

The clinical significances of simple renal cyst: Is it related to hypertension or renal dysfunction?

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Simple renal cyst has controversy related to hypertension and renal dysfunction. We analyzed the impacts of cyst on hypertension and renal dysfunction, focusing on elimination of the confounding factors. We grouped 436 patients and 436 controls by characteristics of cyst and stratified with clinical parameters among 6603 patients who had routine health check-up in Seoul National University Bundang Hospital, Seongnam, Korea. The presence of cyst was related to hypertension but not to renal dysfunction. The number and the size of cyst were independent risk factors to the prevalence of hypertension. The presence of multiple renal cysts was related to hypertension in males, in persons over the age of 60 years, in persons with glomerular filtration rate (GFR) more than 60 ml/min/1.73 m², or in persons without proteinuria. The effect of the large cyst and the peripheral cyst on the prevalence of hypertension was similar to that of the multiple cyst. The blood pressure of the multiple-cyst group, the large-cyst group, or the peripheral-cyst group was higher than that of the single-cyst group, the small-cyst group, or the perihilar-cyst group, respectively, regardless of antihypertensive medications. In conclusion, the presence of cysts or characteristics of cyst were not related to the decreased GFR. In conclusion, the presence of simple renal cyst was related to hypertension but not to renal dysfunction. The effect of simple cyst on hypertension was evident in males, aged persons, and persons without the evidence of renal disease. The number, size, and location were important characteristics of cyst related to hypertension.

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Simple renal cyst is one of the most common types of acquired renal cysts. The prevalence of simple renal cyst increases with age and shows significant difference according to gender.^{1,2} Although the size and the number of cyst increase with age, the natural history of simple renal cyst has been reported to be benign^{2,3} except the concern about the accurate differential diagnosis from cystic renal malignancies⁴ or aggressive cystic renal diseases such as polycystic kidney disease or acquired cystic kidney disease in clinical practice. Another worrying thing about simple renal cyst is the relation to hypertension^{5–9} or decreased renal function.^{10,11} Since the initial report about the development of hypertension by simple renal cyst by Farrell and Young,¹² several authors reported cure or improvement of hypertension after decompression of large cyst.^{6–9,13} Some authors also reported that simple renal cyst was related to high blood pressure in cross-sectional observational studies,⁵ but the other reports showed the opposite results.¹⁴ Recently, Al-Said *et al.*¹⁰ reported that the presence of renal cysts, even a single cyst, was associated with reduced renal function in hospitalized patients younger than 60 years. However, this finding was objected to by Holmberg¹⁵ and Roth.¹⁶

The development of simple renal cyst is closely related to aging process and gender.² The frequency of hypertension and renal dysfunction also increases with age in the natural process¹⁷ and is reported to be different according to gender.¹⁸ Therefore, the relationship between renal cyst and hypertension or renal dysfunction should be cautiously examined with due attention to confounding parameters such as age, gender, proteinuria, glomerular filtration rate (GFR), and hypertension itself, which would have effect on the prevalence of renal cyst as well as hypertension or renal dysfunction or both. To examine the relationships between simple renal cyst and hypertension and/or renal dysfunction, 436 persons with simple renal cyst(s) and 436 controls, matched to age, gender, and body mass index (BMI), were selected among 6603 patients having routine health check-up in Seoul National University Bundang Hospital, Seongnam, Korea. We analyzed retrospectively the medical record of study subjects with careful attention to the confounding effects of age, gender, proteinuria, GFR, and hypertension on the existence of simple renal cyst, hypertension, and renal

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dysfunction. Study subjects were also grouped by the characteristics of cyst, such as the number, the diameter, and the location of cyst, to define features of cyst related to hypertension and renal dysfunction.

RESULTS

Simple renal cyst was found in 513 (7.8%) patients among 6603 people who had health check-up. The mean age of 3567 (54.0%) male subjects was 50.7 years (s.d.: 11.9 years, range: 15–89 years) and that of female subjects was 50.9 years (s.d.: 11.8 years, range: 15–82 years). There was no difference in age between gender groups. The prevalence of cyst was 2.5% in male and 1.4% in female subjects under the age of 40 years and increased to 30.1 and 18.3% in each gender over the age of 70 years (Figure 1). Among 513 persons having simple renal cyst(s), 44 persons whose medical history of hypertension could not be obtained and 33 persons without results of blood pressure and serum creatinine value at the time of health check-up were excluded, and hence total 436 persons with simple renal cyst and the same number of controls matched by age, gender, and BMI were included in this study.

