Serum creatinine [mg/dL]	0.99* (0.44; 3.56)	1.01* (0.66; 4.23)#	0.2062
GFR MDRD [mL/min/1.73m^2]	76.3 ± 28.6	71.2 ± 24.4#	0.1770
SBP [mmHg]	125.5 ± 11.6	125.5 ± 18.8	0.9905
DBP [mmHg]	78.5 ± 8.3	79.0 ± 10.3	0.7420
MAP [mmHg]	94.1 ± 8.5	94.5 ± 12.7	0.8325
PP [mmHg]	47.0 ± 9.0	46.5 ± 11.0	0.8185

*N = 31

Table VI. Clinical characteristics of the patients with NPG at the beginning and at the end of observation (N = 21)

	„0"	„24"	p value
	Mean ± SD Median* (min; max)	Mean ± SD Median* (min; max)	
DPL [g/day]	5.45* (0.32; 19.6)	1.10* (0.00; 10.2)	0.0030
Serum creatinine [mg/dL]	0.84* (0.49; 1.42)	1.00* (0.60; 1.33)	0.1978
GFR MDRD [mL/min/1.73m^2]	95.2 ± 21.2	84.6 ± 20.1	0.0990
SBP [mmHg]	128.9 ± 14.2	119.0 ± 15.3	0.0048
DBP [mmHg]	82.3 ± 12.0	74.3 ± 8.3	0.0035
MAP [mmHg]	97.8 ± 12.0	89.2 ± 9.6	0.0012
PP [mmHg]	46.6 ± 9.0	44.8 ± 11.8	0.5345

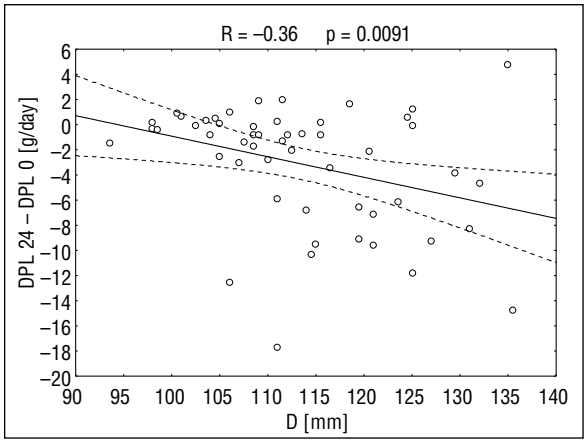

Figure 6. Correlation between DPL changes and D (N = 53)

In the study population, a negative correlation was found between DPL changes and D (Figure 6), whereas no statistically significant correlations were found of DPL changes with D/H, D/BSA or D/BMI. Negative correlations of DPL changes with D, D/H and D/BSA were found only in patients with PG (Figure 7).

In the study population, no statistically significant correlations were found between DPL changes and arterial pressure at the start as well as pressure changes during the observation period. A negative correlation was found between DPL changes and SBP „0" only in patients with NPG (Figure 8).

In multiple regression models obtained for all the analyzed parameters, only the influence of D on DPL changes was statistically significant (Tables VII, VIII).

The criterion for reduced proteinuria was taken to be a decrease in DPL after a two-year observation period by no less than 50% of the value determined at „0". It was found in 58.5% of the study population: 50% of patients with PG and 71.4% of patients with NPG; in 51.3% of patients with hypertension and 75.0% of patients without hypertension. The differences were statistically insignificant.

