

Estimated Glomerular Filtration Rate in Patients With Surgically Acquired Single Kidney Compared With Patients With Congenital Single Kidney: Implications For Kidney Transplant From Live Donors

Florica Nicoleta Gadalean,¹ Gheorghe Gluhovschi,¹ Virginia Trandafirescu,¹ Ligia Petrica,¹ Silvia Velciov,¹ Gheorghe Bozdog,¹ Cristina Gluhovschi,¹ Flaviu Bob,¹ Corina Vernic²

Abstract

Objectives: The pathophysiology of the single kidney is involved in the evolution toward end-stage renal disease. Furthermore, most data suggest that the renal function of the donor is maintained after nephrectomy. This study sought to analyze the difference between surgically acquired single kidney and the congenital single kidney, regarding kidney function at a similar moment in time of the existence of a single kidney.

Materials and Methods: Two groups were enrolled in this study. Group A consisted of 28 patients with surgically acquired single kidney, time from nephrectomy was 30.23 ± 10.82 years; mean age, 54.42 ± 14.99 years. Group B consisted of 20 patients with a congenital single kidney (mean age, 30.3 ± 10.43 years). We assessed glomerular filtration rate (Modification of Diet in Renal Disease 4 Study Equation) and the presence of classic and nonclassic risk factors for chronic kidney disease.

Results: The estimated glomerular filtration rate showed no statistically significant difference between the 2 groups.

Conclusions: Our study did not show any influence of surgical nephrectomy on the evolution of kidney function. Kidney function in the surgically acquired single kidney was similar to the kidney function in the congenital single kidney at a comparable time

interval. Our results have potential favorable implications for kidney transplant from living donors.

Key words: Renal function, Risk factors, One kidney

The pathophysiology of the single kidney is of great interest to current medical practice, owing, in part, to the continuous rise in the number of living-donor kidney transplants. In 2001, the number of transplants in the United States from living donors exceeded the number of kidney transplants from deceased donors (1). This paper discusses the long-term consequences related to single kidney status.

At the beginning of the 1980s, Brenner and associates showed that nephrectomized rats demonstrated compensatory adaptive changes (ie, hypertrophy and hyperfiltration) in the remaining kidney (2). These structural and functional changes are involved in proteinuria, arterial hypertension, and progressive functional renal changes including end-stage renal disease.

Patients born with a single kidney have an increased risk of renal function decline because compensatory adaptation mechanisms begin at birth (3, 4, 5, 6, 7). On the other hand, some authors uphold the hypothesis that a single congenital kidney possesses twice the nephrons of a kidney of a binephric individual. Twice the nephrons would negate compensatory adaptive hyperfiltration and hypertrophy (8, 9).

In clinical practice, the majority of people born with unilateral renal agenesis have stable renal function and a good prognosis for several decades (10, 11). Frequently, this urinary anomaly is diagnosed incidentally when patients are examined

From the ¹Department of Nephrology, County Hospital, University of Medicine and Pharmacy, Timisoara, Romania; and the ²Department of Biostatistics, University of Medicine and Pharmacy, Timisoara, Romania

Address reprint requests to: Dr. Florica Gadalean, Str. Iuliu Grozescu, Bl T27, Et2, Ap10 300107 Timisoara, Romania

Phone: +40 741 346 890 Fax: +40 256 486 967 E-mail: fmmicorici@yahoo.com

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for other renal diseases, such as urinary tract infections or nephrolithiasis.

The question to be considered is whether patients with surgically acquired single kidney and patients with congenital single kidney have similar renal function at a comparable time interval. This is one of the most-interesting and controversial problems debated in the literature.

To answer the above-mentioned question, we have undertaken a study on 2 groups of individuals: patients with surgically acquired single kidney versus patients with congenital single kidney, at a similar moment in time of the existence of a single kidney. The similar period of existence of a single kidney in both groups constituted a starting point in the comparative assessment of the outcome in time of renal function of the surgically acquired versus the congenital single kidney.