The prevalence of hypertension and the systolic, diastolic, and mean blood pressures were higher in cyst group than control group. There were no differences in serum creatinine value and GFR between two groups. Serum high-density lipoprotein value was lower in cyst group than in control group (Table 1). The multiple cyst, defined as more than two in number, was located more frequently in peripheral region than the single cyst (multiple cyst vs single cyst = 75/102 vs 188/334; $P=0.002$). The large cyst, defined as cyst larger than 5 cm in diameter, was also located more frequently in peripheral region than the small cyst (large cyst vs small cyst = 29/30 vs 229/398; $P=0.000$). The patients with multiple cyst had larger cysts over 5 cm in diameter than the patients with single cyst (multiple cyst vs single cyst = 14/99 vs 16/329; $P=0.003$). There were significant relationships between characteristics of cyst and demographic features of persons having cyst. The frequency of large cyst was 0% in patients under the age of 50 years, 3.4% in patients ranging in age from 50 to 59 years, and 11.9% in patients over the age of

60 years of the cyst group ($P=0.000$). The frequency of multiple cyst also increased from 16.1% in patients under the age of 50 years to 28.7% in patients over the age of 60 years ($P=0.024$). The peripheral cyst was observed more frequently in older patients aged more than 60 years than the perihilar cyst was (peripheral cyst vs perihilar cyst = 149/263 vs 74/173; $P=0.006$). Male patients had more multiple-cyst than female patients (male vs female = 81/306 vs 21/130; $P=0.019$).

The prevalence of hypertension was higher in patients with multiple cyst, large cyst, or peripheral cyst than in patients with single cyst, small cyst, or perihilar cyst. The incidence of hypertension was also higher in patients with multiple cyst or large cyst than in patients with single cyst or small cyst, but location of cyst had no effect on the incidence of hypertension (Figure 2).

The effect of cyst characteristics on hypertension was further analyzed with stratification with age, gender, GFR, and the presence of proteinuria. The multiple-cyst group showed a higher prevalence rate and a higher incidence rate of hypertension than the single-cyst group and the control group in patients over the age of 60 years, in male patients, in patients with GFR more than 60 ml/min/1.73 m², in patients without proteinuria, or in male patients over the age of 60 years. The effect of cyst size on the prevalence of hypertension was similar to that of cyst number. Larger cyst size was related to hypertension in older patients, in male patients, in patients with GFR more than 60 ml/min/1.73 m², and in persons without proteinuria (Tables 2, 3).

The peripheral-cyst group had shown more hypertensive in male patients, in patients with GFR more than 60 ml/min/1.73 m², or in male patients over the age of 60 years than the perihilar-cyst group and the control group. The location of cyst had no effect on the incidence of hypertension (Tables 2, 3).

The mean blood pressure of the multiple-cyst group, the large-cyst group, and the peripheral-cyst group was higher than those of the single-cyst group, the small-cyst group, and the perihilar-cyst group, respectively, regardless of hypertensive medication (Table 4).

There was no difference in GFR between the cyst group and the control group (Table 1). However, the multiple-cyst group had lower GFR than the single-cyst group and the control group (multiple-cyst group: single-cyst group: control group = 72.9 ± 14.6: 77.9 ± 12.3: 77.8 ± 11.3 ml/min/1.73 m²; $P=0.001$). The peripheral-cyst group also had a lower GFR than the perihilar-cyst group and the control group (peripheral-cyst group: perihilar-cyst group: control group = 75.6 ± 12.8: 78.4 ± 13.3: 77.8 ± 11.39 ml/min/1.73 m²; $P=0.027$). Multiple regression tests were carried out for the determination of independent risk factors to the presence of hypertension, newly detected hypertension, and GFR. Using the forward stepwise regression with parameters, such as, one of characteristics of cyst, age, gender, BMI, GFR, serum uric acid, serum high-density lipoprotein cholesterol, serum triglyceride, and proteinuria by dipstick test, the number of

