OPEN

Increased Risk of End-Stage Renal Disease in Patients With Renal Cell Carcinoma: A 12-Year Nationwide Follow-Up Study

Peir-Haur Hung, MD, Hung-Bin Tsai, MD, Kuan-Yu Hung, MD, PhD, Chih-Hsin Muo, MPH, Mu-Chi Chung, MD, Chao-Hsiang Chang, MD, and Chi-Jung Chung, PhD

Abstract: The effect of renal cell carcinoma (RCC) on the risk for end-stage renal disease (ESRD) has not been confirmed. The present population-based study used the claims data from the Taiwan National Health Institutes from 1998 to 2010 to compare the risk for ESRD in patients with and without RCC.

The study cohort consisted of 2940 patients who had newly diagnosed with RCC but no history of ESRD; the control cohort consisted of 23,520 matched patients without RCC. Cox proportional hazard regressions were performed to compute ESRD risk after adjusting for possible confounding factors. Kaplan–Meier analysis and the log-rank test were also used to compare patients and controls.

A total of 119 patients in the RCC group (incidence rate: 119/2940; 4.05%) and 160 patients in the control group (incidence rate: 160/23,520; 0.68%) were diagnosed with ESRD during the follow-up period. After adjusting for potential confounders, the RCC group had an ESRD hazard ratio (HR) of 5.63 [95% confidence interval (CI): 4.37–7.24] relative to the control group. In addition, among patients with RCC, females (adjusted HR: 6.95, 95% CI: 4.82–10.1) had a higher risk for ESRD than males (adjusted HR: 4.79, 95% CI: 3.37–6.82). Finally, there were significant joint effects of chronic kidney disease and diabetes on increasing the risk of ESRD in patients with and without RCC ($P < 0.01$). The limitations of this study include the retrospective design and the inability to assess methods of treatment and measure the aggressiveness of RCC.

Our data indicates that RCC is an independent risk factor for ESRD, especially in females.

(*Medicine* 93(8):e52)

Abbreviations: CIPR = catastrophic illness patient registry, CKD = chronic kidney disease, ESRD = end-stage renal disease, GFR = glomerular filtration rate, HR = hazard ratio, NHI = National Health Insurance, RCC = renal cell carcinoma.

INTRODUCTION

Previous studies have examined the association between renal cell carcinoma (RCC) and end-stage renal disease (ESRD).[19,27] In particular, Maisonneuve et al[19] reported that patients with ESRD have increased risk of cancer, but that the increased risk gradually declined with age. Stewart et al[27] reported an elevated risk for renal parenchymal cancer in patients undergoing dialysis. However, Mandel and Kjellstrand[20] concluded that RCC is an unusual cause of ESRD, occurring in only 0.1%–1% of patients treated by dialysis or transplantation. Epidemiological and clinical evidence has shown links between hypertension, diabetes, obesity, and metabolic syndrome with the onset and progression of chronic kidney disease (CKD).[12] However, the complete nature of the association between CKD and RCC has not been thoroughly analyzed.

Patients with RCC may have a higher risk for CKD because of the presence of confounding factors, such as older age, diabetes, hypertension, smoking, and low preoperative glomerular filtration rate (GFR).[6,13,14] In other words, these same risk factors and systemic comorbidities might predispose patients toward renal tumors and CKD.[9,17] Additional factors include baseline demographics, genetic factors, environmental factors and habits, comorbid conditions, and preexisting abnormalities in the non-neoplastic kidney parenchyma. Recent reports have shown that RCC is a potential cause and outcome of decreased GFR. In particular, independent predictors of low preoperative GFR in patients with RCC include year of surgery, tumor size, Charlson–Romano index, and hypertension.[10,23]

The risks of new-onset or exacerbated CKD and development of ESRD after RCC might be linked. Thus, we used multivariable analysis to examine whether patients with RCC have increased risk for ESRD by retrospective use of claims data from the National Health Insurance (NHI) service of Taiwan.