Materials and Methods

A retrospective study was performed on 2 groups of patients: group A: 28 patients (p) with surgically acquired single kidney, and group B: 20 patients (p) with congenital single kidney. The selection of cases was performed out of 183 patients with single kidney who were hospitalized in the nephrology department. Selection criterion was represented by the duration of existence of the single kidney in both groups by an average of 30.23 ± 10.82 years, with a time frame of 17-54 years, from the moment of nephrectomy for group A, comparable to the average age of patients with congenital single kidney (group B): 31.30 ± 10.43 years. The assessment was performed at a similar time interval of the existence of a single kidney in both groups.

For group A patients (n=28; mean age, 54.42 ± 14.99 years; 35.71% male; n=10; and 64.28% female; n=18), the mean time from nephrectomy was 30.23 ± 10.82 years (17-54 years). The causes of nephrectomy included complicated renal lithiasis (n=18; 64.26%), scleroatrophic kidney (n=3; 10.7%), renal trauma (n=2; 7.14%), renal tumor (n=2; 7.14%), renal tuberculosis (n=1; 3.57%), renal artery stenosis (n=1; 3.57%), and pyelo-ureteral junction stenosis (n=1; 3.57%). At the time of nephrectomy, renal function was normal in all 28 patients. Average age at nephrectomy was 24.9 ± 11.30 years.

Group B consisted of patients with a congenital single kidney (n=20; 45% male; n=9; 55% female;

n=11; aged 17-54 years; mean age, 31.30 ± 10.43). The study conforms with the ethical guidelines of the 1975 Helsinki Declaration. Written informed consent was signed from the patients and the Hospital Ethics Committee approved the study protocol.

We assessed patients on the following parameters: serum creatinine, glomerular filtration rate, and traditional and nontraditional risk factors for chronic kidney disease initiation and progression, as specified by Taal and Brenner (12), including hypertension, proteinuria, anemia, obesity, dyslipidemia, coronary heart disease, diabetes mellitus, smoking, inflammation markers (fibrinogen, C-reactive protein), renal lithiasis, and recurrent urinary tract infection.

Laboratory methods

Using a routine biochemical examination, we measured serum creatinine, cholesterol, triglycerides, fibrinogen, C-reactive protein, hemoglobin, glomerular filtration rate, glycemia, uric acid, and urine culture.

In conformity with laboratory practice, pathological values were as follows: serum creatinine $> 132.6 \mu\text{mol/L}$ in males and $> 114.92 \mu\text{mol/L}$ in females, glycemia $> 6.99 \text{ mmol/L}$, serum cholesterol $> 5.18 \text{ mmol/L}$, triglycerides $> 2.26 \text{ mmol/L}$, uric acid $> 386.65 \mu\text{mol/L}$, proteinuria $> 0.150 \text{ g/24h}$, C-reactive protein $> 28.57 \text{ nmol/L}$, fibrinogen $> 11.76 \mu\text{mol/L}$, hemoglobin (Hb) $< 120 \text{ g/L}$ in males and $< 110 \text{ g/L}$ in females, systolic blood pressure $\geq 140 \text{ mm Hg}$, and diastolic blood pressure $\geq 90 \text{ mm Hg}$. Obesity was defined as body mass index $> 30 \text{ kg/m}^2$, overweight as body mass index between $25\text{-}29.9 \text{ kg/m}^2$, and smoking was assessed as pack numbers/year.

Chronic kidney disease was defined as either kidney damage (pathological abnormalities or markers of damage including abnormalities in blood or urine samples) or glomerular filtration rate $< 60 \text{ mL/min}$ for more than 3 months. The stages of chronic kidney disease (1-5) were established according to the K/DOQI guidelines 2002, revised by the KDIGO guidelines 2005 (estimated glomerular filtration rate-MDRD4 equation formula: $186 \times (\text{SC in mg/dL})^{-1.154} \times (\text{age in years})^{-0.203} \times (0.742 \text{ if female} - \text{K/DOQI 2002; KDIGO 2005})$: stage 1 glomerular filtration rate $> 90 \text{ mL/min/1.73m}^2$; stage 2 glomerular filtration rate $60\text{-}90 \text{ mL/min/1.73m}^2$; stage 3 glomerular

filtration rate 30-60 mL/min/1.73m²; stage 4 glomerular filtration rate 30-15 mL/min/1.73m²; stage 5 glomerular filtration rate < 15 mL/min/1.73m² (13). Presence of obstructive uropathy was assessed using abdominal ultrasound, and in some cases, urography and/or CT scan were used.