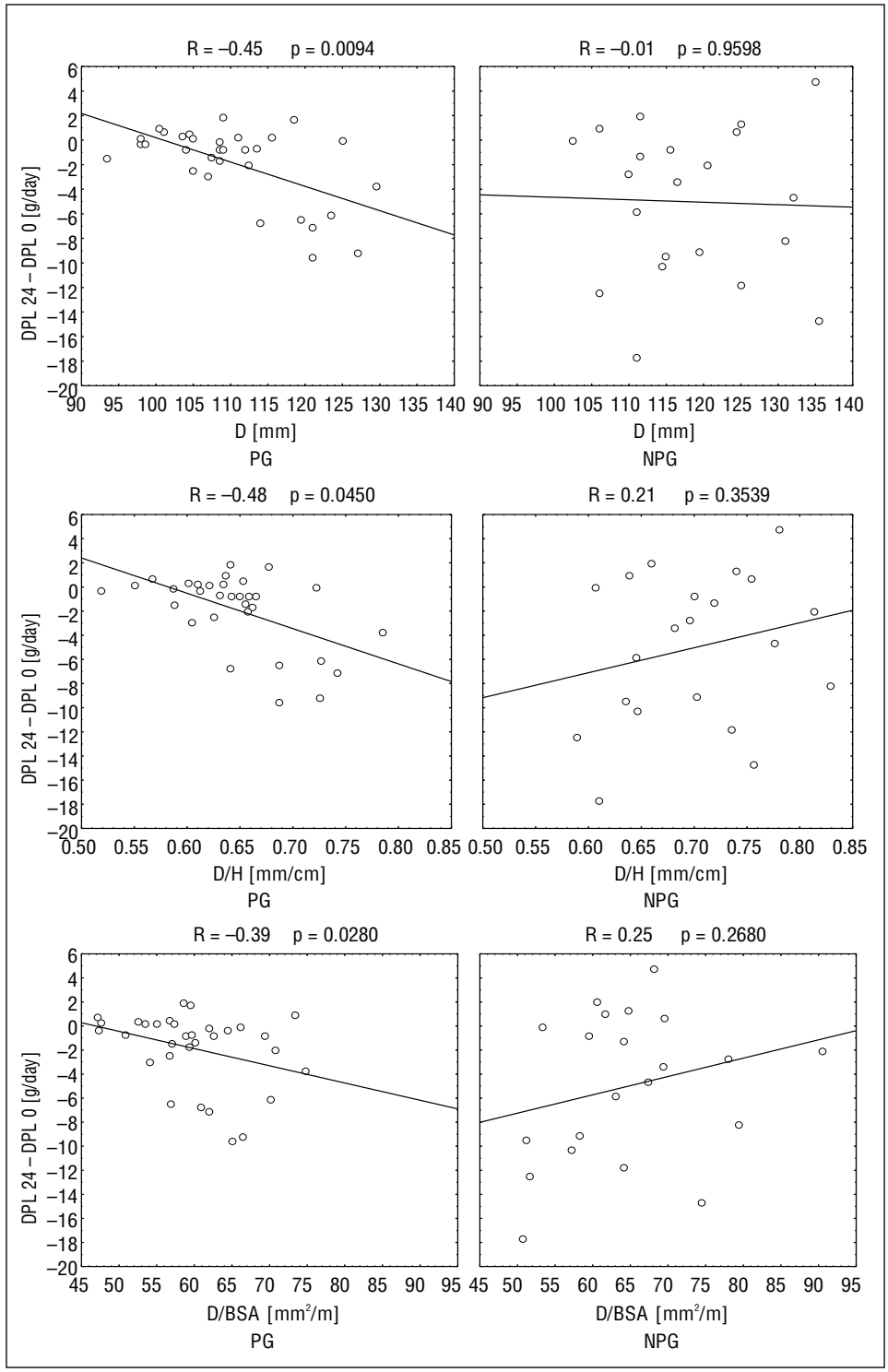

Figure 7. Correlations between DPL changes and D, D/H and D/BSA depending on the type of glomerulonephritis

Both in the whole study population and in the group of PG patients whose DPL values decreased by at least 50%, mean D, D/H and D/BSA values were higher (Tables IX, X). The differences were not observed in patients with NPG (Table XI).