Editor: Tuomo Rantanen.
Received: April 9, 2014; revised: June 12, 2014; accepted: June 17, 2014.
From the Department of Internal Medicine, Ditmanson Medical Foundation Chiayi Christian Hospital, Chia-yi, and Department of Applied Life Science and Health (P-HH), Chia-Nan University of Pharmacy and Science, Tainan; Department of Tramatology (H-BT); Department of Internal Medicine (K-YH), National Taiwan University Hospital, Taipei; Department of Medicine (C-HM, C-HC), College of Medicine, China Medical University; Management Office for Health Data (C-HM), China Medical University and Hospital; Division of Nephrology (M-CC), Department of Medicine, Taichung Veterans General Hospital; Department of Urology (C-HC), China Medical University and Hospital; and Department of Health Risk Management, College of Public Health, China Medical University, and Department of Medical Research (C-JC), China Medical University Hospital, Taichung, Taiwan.
Correspondence: Chi-Jung Chung, PhD, Department of Health Risk Management, China Medical University, No. 91 Hsueh-Shih Road, Taichung 404, Taiwan (e-mail: cjchung@mail.cmu.edu.tw).
This study was supported by the grants from the Taiwan Department of Health Clinical Trial and Research Center for Excellence (grant number DOH102-TD-B-111-004) and Taiwan Department of Health Cancer Research Center of Excellence (DOH102-TD-C-111-005). The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.
We disclosed all financial and interpersonal relationships that could be viewed as a potential conflict of interest.
Copyright © 2014 Wolters Kluwer Health | Lippincott Williams & Wilkins. This is an open access article distributed under the Creative Commons Attribution-NonCommercial-NoDerivatives License 4.0, where it is permissible to download, share and reproduce the work in any medium, provided it is properly cited. The work cannot be changed in any way or used commercially.
ISSN: 0025-7974
DOI: 10.1097/MD.0000000000000052

METHODS

Dataset Sources

The Taiwan Bureau of the NHI established a single-payer National Insurance Program in 1995, a program that covers almost the entire population in Taiwan. The NHI Research Databases were derived from this program by the National Health Institutes. We used the inpatient database and the catastrophic illness patient registry (CIPR) for this retrospective cohort study. Nearly all patients with severe illnesses, including those with cancer and those undergoing dialysis, apply for catastrophic illness cards and are exempted from cost sharing. Thus, we validated the diagnosis of diseases through this dataset. These databases included medical claims and the information of each beneficiary from 1996 to 2010. The identification code of each beneficiary was encrypted to ensure privacy. This study was approved by the China Medical University Hospital Institutional Review Board in Taiwan.

Study Individuals

The patients included adults (≥25 y old) with newly diagnosed RCC, based on *The International Classification of Diseases, 9th Revision-Clinical Modification* (ICD-9-CM), 189.0, from 1998 to 2010. All cases were collected from the CIPR. The date of RCC diagnosis was defined as the index date. The patients were excluded if they were diagnosed with malignancies (ICD-9-CM, 140–188.9 and 189.1–208) or ESRD (ICD-9-CM, 585 from CIPR) before the index date. We used 1:8 matching to select control subjects in order to increase the statistical power of comparisons. Thus, for each case, 8 controls were randomly selected. The cases and controls were matched by age, gender, index year, and index month. All patients were followed from the index date to the date of ESRD diagnosis, to the end of 2010, or the date when they left this program.

Covariate Assessment

The variables in this study included sex, age (25–44, 45–64, and ≥65 y old at the index date), region of residence (northern, central, southern, and eastern Taiwan), occupation (white collar, blue collar, and other), monthly income (≤NT $15,840, NT $15,841–NT $20,100, and >NT $20,100), and presence of comorbidities. We used NT $15,840 as the lowest income level because it is the government-stipulated minimum wage for employees in Taiwan. The comorbidities included hypertension (ICD-9-CM, 401–405), diabetes mellitus (ICD-9-CM, 250), coronary heart disease (ICD-9-CM, 410–414 and

TABLE 1. Distribution of Sociodemographic Factors and Comorbidity Between Cohorts With and Without RCC