Statistical analyses

We present the clinical and biological parameters as means, standard deviations, and proportions. Statistical analyses were performed with SPSS software for Windows (Statistical Product and Service Solutions, version 10.0, SSPS Inc, Chicago, IL, USA) and OpenEpi (www.openepi.com). To compare mean values, we used the unpaired *t* test; to compare proportions, we used the chi-square test. The correlation analysis used the Pearson correlation coefficient (*r*). Statistical significance was set at *P* < .05.

Results

Glomerular filtration rate assessment of renal function using MDRD4 revealed the following distribution of chronic kidney disease stages for group A: stage 2-15p (53.37%); stage 3-9p (32.14%); stage 4-1p (3.57%), and stage 5-3p (10.71%). For group B, the chronic kidney disease stage distribution was as follows: stage 1-5p (25%), stage 2-7p (35%), stage 3-6p (30%), stage 4-1p (5%), and stage 5-1p (5%).

Characteristics of the patients studied with regard to the clinical and biological data are presented in Table 1. There was a statistically significant age difference between groups A and B (*P* < .001), which was required to analyze kidney function at a comparable time interval. To avoid this difference, patients with unilateral nephrectomy in childhood would have been necessary (which is obviously difficult to obtain). We also observed statistically significant differences between groups A and B for the following factors: systolic blood pressure (*P* = .0423), duration of hypertension (*P* < .001), serum cholesterol (*P* = .0183), and cardiovascular disease (*P* = .008), which reflect existing data in the literature (14-18), and these differences are explained by the age differences between the 2 groups. Epidemiologic studies have shown that hypertension is significantly associated with age (15, 16). A data series showed that the prevalence of high-isolated

Table 1. Clinical and biological patient characteristics.

Parameter	Patients with surgically acquired single kidney (group A) n=28	Patients with congenital single kidney (group B) n=20	P value
Age (y)	54.42 ± 14.99	31.30 ± 10.43	< .001
Duration hypertension (y)	9.74 ± 7.64 (n=14)	3.16 ± 2.51 (n=5)	< .001
Mean age at hypertension start (y)	55.04 ± 14.42 (n=14)	27.63 ± 9.26 (n=5)	NS
Body mass index, kg/m ²	26.15 ± 5.03	23.97 ± 4.85	NS
Systolic blood pressure, mm Hg	132.5 ± 26.47	118.5 ± 16.55	= .04234
Diastolic blood pressure, mm Hg	77.5 ± 12.94	71 ± 11.87	NS
Hb, g/L	124.6 ± 19.5	125.6 ± 20.3	NS
Serum creatinine, μmol/L	139.67 ± 120.22	122.88 ± 81.33	NS
Glycemia, mmol/L	5.38 ± 0.84	5.13 ± 0.47	NS
Serum cholesterol, mmol/L	5.32 ± 1.30	4.65 ± 1.29	= .01836
Triglycerides, mmol/L	1.53 ± 0.65	1.51 ± 1.30	NS
Uric acid, μmol/L	341.44 ± 109.45	289.10 ± 107.07	NS
Fibrinogen, μmol/L	10.74 ± 3.43	11.57 ± 3.32	NS
C-reactive protein, nmol/L	41.05 ± 56.00	59.91 ± 97.81	NS
Proteinuria, g/24 h	0.24 ± 0.33	0.28 ± 0.25	NS
GFR, mL/min/1.73 m ²	56.51 ± 22.09	68.78 ± 25.72	NS
Smoking (%)	35.71 (n=10)	35 (n=7)	NS
Cardiovascular disease (%)	35.71 (n=10)	0 (n=0)	= .00821
Renal stone (%)	21.42 (n=6)	15 (n=3)	NS
Urinary infection (%)	46.42 (n=13)	55 (n=11)	NS

Data are presented as mean ± standard deviation or number (%) of patients.

Abbreviations: GFR, glomerular filtration rate; Hb, hemoglobin; NS, not significant.

systolic blood pressure sharply increased with age in both men and women (17). Dyslipidemia also was significantly associated with age (18).