ROC curves were plotted for all the analyzed parameters. Cut-off values, differentiating the population in terms of the likelihood of DPL decreasing by no less than 50%, were determined only for D, D/H, D/BSA and DPL „0" (Figure 9). For the said

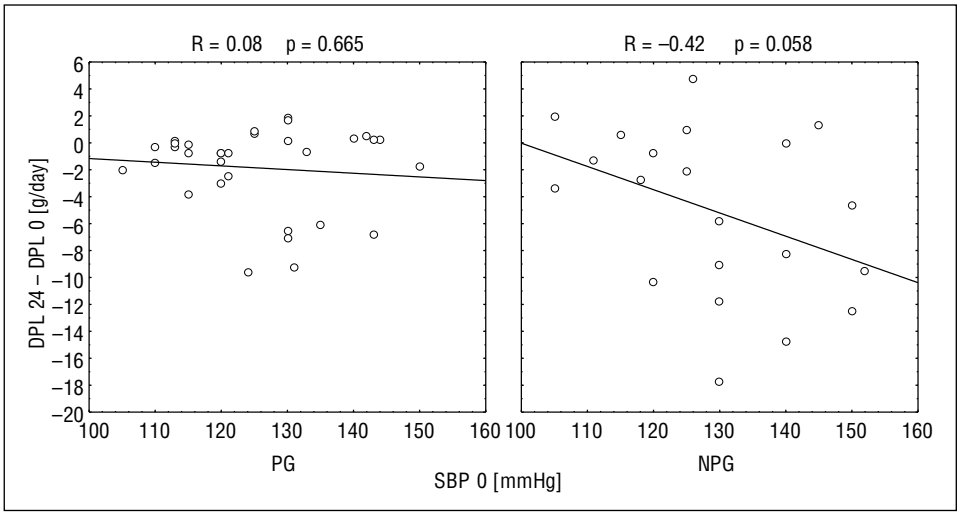

Figure 8. Correlations between DPL changes and SBP „0" depending on the type of glomerulonephritis

Table VII. Multiple regression analysis for dependent variable DPL 24 — DPL 0 with parameters at the beginning of observation (N = 53)

Dependent variable DPL 24 — DPL 0 [g/day]			$R^2 = 0.172$
Independent variable	**BETA**	**Std. Error BETA**	**p**
D [mm]	–0.29	0.13	0.0323
SBP 0 [mmHg]	–0.23	0.13	0.0818

Table VIII. Multiple regression analysis for dependent variable DPL 24 — DPL 0 with changes of parameters after a two-year observation period (N = 52)

Dependent variable DPL 24 — DPL 0 [g/day]			$R^2 = 0.209$
Independent variable	**BETA**	**Std. Error BETA**	**p**
D [mm]	–0.30	0.13	0.0240
SBP 24 — SBP 0 [mmHg]	0.26	0.13	0.0520
Age [years]	–0.14	0.13	0.2850

parameters and their cut-off points, the following statistics were calculated: area under curve (AUC), sensitivity, specificity, accuracy, positive and negative predictive value, and likelihood ratio (LR) (Table XII).

In the study population, no statistically significant correlations were found of GFR MDRD „0" and GFR MDRD changes with D values and relative renal length parameters. None were also found between GFR MDRD changes and arterial pressure at the start as well as pressure changes during the observation period.

The criteria for renal function decline were taken to be: a double increase in initial serum creatinine levels or a decrease in GFR MDRD values by at least 4 ml/min/1.73 m^2/year or the need to implement renal replacement therapy during a two-year observation period. The said criteria were observed in 49.1% of patients from the study population: 46.9% of patients with PG and 52.4% of patients with NPG; 48.6% of patients with hypertension and 50.0% of patients without hypertension. The differences were statistically insignificant. In the two-year observation period, the median of the value of annual GFR MDRD change was –3.51 mL/min/1.73 m^2/year in the study population, and –10.63 mL/min/1.73 m^2/year in the group of patients with renal function decline.

No differences were found in mean values of D, relative renal length parameters, and mean values of arterial pressure at „0" between patients whose excretory renal function deteriorated and those with no renal function decline (data not presented).