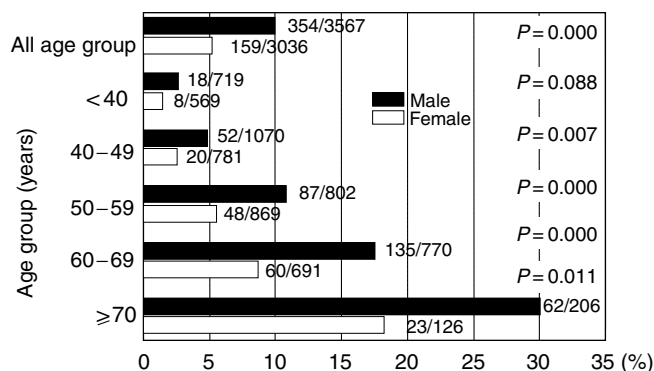


Figure 1 | Prevalence of simple renal cyst in whole patients having health check-up.

Table 1 | The clinical characteristics of patients

Findings (scale)	Control group	Cyst group	P-value
Age (mean±s.d.: years)	58.0±10.9	58.0±10.9	1.000
Sex (frequency: male:female)	306:130	306:130	1.000
BMI (mean±s.d.: kg/m ²)	24.4±3.0	24.4±2.7	0.932
Diabetes mellitus (frequency)	47/435	49/433	0.829
Prevalence of hypertension (frequency)	157/436	190/436	0.027
Incidence of hypertension (frequency)	45/324	50/294	0.315
SBP (mean±s.d.: mmHg)	122.3±15.4	124.7±16.2	0.021
DBP (mean±s.d.: mmHg)	77.4±10.5	80.0±11.1	0.000
MBP (mean±s.d.: mmHg)	92.4±11.2	94.9±11.8	0.001
BUN (mean±s.d.: mg/dl)	13.5±3.2	13.5±3.3	0.917
Creatinine (mean±s.d.: mg/dl)	0.99±0.17	1.01±0.20	0.088
GFR (mean±s.d.: ml/min/1.73m ² BSA)	77.8±11.3	76.7±13.0	0.187
Glucose (mean±s.d.: mg/dl)	101.4±23.1	104.0±42.1	0.258
Cholesterol (mean±s.d.: mg/dl)	206.6±33.0	206.4±35.2	0.945
Triglyceride (mean±s.d.: mg/dl)	133.0±92.8	138.0±82.4	0.394
LDL cholesterol (mean±s.d.: mg/dl)	117.9±25.8	118.1±28.0	0.922
HDL cholesterol (mean±s.d.: mg/dl)	55.5±14.3	53.1±13.6	0.012
Uric acid (mean±s.d.: mg/dl)	5.7±1.4	5.7±1.5	0.911
Urine proteinuria by dipstick (frequency)	—	—	0.942
None	322/436	318/436	—
≥Trace	114/436	118/436	—
Urine RBC (frequency: RBC/HPF)	—	—	0.310
<5/HPF	401/430	398/436	—
≥5/HPF	29/430	38/436	—

BMI, body mass index; BSA, body surface area; BUN, blood urea nitrogen; DBP, diastolic blood pressure; GFR, glomerular filtration rate; HDL, high-density lipoprotein; HPF, high-power field; LDL, low-density lipoprotein; MBP, mean blood pressure; RBC, red blood cell; SBP, systolic blood pressure; s.d., standard deviation.

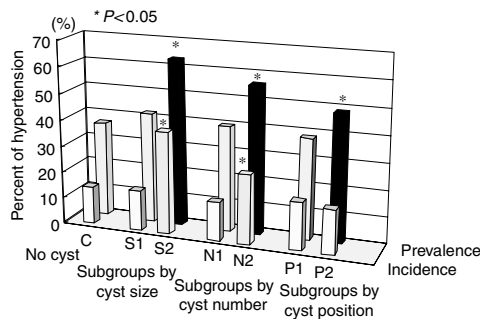


Figure 2 | Prevalence and incidence of hypertension among patients grouped by cyst size, cyst number, or cyst position.