The assessment of chronic kidney disease risk factors in group A revealed statistically significant differences between the subgroup of patients with normal renal function (1A) versus the subgroup of patients with chronic kidney disease (2A) for the following parameters (Table 2): mean age (*P* = .0029), duration from nephrectomy (*P* = .00625), systolic blood pressure (*P* = .03185), Hb (*P* = .01586), proteinuria (*P* = .04039), and C-reactive protein (*P* = .02618).

In group B, chronic kidney disease risk-factors analysis revealed statistically significant differences between the subgroup of patients with normal renal function (1B) versus patients with chronic renal disease (2B) for the following parameters (Table 3): mean age (*P* = .006), proteinuria (*P* < .0001), C-reactive protein (*P* = .022), serum triglycerides (*P* = .044), and body mass index (*P* = .0091). There was no difference in hypertension between the 2 subgroups, but we did observe that in these patients hypertension starts at a younger age (27.63 ± 9.26 years).

Table 2. Clinical and biological parameters of patients with surgically acquired single kidney (group A).

Parameter	Patients with normal renal function (group 1A) n=15	Patients with chronic renal failure (group 2A) n=13	P value
Age (y)	47 ± 14	63 ± 11.35	= .0029
Duration hypertension (y)	25.26 ± 7.94	35.99 ± 11.08	= .00625
Mean age at hypertension start (y)	21.74 ± 11.5 (n=14)	27.01 ± 10.8 (n=5)	NS
Body mass index, kg/m ²	26.73 ± 4.51	25.48 ± 5.68	NS
Systolic blood pressure, mm Hg	122.66 ± 21.94	143.84 ± 27.47	= .0318551
Diastolic blood pressure, mm Hg	73.33 ± 10.96	82.30 ± 13.78	NS
Hb, g/L	132.6 ± 12.9	115.3 ± 22	= .0158608
Serum creatinine, μmol/L	88.4 ± 7.96	198.9 ± 160	= .0126404
Glycemia, mmol/L	5.54 ± 1.09	5.2 ± 0.39	NS
Serum cholesterol, mmol/L	5.13 ± 1.54	5.54 ± 0.99	NS
Triglycerides, mmol/L	1.42 ± 0.67	1.65 ± 0.63	NS
Uric acid, μmol/L	312.3 ± 97.56	374.76 ± 116.59	NS
Fibrinogen, μmol/L	10 ± 3.18	11.61 ± 3.63	NS
C-reactive protein, nmol/L	19.52 ± 24	65.81 ± 71.72	= .0261865
Proteinuria, g/24 h	0.122 ± 0.06	0.38 ± 0.46	= .0403953
GFR, mL/min/1.73 m ²	72.63 ± 9.31	37.91 ± 17.24	< .001
Smoking (%)	53.33 (n=8)	15.38 (n=2)	NS
Cardiovascular disease (%)	26.67 (n=4)	46.15 (n=6)	NS
Renal stone (%)	13.33 (n=2)	30.77 (n=4)	NS
Urinary infection (%)	40 (n=6)	53.85 (n=7)	NS

Data are presented as mean ± standard deviation or number (%) of patients.

Abbreviations: GFR, glomerular filtration rate; Hb, hemoglobin; NS, not significant.

Table 3. Clinical and biological characteristics of patients with congenital single kidney (group B).

Parameter	Patients with normal renal function (group 1B) n=12	Patients with chronic renal failure (group 2B) n=8	P value
Age (y)	26.25 ± 6.79	38.75 ± 11.27	.00605249
Body mass index, kg/m ²	21.78 ± 3.25	27.26 ± 5.18	.0091
Systolic blood pressure, mm Hg	117.5 ± 15.30	120 ± 19.27	NS
Diastolic blood pressure, mm Hg	72.5 ± 12.52	68.75 ± 11.25	NS
Hb, g/L	132.2 ± 16.4	115.7 ± 22.6	NS
Serum creatinine, μmol/L	85.75 ± 15.03	179.45 ± 106.96	.00718293
Glycemia, mmol/L	5.06 ± 0.54	5.22 ± 0.37	NS
Serum cholesterol, mmol/L	4.27 ± 0.86	5.23 ± 1.65	NS
Triglycerides, mmol/L	1.04 ± 0.51	2.22 ± 1.81	.0441052
Uric acid, μmol/L	258.16 ± 85.66	335.5 ± 123.73	NS
Fibrinogen, μmol/L	10.78 ± 2.5	12.76 ± 4.17	NS
C-reactive protein, nmol/L	20.38 ± 11.05	119.15 ± 138.29	.02246515
Proteinuria, g/24 h	0.13 ± 0.06	0.52 ± 0.24	.0000355
GFR, mL/min/1.73 m ²	86.44 ± 12.12	42.30 ± 15.15	< .001
Smoking (%)	33.33 (n=4)	37.5 (n=3)	NS
Cardiovascular disease (%)	0 (n=0)	0 (n=0)	NS
Renal stone (%)	25 (n=3)	0 (n=0)	NS
Urinary infection (%)	50 (n=6)	62.5 (n=5)	NS