Table IX. Values of absolute renal length and of relative renal length indicators in groups with and without the reduction of DPL by no less than 50% during a two-year observation period (N = 53)

	With the reduction of DPL by no less than 50% (N = 31)	Without the reduction of DPL by no less than 50% (N = 22)	p value
	Mean ± SD	Mean ± SD	
D [mm]	116.1 ± 8.7	109.7 ± 10.8	0.0181
D/H [mm/cm]	0.69 ± 0.06	0.64 ± 0.06	0.0136
D/BSA [mm/m^2]	63.9 ± 9.2	58.8 ± 7.1	0.0336
D/BMI [mm/kg/m^2]	4.80 ± 0.90	4.47 ± 0.6	0.3111

Table X. Values of absolute renal length and of relative renal length indicators in groups with and without the reduction of DPL by no less than 50% during a two-year observation period in patients with PG (N = 32)

	With the reduction of DPL by no less than 50% (N = 16)	Without the reduction of DPL by no less than 50% (N = 16)	p value
	Mean ± SD	Mean ± SD	
D [mm]	114.1 ± 8.2	106.7 ± 8.7	0.0187
D/H [mm/cm]	0.67 ± 0.05	0.62 ± 0.05	0.0081
D/BSA [mm/m^2]	6.6 ± 6.5	57.2 ± 7.0	0.0305
D/BMI [mm/kg/m^2]	4.76 ± 0.85	4.43 ± 0.64	0.2185

Table XI. Values of absolute renal length and of relative renal length indicators in groups with and without the reduction of DPL by no less than 50% during a two-year observation period in patients with NPG (N = 21)

	With the reduction of DPL by no less than 50% (N = 15)	Without the reduction of DPL by no less than 50% (N = 6)	p value
	Mean ± SD	Mean ± SD	
D [mm]	118.3 ± 8.9	117.4 ± 12.7	0.2701
D/H [mm/cm]	0.70 ± 0.07	0.70 ± 0.07	1.0000
D/BSA [mm/m^2]	65.3 ± 11.5	63.0 ± 5.9	0.1455
D/BMI [mm/kg/m^2]	4.85 ± 0.96	4.59± 0.45	0.1023

Table XII. Determination of predictive values for the reduction of DPL by no less than 50% during a two-year observation period at determined cut-off values

Parameter	Cut-off value	AUC	Sensitivity	Specificity	Accuracy	Positive predictive value	Negative predictive value	LR
D [mm]	106.0	0.698	0.935	0.455	0.736	0.710	0.833	1.7
D/H [mm/cm]	0.64	0.707	0.806	0.600	0.720	0.735	0.684	2.0
D/BSA [mm/m^2]	60.92	0.658	0.613	0.682	0.640	0.731	0.555	1.9
DPL 0 [g/day]	4.50	0.790	0.613	0.910	0.740	0.905	0.625	6.7