C: Patient without cyst. S1: Patient with cysts less than 5 cm in diameter. S2: Patient with cysts more than 5 cm in diameter. N1: Patient with single cyst. N2: Patient with cysts more than two. P1: Patient with perihilar cysts. P2: Patient with peripheral cysts.

cyst was independently related to the presence of hypertension. The diameter of cyst was also related to the presence of hypertension in the same model but the location of cyst was not. The diameter of cyst was independently related to the newly detected hypertension in multiple regression model using factors, such as one of the characteristics of the cyst, age, gender, BMI, and GFR. None of the characteristics of cyst were independently related to the degree of GFR by the multiple linear regression test. All the parameters used in the regression model were univariate risk factors to the presence of hypertension, newly developed hypertension, and the degree of GFR.

DISCUSSION

Consistent with previous reports, we also found that simple renal cyst was more prevalent in male and old persons. In this study, the overall prevalence of simple renal cyst was 7.8% and lower than other studies. The difference in prevalence might result from differences in study population and detection methods of cyst. The population having health screening² like our subjects showed lower prevalence of simple renal cyst than the population who were admitted or followed at clinics.^{1,3,10,14} The prevalence of simple renal cyst detected by computerized tomography^{1,10} was higher than the prevalence determined by ultrasonography.^{3,14,19}

Our study showed that, despite no differences in age, gender, GFR, and proteinuria between persons having simple renal cyst and control group, the presence of cyst was related to higher prevalence of hypertension and also related to higher systolic, diastolic, and mean blood pressure. The mechanism by which the presence of simple renal cyst is related to hypertension is not still clear. Lüscher *et al.*¹³ suggested the possible causal relationship between renal cyst and hypertension at least in some patient by demonstrating normalization of blood pressure after cyst removal, which was attributed to the inactivation of the renin-angiotensin system in the involved kidney. The chance of renal cyst to activate the renin-angiotensin system by compressing renal artery might be related to location as well as the size and the number of cyst. The renin-angiotensin system would be more vulnerable to activation by the cyst located in the perihilar region than in the peripheral region of kidney. In this study, persons with the peripheral cyst had higher prevalence of

Table 2 | The prevalence of hypertension among patients grouped by cyst number, cyst size, and cyst location with stratification by parameters

Parameter	Subgroups by cyst number				Subgroups by cyst size				Subgroups by cyst location			
	Control	Single	Multiple	P-Value	Control	Small	Large	P-Value	Control	Perihilar	Peripheral	P-Value
<i>Age (years)</i>												
<50	17/93	17/78	4/15	0.700	17/93	21/91	—	0.469	17/93	13/51	8/42	0.572
50-59	33/120	35/97	9/23	0.302	33/120	42/115	1/4	0.318	33/120	15/48	29/72	0.184
≥60	107/223	81/159	44/64	0.013	107/223	104/192	18/26	0.087	107/223	37/74	88/149	0.103
<i>Gender</i>												
Male	116/306	94/225	49/81	0.001	116/306	124/278	15/21	0.006	116/306	44/118	99/188	0.003
Female	41/130	39/109	8/21	0.719	41/130	43/120	4/9	0.616	41/130	21/55	26/75	0.673
<i>GFR</i>												
≥60	142/415	120/315	45/87	0.009	142/415	145/367	17/28	0.011	142/415	59/164	106/238	0.029
<60	15/21	13/19	12/15	0.742	15/21	22/31	0/2	0.670	15/21	6/9	19/25	0.852
<i>Proteinuria</i>												
Absent	109/322	91/250	35/68	0.023	109/322	109/290	14/22	0.017	109/322	44/127	82/191	0.103
Present	47/108	42/84	22/34	0.096	47/108	58/108	5/8	0.242	47/108	21/46	43/72	0.090
<i>Gender and age</i>												
M<50	13/63	14/50	3/13	0.658	13/63	17/61	—	0.404	13/63	10/33	7/30	0.571
M=50-59	23/79	25/63	8/16	0.186	23/79	32/77	0/1	0.202	23/79	12/33	21/46	0.175
M≥60	80/164	55/112	38/52	0.006	80/164	75/140	15/20	0.081	80/164	22/52	71/112	0.015
F<50	4/30	3/28	1/2	0.287	4/30	4/30	—	1.000	4/30	3/18	1/12	0.805
F=50-59	10/41	10/34	1/7	0.683	10/41	10/38	1/3	0.934	10/41	3/15	8/26	0.725
F≥60	27/59	26/47	6/12	0.620	27/59	29/52	3/6	0.575	27/59	15/22	17/37	0.167