Variables	RCC N = 2940		Non-RCC N = 23,520		*P* value
	N	%	N	%	
Age					0.99
25–44	2552	10.9	319	10.9	
45–64	10,352	44.0	1294	44.0	
≥65	10,616	45.1	1327	45.1	
Sex					0.99
Male	14,480	61.6	1810	61.6	
Female	9040	38.4	1130	38.4	
Geographic region					<0.0001
Northern	9965	27.3	802	42.4	
Central	4855	12.8	375	20.6	
Southern	6496	46.6	1371	27.6	
Eastern	2203	13.3	392	9.37	
Occupation					0.24
White collar	11,251	49.2	1447	47.9	
Blue collar	9624	40.4	1188	40.9	
Others	2631	10.3	304	11.2	
Monthly income, NTD					<0.0001
≤15,840	11,570	50.8	1494	49.2	
15,841–20,100	1136	7.18	211	4.83	
>20,100	10,814	42.0	1235	46.0	
Comorbidity					
Diabetes	576	19.6	1811	7.70	<0.0001
Hypertension	1164	39.6	3270	13.9	<0.0001
Coronary heart disease	294	10.0	1586	6.74	<0.0001
Atrial fibrillation	57	1.94	293	1.25	0.002
Heart failure	96	3.27	454	1.93	<0.0001
Chronic kidney disease	53	1.80	108	0.46	<0.0001
Hyperlipidemia	182	6.19	854	3.63	<0.0001

NTD = New Taiwan dollar, RCC = renal cell carcinoma.

© 2014 Lippincott Williams & Wilkins

429.2), atrial fibrillation (ICD-9-CM, 427.31),CKD (ICD-9-CM, 585), and hyperlipidemia (ICD-9-CM, 272). The comorbidities were defined by the presence of "at least three medical visits" before the index date, based on the inpatient database.

The Taiwan Society of Nephrology launched a nationwide CKD Preventive Project in 2004 and adopted the simplified Modification of Diet in Renal Disease equation to calculate the estimated GFR in late-2005.[15,33] This provides a five-stage classification of CKD, based on criteria of the National Kidney Foundation's Kidney Disease Outcome Quality Initiative.[25] The ICD-9 code 585 is consistent with the definition of CKD stages 1–5 and allows for comparisons of the prevalence and incidence of CKD in Taiwan and the United States.[10]We defined CKD based on the presence of 1 inpatient or 2 outpatient ICD-9 code 585 in the claims data,[10] but without a catastrophic illness registration card for ESRD (which would indicate the need for renal replacement therapy).

Statistical Analysis

A chi-square test was used to assess sociodemographic differences "between the RCC and control cohorts." The person-years of follow-up was estimated from the index date to the date of ESRD diagnosis, loss to follow-up, death, or the end of 2010. We estimated the overall cumulative incidence densities and calculated the incidence rate ratios (per 100,000 person-years) and 95% confidence intervals (CIs) with stratification by gender using the Poisson regression model. Kaplan–Meier analysis was used to plot the cumulative incidence for ESRD and the log-rank test was used to test the difference between the two cohorts. The hazard ratios (HRs) and 95% CIs for ESRD were measured using Cox proportional hazards regression. The interaction of RCC and CKD with ESRD was estimated. The trend test was employed Cox proportional hazards regression. All data analyses were conducted using the SAS (ver. 9.3) statistical package for Windows (SAS Institute, Cary, NC), and the significant level was set at 0.05 in a two-sided test.

RESULTS

Significant Demographic Differences of RCC and Control Cohorts

We included 2940 RCC and 23,519 control subjects in this retrospective cohort study (Table 1). Compared with the control cohort, more RCC group lived in the southern areas and had monthly income $\leq$20,100. In addition, the RCC group had more comorbidities than the control group, the most common of which were hypertension, diabetes, and coronary heart disease.