Data are presented as mean ± standard deviation or number (%) of patients.

Abbreviations: GFR, glomerular filtration rate; Hb, hemoglobin; NS, not significant.

Discussion

Previous studies concerning patients with congenital single kidney or surgically acquired single kidney discuss the long-term risk of progressive alteration of renal function. In some cases, this may lead to end-stage renal disease (5, 19-21). Other authors have observed that patients with a single kidney have a renal function comparable to that of people with 2 kidneys (6, 22-25). Especially important are the additional studies where single kidneys are at risk for superimposition of another disease, such as diabetes mellitus; this is also an important consideration for living-kidney donors (26).

Renal function in patients with surgically acquired single kidney versus patients with a single congenital kidney at a comparable time interval

The function of single kidneys over time has been the subject of numerous studies, although there are few comparative studies of renal function over time in patients with surgically acquired single kidney versus congenital single kidney.

In this study, we revealed that surgically acquired single kidney patients had a mean glomerular filtration rate of 56.51 ± 22.03 mL/min; congenital single kidney patients had a mean glomerular filtration rate of 68.78 ± 25.72 mL/min, which was a nonsignificant difference ($P > .05$). From this result, we conclude that a surgically acquired single kidney behaves similarly to congenital single kidney with regard to renal function.

In this study, we sought to determine whether there are differences in renal function between patients with a surgically acquired single kidney and a congenital single kidney at comparable times. This is an interesting research question, as according to the literature, surgically acquired single kidneys, and congenital single kidneys seem to display completely different adaptive phenomena.

In the case of a surgically acquired single kidney, the reduction by 50% of the number of nephrons leads to adaptive compensatory changes at the level of the remaining nephrons. Thus, in the first hours after nephrectomy, there is an increase in the glomerular filtration rate. After 30 days, glomerular filtration rate reaches 69% of the pre-nephrectomy value (27). The remaining nephrons are affected by hypertrophy and hyperfiltration that in line with Kriz's "overload" theory can trigger

glomerulosclerosis. A vicious circle occurs in which the stimulus represented by the reduction of nephrons produces compensatory changes in the remaining nephrons that will lead to glomerulosclerosis and the loss of the functionality of the nephrons (28).

In the case of a single congenital single kidney, however, some authors uphold that compensatory adaptive phenomena are produced through hyperplasia with a subsequent increase in the numbers of nephrons. These phenomena start in utero. Thus, newborns with unilateral renal agenesis are born with larger kidneys compared to those of binephric newborns. According to Glazebrook, this is due to an increase in the number of nephrons (29). Maluf demonstrated that the kidney in a unilateral renal agenesis patient had twice the number of nephrons and weighed 1.8 times more compared with a control kidney (9). This observation is concordant with animal data (30). Douglas and associates confirmed this hypothesis in sheep embryos, showing that unilateral nephrectomy performed during organogenesis is associated with an increase in the number of nephrons to approximately 70% of the number of nephrons of 2 normal kidneys (30).

Thus, patients with unilateral renal agenesis are protected from the compensatory mechanisms of hyperfiltration and hypertrophy that can lead to glomerulosclerosis, hypertension, proteinuria, and alteration of renal function (8, 31, 32).

Some authors suggest that congenital single kidney presents an increased risk of hypertrophy and hyperfiltration, glomerulosclerosis and progressive alteration of renal function. Other studies report renal function alteration in 13% to 43% of patients with single renal agenesis (3, 5, 19, 20).