Control: patients without cyst, single: patients with single cyst, multiple: patients with cysts more than two, small: patients with cysts less than 5 cm in diameter, large: patients with cysts more than 5 cm in diameter, perihilar: patients with cysts located in perihilar area, peripheral: patients with cysts located outer region of kidney, GFR: glomerular filtration rate, presented by unit (ml/min/1.73 m²), proteinuria present: proteinuria more than trace amount measured by dipstick test, M<50: male aged less than 50 years, M=50-59: male aged from 50 to 59 years, M≥60: male aged more than 60 years, F<50: female aged less than 50 years, F=50-59: female aged from 50 to 59 years, F≥60: female aged more than 60 years.

hypertension than those with the perihilar cyst. Although the diameter of cyst was smaller and the number of cyst was lesser in persons with the perihilar cyst than in persons with the peripheral cyst, the location of cyst was not independent risk factor for the presence of hypertension. Taken together, this study did not support the role of activated renin-angiotensin system in the development of hypertension in persons having simple renal cyst.

The other explanation why simple renal cyst was related to hypertension might be that the loss of nephrons along with aging was involved in both development of hypertension and formation of simple renal cyst. The prevalence of simple renal cyst increases with age,^{1,2,10,19} and the number and the size of cyst also increase with aging process.^{2,20} The loss of renal mass with age is confined mainly to the cortex²¹ and the insulin clearance decreased around 1% per year with increasing age.²² The loss of nephron increases work loads of tubules and may cause hypertrophy and hyperplasia of tubular cells to the extent of causing cyst formation.²³ Primary hypertension is closely related to the reduced number of nephron.^{24,25} In this study, size and number were important characteristics of cyst related to hypertension and persons with the peripheral cyst had higher prevalence of hypertension than those with the perihilar cyst. Although cyst was not related to renal function in multiple regression analysis, GFR in patients with the peripheral cyst was lower

than in patients with the perihilar cyst, especially in subgroup aged more than 60 years. Therefore, our result raises the possibility that aging process along with decreased cortical mass causes aberrant tubular growth to generate cyst formation, especially in peripheral region as well as hypertension subsequent to reduced number of nephron. Additional loss of renal cortex by peripheral cyst may increase the probability of hypertension. This hypothesis was also compatible to the finding that relationship between cyst and hypertension was not significant in female patients because female was protected from both the decrease in GFR and the structural damage with aging.^{22,26}

We found that the impacts of multiple or large renal cyst on the prevalence of hypertension were significant only in patients with GFR more than 60 ml/min/1.73 m² or without proteinuria. When we consider that the prevalence and incidence of hypertension were significantly higher in patients with GFR less than 60 ml/min/1.73 m² and the prevalence of hypertension was also higher in patients with proteinuria in this study (data were not shown), it is reasonable to speculate that the strong influence of renal disease on hypertension might have obscured the relationship between renal cyst and hypertension.

There are several limitations in our studies. Although we tried to carefully select study subject, all problems inherent to retrospective study are unavoidable and might influence the

Table 3 | The incidence of hypertension among patients grouped by cyst number, cyst size, and cyst location with stratification by parameters