Positive Association of RCC and ESRD Risk

Table 2 compares the incidences and HRs of ESRD risk of the two cohorts. The mean follow-up duration was 2.8 years in the ESRD group and 3.7 years in the control group ($P = 0.0002$, data not shown). The results of the multivariate analysis indicate a 5.63-fold increased risk of ESRD in the RCC group compared with the control group. Compared with the control cohort, more patients in the RCC cohort developed ESRD in all 3 age groups (crude HRs: 7.53–54.8). Among patients with RCC, the mean follow-up duration was 3.4 years for males and 3.2 years for females ($P = 0.61$, data not shown). Further stratified by sex, uniform association existed between RCC and ESRD risk (Figure 1; $P < 0.0001$). After adjusting for other factors, the association was stronger for females (HR: 7.06, 95% CI: 4.90–10.2) than for males (HR: 4.76, 95% CI: 3.34–6.78) (Table 2). In addition, for patients without comorbidities, the RCC group had a 5.5–7-fold increased risk of ESRD compared with the control group.

Synergistic Effects of RCC and Comorbidities on ESRD Risk

Next, we compared patients with and without RCC and evaluated the potential risk factors for prediction of ESRD (Table 3). Old age ($\geq$65 y old), diabetes, and CKD were

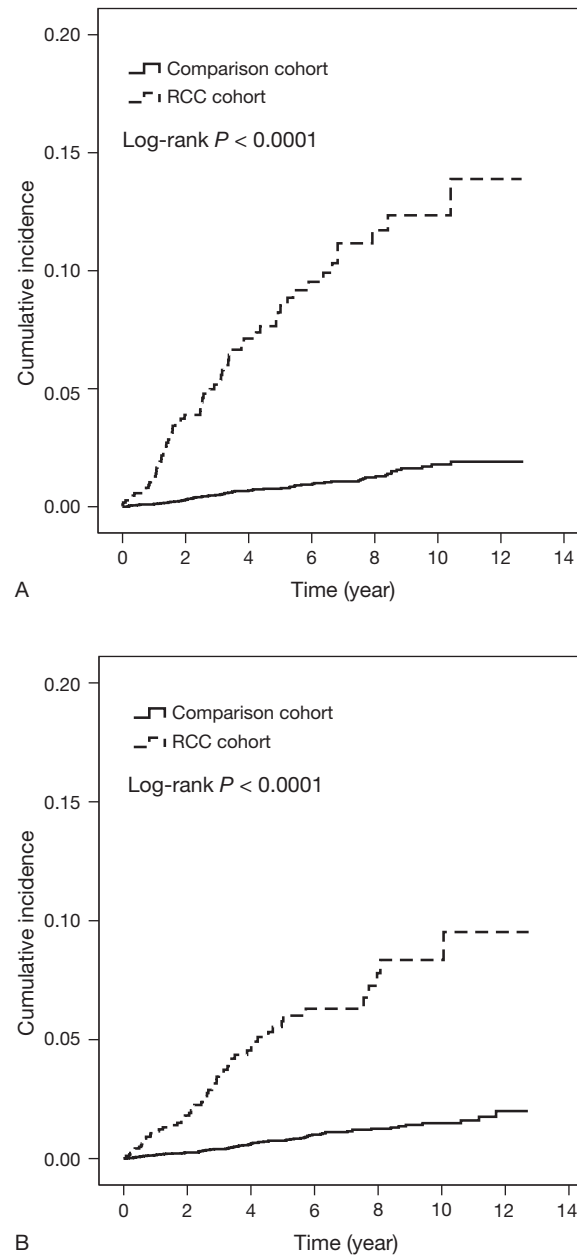

FIGURE 1. Cumulative incidence of ESRD in (A) females and (B) males with and without RCC.

© 2014 Lippincott Williams & Wilkins

TABLE 2. Comparisons of the Incidence Rate Ratios and Hazard Ratios of ESRD in Cohorts With and Without RCC