We conclude that a surgically acquired single kidney and a congenital single kidney have similar long-term behaviors regarding functional adaptability to this condition.

Age

In our study, the comparison between the groups A and B revealed a statistically significant difference for mean age ($P < .001$). This is due to the starting point in the comparative assessment to obtain a similar period of single kidney existence in both groups. For age to be equivalent across groups, children with unilateral nephrectomy would be necessary (who are obviously difficult to obtain). In addition, nephrectomies, for therapeutic purposes or for organ donations, are carried out, in most cases, on adults. For this reason, the authors considered that analyzing a group of underaged nephrectomized patients as being nonrepresentative for the purpose of this study.

We found that age is a risk factor for renal function decline in both groups. A strong, indirect correlation was found for both groups between glomerular filtration rate and age (Table 4 and Table 5); this finding is in agreement with previous literature data (23, 33).

According to the literature, the time criterion is necessary to correctly assess risk in patients with a single kidney (5, 26, 34).

Arterial hypertension

Comparisons between the 2 groups revealed that systolic blood pressure was significantly higher in patients with surgically acquired single kidney compared with patients with congenital single kidney ($P = .04$).

Table 4. Correlation analysis for risk factors for chronic kidney disease in patients with surgically acquired single kidney (group A).

Variable	Parameter		Systolic blood pressure		Proteinuria		C-reactive protein		Fibrinogen		Hb	
	r	P	r	P	r	P	r	P	r	P	r	P
GFR	-0.575	.001	-0.407	.031	-0.476	.01	-0.550	.002	-0.395	.038	0.605	.001

Abbreviations: GFR, glomerular filtration rate; Hb, hemoglobin.

Table 5. Correlation analysis for risk factors for chronic kidney disease in patients with congenital single kidney (group B).

Variable	Parameter		Proteinuria		C-reactive protein		Fibrinogen	
	r	P	r	P	r	P	r	P
GFR	-0.557	.011	-0.801	<.0001	-0.633	.003	-0.446	.048

Abbreviations: GFR, glomerular filtration rate.

In our study, 50% of uninephrectomized patients (14p) presented hypertension, whereas only 25% of patients (5p) with a congenital single kidney presented hypertension. In nephrectomized patients, hypertension appeared after 27.17 ± 13.85 years after the nephrectomy. In the group of patients with a congenital single kidney, the onset of hypertension was 27.63 ± 9.26 years of age.

Arterial hypertension was a statistically significant progression factor for chronic kidney disease; in group A, there was a strong indirect correlation between glomerular filtration rate-systolic blood pressure (Table 4); this agrees with previous data (35). No significant differences were found regarding diastolic blood pressure. In the subgroups of patients with normal and impaired renal function within group B, neither systolic blood pressure nor diastolic blood pressure differed significantly.

Keller and associates showed a relation between a reduced number of nephrons and hypertension in a histopathological study. He demonstrated that hypertensive individuals have fewer nephrons, compared with normotensive individuals (36). Individuals with a low birth weight and fewer nephrons have an increased risk of hypertension, albuminuria, and chronic renal failure compared with individuals of a normal birth weight (37, 38).

The prevalence of hypertension in patients with a single kidney is increased when the follow-up is prolonged (5, 20, 39). Heinonen found that pregnant women with single kidney agenesis and uterine anomalies had a 2.3-fold increased risk for gestational hypertension, preeclampsia, or gestational proteinuria (40). In nephrectomized adults, the study of the single kidney-hypertension relation is difficult, because blood pressure increases with age. Studies have shown that nephrectomized patients had significantly increased blood pressure values compared with individuals with 2 kidneys (23, 41, 42, 43).

Proteinuria

In our study, a statistical comparison between the 2 groups revealed no significant difference for proteinuria ($P > .05$). Risk factor assessment for chronic kidney disease progression revealed that proteinuria is a common risk factor in both groups, and there is a strong indirect correlation between proteinuria and glomerular filtration rate (Tables 4

and 5). Our study revealed the presence of proteinuria in 42.8% of group B patients (12p) and in 55% of group A patients (11p); this agrees with the data provided by another study using a follow-up of the single kidney of 26 years (6). We emphasize that proteinuria is a statistically significant factor for chronic kidney disease progression in both groups of patients, concordantly with other studies (44, 45).