Parameter	Subgroups by cyst number				Subgroups by cyst size				Subgroups by cyst location			
	Control	Single	Multiple	P-Value	Control	Small	Large	P-Value	Control	Perihilar	Peripheral	P-Value
<i>Age (years)</i>												
<50	7/83	9/68	3/13	0.559	7/83	11/79	—	0.322	7/83	8/44	3/37	0.202
50-59	12/99	9/71	2/16	0.994	12/99	11/84	0/3	0.791	12/99	5/38	6/49	0.986
≥60	26/142	16/94	12/32	0.032	26/142	20/108	7/15	0.029	26/142	10/47	18/79	0.713
<i>Gender</i>												
Male	35/225	27/156	15/47	0.028	35/225	35/187	6/12	0.009	35/225	17/89	25/114	0.337
Female	10/99	7/77	1/14	0.929	10/99	7/84	1/6	0.767	10/99	6/40	2/51	0.192
<i>GFR</i>												
≥60	14/314	29/222	14/56	0.051	14/314	36/256	6/17	0.037	14/314	20/123	23/155	0.665
<60	4/10	5/11	2/5	0.962	4/10	6/15	1/1	0.492	4/10	3/6	4/10	0.910
<i>Proteinuria</i>												
Absent	25/248	22/180	12/45	0.047	25/248	27/207	6/14	0.009	25/248	15/97	19/128	0.946
Present	10/71	12/53	4/16	0.375	10/71	15/64	1/4	0.360	10/71	8/32	8/37	0.359
<i>Gender and age</i>												
M<50	6/56	8/42	2/12	0.499	6/56	10/52	—	0.281	6/56	7/28	3/26	0.191
M=50-59	6/62	8/46	2/10	0.422	6/62	10/55	0/1	0.376	6/62	4/25	6/31	0.404
M≥60	23/107	11/68	11/25	0.016	23/107	15/80	6/11	0.027	23/107	6/36	16/57	0.411
F<50	1/27	1/26	0/1	0.980	1/27	1/27	—	1.000	1/27	1/16	0/11	0.700
F=50-59	6/37	1/25	0/6	0.205	6/37	1/29	0/2	0.212	6/37	1/13	0/18	0.168
F≥60	3/35	5/26	1/7	0.476	3/35	5/28	1/4	0.440	3/35	4/11	2/22	0.088

Control: patients without cyst, single: patients with single cyst, multiple: patients with cysts more than two, small: patients with cysts less than 5 cm in diameter, large: patients with cysts more than 5 cm in diameter, perihilar: patients with cysts located in perihilar area, peripheral: patients with cysts located outer region of kidney, GFR: glomerular filtration rate, presented by unit (ml/min/1.73 m²), proteinuria present: proteinuria more than trace amount measured by dipstick test, M<50: male aged less than 50 years, M=50-59: male aged from 50 to 59 years, M≥60: male aged more than 60 years, F<50: female aged less than 50 years, F=50-59: female aged from 50 to 59 years, F≥60: female aged more than 60 years.

Table 4 | The differences of blood pressures among patients grouped by cyst number, cyst size, and cyst location

	Subgroups by cyst number				Subgroups by cyst size				Subgroups by cyst location			
	Control	Single	Multiple	P-Value	Control	Small	Large	P-Value	Control	Perihilar	Peripheral	P-Value
SBP	122.3 ± 15.4	123.7 ± 16.0	128.3 ± 16.1	0.003	122.3 ± 15.4	124.1 ± 15.9	130.2 ± 16.7	0.014	122.3 ± 15.4	123.1 ± 16.0	125.8 ± 16.2	0.014
DBP	77.4 ± 10.5	79.7 ± 11.4	80.9 ± 10.3	0.001	77.4 ± 10.5	79.8 ± 11.2	81.4 ± 11.0	0.003	77.4 ± 10.5	79.4 ± 11.4	80.4 ± 11.0	0.001
MBP	92.4 ± 11.2	94.3 ± 12.1	96.7 ± 11.0	0.001	92.4 ± 11.2	94.5 ± 11.9	97.5 ± 11.5	0.005	92.4 ± 11.2	93.8 ± 12.2	95.6 ± 11.7	0.002

Value: presented by mean ± s.d., control: patients without cyst, single: patients with single cyst, multiple: patients with cysts more than two, small: patients with cysts less than 5 cm in diameter, large: patients with cysts more than 5 cm in diameter, perihilar: patients with cysts located in perihilar area, peripheral: patients with cysts located outer region of kidney, SBP: systolic blood pressure, presented by unit (mm Hg), DBP: diastolic blood pressure, presented by unit (mm Hg), MBP: mean blood pressure, presented by unit (mm Hg).