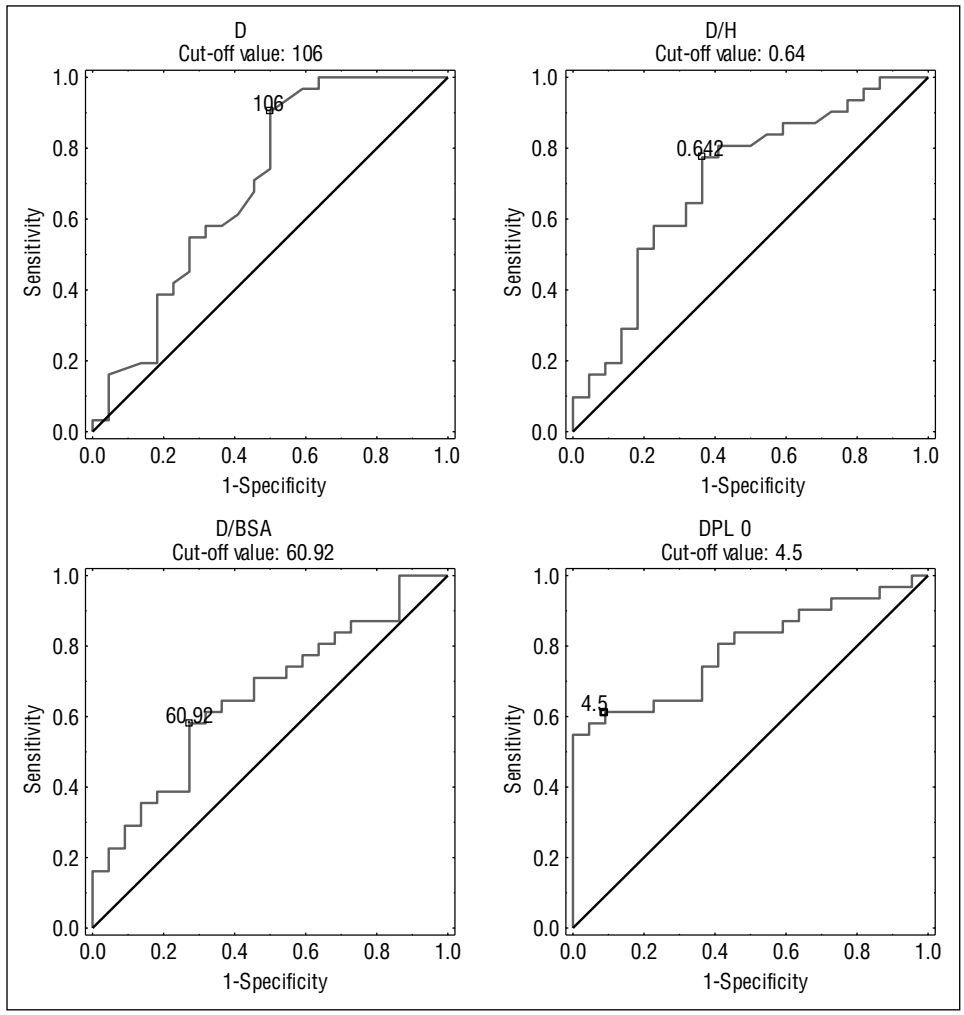

Figure 9. ROC curves for D, D/H, D/BSA and DPL „0" presenting cut-off values for the DPL reduction by no less than 50% during a two-year observation period

ROC curves were also plotted for the above parameters, though they did not differentiate the study population in terms of the risk for excretory renal function decline (data not presented).

Discussion

Renal length measurements obtained in patients with primary, chronic glomerulopathies, the broad range of their values and interrelations between left and right kidney length (Tables I–III) are consistent with results obtained in studies involving populations of patients with no diagnosis of a present or past kidney disease [8, 14, 15].

In the present study, relative renal length indicators were calculated and presented in Tables II and III. In a study by Mileticia et al., an attempt was also made to examine the correlation between kidney length and height. Right and left kidney lengths were related to height and the KBR parameter (kidney length/body height ratio) was calculated, corresponding to the D/H parameter used in the present study. In a group of patients aged 20–59 — an age range similar to that in the present study — mean KBR values were 0.672–0.664 mm/cm for the left and 0.661–0.647 mm/cm for the right kidney [16]. The values were thus comparable to mean D/H values obtained in the present study. The literature lacks data on value ranges for the remaining relative renal length ratios (D/BSA and D/BMI), both in healthy adults and in patients with chronic kidney disease.

In the study population, no statistically significant correlations were found of D with H, BSA or BMI. Numerous studies have reported such correlations, though they were of moderate or low significance, which suggests the need to critically reconsider the said correlations [14, 17]. In the study population, no correlations were also found between D values

and age, which is understandable considering the age of subjects included in the study and the fact that renal length remains constant between age 30–60 and can be expected to decrease in patients aged over 60–70 [14, 15, 18].

Analysis of differences in renal length parameters (Table III) and renal excretory functions at the beginning of observation (Table IV) between patients with PG and those with NPG allows to assume that the level of progression of tubulointerstitial changes determining the functional status and structural changes of the kidneys in patients with PG could be higher. PG is more often associated with lower proteinuria, active urinary sediment and arterial hypertension (often incorrectly diagnosed as primary hypertension). These are indicators of nephritic syndrome, which is presumably identified later than nephrotic syndrome — a common indicator of NPG — which in turn might promote the progression of tubulointerstitial changes.