Proteinuria is a known risk factor for renal function decline in patients with a surgically acquired single kidney and is the consequence of the adaptive hypertrophy and compensatory hyperfiltration phenomena (5, 23, 46, 47). In the case of patients with congenital single kidney, studies find that the prevalence of proteinuria increases with the duration of the follow-up (5, 6, 20, 48).

Inflammation markers: C-reactive protein and fibrinogen

Several studies have shown that inflammation is an important risk factor for chronic kidney disease progression. Inflammation is associated with the prevalence, progression, and prognosis of renal dysfunction (49-53).

In both groups studied, statistically significant differences regarding C-reactive protein in patients with impaired renal function versus patients with normal renal function have been found (Tables 2 and 3). The role of C-reactive protein as an independent predictor of all-cause mortality, including cardiovascular one (54), supports the monitoring of this parameter in patients with a single kidney and impaired renal function. In both groups, a strong indirect correlation between glomerular filtration rate and C-reactive protein as well as between glomerular filtration rate and fibrinogen has been found (Tables 4 and 5). These findings are consistent with data from the literature (50, 52, 53).

Anemia

Anemia, a progression factor of chronic kidney disease (12), represents one of the parameters followed up in both groups; no significant difference between the 2 groups was found. In patients with a surgically acquired single kidney, a strong, direct correlation was found between glomerular filtration rate and Hb (Table 4). The value of Hb was significantly lower in patients with a surgically acquired single kidney and renal function impairment, compared with patients with a

surgically acquired single kidney and normal renal function. In the group of patients with a congenital single kidney, serum Hb did not differ significantly between patients with renal function impairment versus those with normal renal function.

Obese and overweight patients

Praga and Gonzales reported that obesity is associated with an increased risk for renal dysfunction in patients with a single kidney (26, 46, 55). Our study confirmed these results, but only in group B. According to Praga, overweight patients with a single kidney have an increased risk of proteinuria and renal dysfunction through increased hypertrophy and compensatory hyperfiltration phenomena (46).

Hypertriglyceridemia

Hypertriglyceridemia is a risk factor for chronic kidney disease progression (56, 57). In our study, hypertriglyceridemia was significantly increased in patients with a congenital single kidney and renal function impairment, compared with patients with a congenital single kidney and normal renal function (Table 3). In the case of patients with a surgically acquired single kidney, we did not find a statistically significant difference between the subgroup with renal function impairment and the subgroup with normal renal function regarding hypertriglyceridemia.

Conclusions

Our study did not show any influence of surgical nephrectomy on kidney function. Thus, kidney function in patients with surgically acquired single kidney is similar to that found in congenital single kidney patients at a comparable time interval. Individuals with a surgically acquired single kidney for therapeutic reasons do not present a higher risk for renal dysfunction than individuals with unilateral renal agenesis.

Statistically significant differences for systolic blood pressure, duration of hypertension, serum cholesterol, and cardiovascular disease between the 2 groups of patients were due to the significantly older age of patients with surgically acquired single kidney. This significantly older age is the consequence of the common comparison criteria of the 2 groups (ie, the similar duration of single kidney existence).

Proteinuria, inflammation, and age were risk factors for renal function impairment for both groups. In addition, group A had following risk factors: systolic blood pressure, hemoglobin, and duration from nephrectomy. Group B had the following risk factors: obesity and hypertriglyceridemia.

Our study has several limitations. First, the number of patients was small. Second, there was a statistically significant difference between the ages of the 2 groups; to overcome this, a group of children with unilateral nephrectomy would have been necessary (which is obviously difficult to obtain).

Perspectives

This paper underscores the necessity of performing prospective studies on patients with single kidney, whether surgically acquired or congenital, for a better medical assessment of nephrectomy risks, especially in the situation of living donors.

A follow-up of patients with a single kidney is required to monitor microalbuminuria, serum creatinine, and arterial blood pressure every 2 years (58). Our results indicate that patients with a single kidney do not have an increased risk of end-stage renal disease and have the potential for favorable implications for transplant from live kidney donors.

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