results. We did not correct the intrapersonal or interpersonal variability to detect and localize the simple renal cyst or to measure the maximum diameter of cyst between two radiologists in charge of routine health check-up. We did not have evidence to verify whether large renal cyst could compress renal vasculature or increase plasma renin activity. We cannot ascertain whether individuals with renal cyst really have reduced number of nephron. Hence, our suggestion for relation of simple renal cyst to hypertension and reduced nephron number should be more examined in future studies.

In conclusion, the presence of simple renal cyst was related to hypertension but not to renal dysfunction. The effect of simple cyst on hypertension was evident in male, aged person, and persons without the evidence of renal disease.

The number, size, and location were important characteristics of cyst related to hypertension.

MATERIALS AND METHODS

Patients and data collection

Subjects who had taken routine health check-up including abdominal ultrasonography between 6 May 2003 and 16 June 2004 were included. All subjects were in outpatient clinic at health promotion center. The patient group with simple renal cyst was paired to control group without cyst who also had routine health check-up during the same period. We matched age and gender between the patient and the control group. The following patient information was obtained from chart review by nephrologists: height, weight, age, sex, history of diabetes mellitus, history of hypertension, antihypertensive medication, blood pressure, serum

creatinine, blood urea nitrogen, serum albumin, serum uric acid, serum cholesterol, serum triglyceride, serum low-density lipoprotein cholesterol, serum high-density lipoprotein cholesterol, and the findings of urinalysis by dipstick and microscopy. Medical history and physical examination including blood pressure were primarily recorded by physicians at the health promotion center before ultrasonography. We had also telephoned patients to confirm whether they had hypertension at the time of their health check-up. We excluded the patients whose history of hypertension was not confirmed or values of blood pressures were not defined. All laboratory tests were performed after overnight fasting. Abdominal ultrasonography was performed by two radiologists using static gray scale and real-time B-mode units with a 3.5 or 5 MHz transducer. The simple renal cyst was defined as the anechoic lesion with homogeneity, water content, and a sharp interface to the adjacent renal parenchyma that did not have wall thickening, calcification, or enhancement on ultrasonography. We excluded patients with congenital renal cystic diseases.

Analysis

We calculated BMI through dividing weight (kg) by square of height (m). The GFR was calculated by modified Modification of Diet in Renal Disease equation.²⁷ We defined newly developed hypertension as high blood pressure, systolic blood pressure more than 140 mm Hg, or diastolic blood pressure more than 90 mm Hg, without history of hypertension and antihypertensive medications at the time of evaluation. We grouped the values of age, presence of hypertension, proteinuria by a dipstick test, and GFR as follows: age less than 50 years, age 50–59 years, and age more than 60 years, hypertension, newly developed hypertension, no proteinuria, proteinuria more than trace by dipstick test, GFR more than 60 ml/min/1.73 m² body surface area, and GFR less than 60 ml/min/1.73 m² body surface area. The radiologist reviewed reports and images of ultrasonography and classified characteristics of the cyst, like the number of cyst as single cyst and multiple cyst, which means more than two cysts, the maximum diameter of cyst as large cyst sized larger than 5 cm in diameter and small cyst, and the location of cyst as perihilar cyst located in the parahilar area and peripheral cyst. We divided patients into subgroups by the number of cyst, the maximum diameter of cyst, or the location of cyst, and stratified with age, gender, GFR, and proteinuria.

Statistics

The SPSS (SPSS version 12.0, Chicago, IL, USA) package was used for statistical analysis. Differences in proportions among different patient groups were compared by the χ^2 test. Group differences for continuous variables were assessed by the *t*-test or one-way analysis of variance test according to the number of groups. Multivariate analysis was performed by multiple regression analysis for the factors influencing the presence of hypertension, newly developed hypertension, or severity of renal dysfunction expressed by GFR. Two-sided *P*-values are reported, with 0.05 taken as the level of statistical significance. All data are shown as mean \pm s.d. or frequency per observation.

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