As regards the influence of arterial hypertension and its changes on changes in proteinuria and GFR, the present findings are unlike those revealed by many studies which observed significant correlations between hypertension, proteinuria and GFR [19–22]. A likely cause of the discrepancies is the fact that despite the high rate of diagnosis of hypertension, the values of arterial blood pressure remained relatively low both at the start and during the two-year observation period (Tables IV–VI). This might be the result of the intensive pharmacotherapy administered (including RAA blockers), allowing to achieve the lowest pressure values which were well tolerated by patients, but consequently precluding the possibility to determine a possible influence of arterial pressure on changes in proteinuria and GFR. Since the course of arterial hypertension accompanying glomerulonephritis is characterized by complex interrelations between systemic arterial pressure and hemodynamic conditions within renal glomeruli, damage to glomerular structures caused by hyperfiltration, hyperperfusion and barotrauma might be largely unaffected by the value of systemic pressure. Analysis of pressure changes and its correlations with changes in proteinuria allows to assume that the role of systemic systolic blood pressure in inducing proteinuria changes is most significant in patients with NPG (Figure 8), which might be associated with a different pathogenesis of glomerular changes depending on the type of glomerulopathy, including the active role of podocytes and mesangiocytes in the inflammatory process, the autoregulation of blood flow, and the degree of transmission of systemic pressure onto glomerular circulation [23, 24].

Proteinuria and its changes, serving as an indicator of treatment efficacy, seem to be connected with renal length (Tables VII–X; Figures 3–7, 9). Analysis of ROC curves allowed to determine the values of D, D/H and D/BSA, which best divide the study population into a sub-group with a higher likelihood of DPL decreasing by at least 50%, and a sub-group in which the said likelihood is lower. The highest AUC values reaching 0.698 and 0.707 were observed for D and D/H, respectively. For D and D/H, relatively high values of sensitivity were also observed, standing at 0.935 and 0.806, at specificity of 0.455 and 0.600, and accuracy of 0.736 and 0.720. AUC value, sensitivity and accuracy for D/BSA were lower, and the specificity was 0.682. The positive predictive value for all three kidney size parameters was similar and ranged from 0.710 to 0.735, which means that in 71.0% of patients with D ≥ 106 mm, in 73.5% with D/H ≥ 0.64 mm/cm and in 73.1% with D/BSA ≥ 60.92 mm/m^2, DPL value decreased by at least 50% during the two-year observation period (Table XII). The obtained results might indicate that as the value of renal length increases, the level of DPL at the beginning of observation increases as well, but so also does the likelihood of its reduction during the two-year observation period. It also seems that the type of glomerulopathy might determine the correlations between proteinuria and its changes, and renal length (Tables X, XI; Figure 7). Further studies are required to verify the above observations.

The most significant changes in renal length are found at GFR 30–90 mL/min, which suggests that processes leading to structural changes are most numerous in CKD stage 2 and 3 [11]. The rate of glomerular filtration defect might inversely affect the reduction of renal length [25]. Considering the above, it might be assumed that the high percentage of patients remaining in stage 1–2 of CKD (Figure 2) and the severe dynamics of GFR MDRD defect could account for the lack of correlations of GFR MDRD at the beginning of the two-year observation and its changes during that period with renal length. Additional information could be provided by sequential measurements of renal length performed during a longer period of observation.

Conclusions

Renal length of adult patients with primary, chronic glomerulonephritis in the early stages of chronic kidney disease and with normal or slightly decreased glomerular filtration rate is comparable to renal length in healthy people.

No influence of arterial blood pressure and its changes on the efficacy of treatment was discovered.

Renal length does not constitute a prognostic factor for changes in glomerular filtration rate; however, it can be a prognostic factor for proteinuria changes, particularly in patients with proliferative glomerulonephritis. The highest prognostic value is displayed by absolute renal length and relative renal length measurements D/H and D/BSA.

Renal length was not found to be a factor modifying the influence of arterial blood pressure and its changes on treatment efficacy.

Influence of arterial blood pressure and renal length on treatment efficacy may depend on the type of glomerulonephritis.

Contribution statement

Both authors contributed equally to this study. EM designed and performed the study; EM and JM analyzed the data, discussed the results and commented on the manuscript. JM approved the final version to be published. EM and JM are accountable for all aspects of the work.

Compliance with Ethical Standards

Funding

Neither of the Authors has been awarded a grant, therefore both Authors declare no conflict of interests.

Ethical approval

The Bioethics Committee at the Nicolaus Copernicus University Collegium Medicum in Bydgoszcz approved this study (permission no. KB 81/2007) in accordance with amendments to the 1964 Helsinki declaration.

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