	Non-RCC			RCC				
Variables	**Cases**	**PY**	**Rate**	**Cases**	**PY**	**Rate**	**Crude HRs (95% CI)**	**Multivariate-HRs (95% CI)**
All	160	101,611	1.57	119	9464	12.57	8.24 (6.50–10.5)***	5.63 (4.37–7.24)***
Age								
25–44	1	1187	0.09	6	1192	5.03	54.8 (6.59–456)***	41.8 (4.57–383)**
45–64	53	46,063	1.15	42	4321	9.72	8.52 (5.68–12.8)***	4.05 (2.54–6.45)***
≥65	106	44,360	2.39	71	3951	17.97	7.53 (5.57–10.2)***	5.57 (4.07–7.64)***
Sex								
Male	91	59,598	1.53	57	5545	10.28	6.74 (4.84–9.40)***	4.76 (3.34–6.78)***
Female	69	42,013	1.64	62	3919	15.82	9.58 (6.79–13.5)***	7.06 (4.90–10.2)***
Comorbidity								
Diabetes								
No	112	95,792	1.17	82	8033	10.21	8.80 (6.62–11.7)***	7.15 (5.27–9.70)***
Yes	48	5819	8.25	37	1431	25.85	3.14 (2.04–4.82)***	2.98 (1.90–4.68)***
Hypertension								
No	104	90,875	1.14	65	6251	10.40	9.15 (6.71–12.5)***	6.77 (4.83–9.50)***
Yes	56	10,735	5.22	54	3213	16.81	3.26 (2.24–4.74)***	3.61 (2.45–5.32)***
Coronary heart disease								
No	135	96,217	1.40	107	8691	12.31	8.83 (6.85–11.4)***	6.28 (4.79–8.23)***
Yes	25	5394	4.64	12	772	15.54	3.34 (1.67–6.65)***	2.49 (1.22–5.07)*
Atrial fibrillation								
No	157	100,742	1.56	118	9348	12.62	8.09 (6.37–10.3)***	5.65 (4.38–7.29)***
Yes	3	869	3.45	1	116	8.62	2.49 (0.29–24.0)	3.40 (0.17–67.3)
Heart failure								
No	1153	100,336	1.52	113	9244	12.22	8.04 (6.30–10.3)***	5.53 (4.26–7.17)***
Yes	7	1274	5.49	6	220	27.29	4.83 (1.62–14.4)**	3.79 (1.17–12.3)*
Chronic kidney disease								
No	146	101,401	1.44	100	9343	10.70	7.53 (5.83–9.71)***	5.74 (4.39–7.51)***
Yes	14	210	66.81	19	121	157.36	2.60 (1.30–5.22)**	2.13 (0.94–4.81)
Hyperlipidemia								
No	143	98,908	1.45	109	8994	12.12	8.42 (6.56–10.8)***	5.87 (4.48–7.68)***
Yes	17	2703	6.29	10	470	21.30	3.33 (1.52–7.29)**	3.46 (1.53–7.79)**

CI = confidence interval, ESRD = end-stage renal disease, HR = hazard ratio, IRR = incidence rate ratio, PY = person-years, RCC = renal cell carcinoma.

*$P < 0.05$.

**$P < 0.01$.

***$P < 0.0001$.

significantly associated with ESRD incidence in patients with and without RCC. In addition, female sex was a significant predictor of ESRD in the RCC group and hypertension was a significant predictor of ESRD in the non-RCC group.

Finally, we examined the combined effects of RCC with age, CKD, and diabetes on the risk for ESRD (Table 4). Each of these factors increased the risk of ESRD in patients with and without RCC ($P < 0.0001$ for all comparisons). Examination of the interaction of factors associated with ESRD indicated that there were significant synergistic interactions of CKD and RCC and of diabetes and RCC (interaction $P < 0.005$ for both). In other words, the joint effects of CKD and RCC and of diabetes and RCC were significantly greater than the combined independent effects.

DISCUSSION

This study is the first large-scale study to examine the renal outcome in patients with RCC over a 12-year follow-up period. This study has three novel findings. First, we found that male and female patients with RCC in Taiwan had increased risk for ESRD. Second, females with RCC had higher risk for ESRD than males. Third, patients with RCC along with CKD or diabetes were more likely to have ESRD.

CKD is common in patients who have received therapy for RCC, because therapy often involves nephrectomy and administration of an antivascular endothelial growth factor.[8] The loss of a functioning renal mass after nephrectomy induces compensatory renal growth.[24,25,28] Adaptive renal hypertrophy occurs immediately after nephrectomy and the subsequent decrease in GFR is transient and subclinical.[4,11] However, some nephrectomy patients experience clinically evident ESRD. Information on ESRD after nephrectomy is limited. Our study provides some evidence of an increased incidence of CKD after nephrectomy because of RCC. This may be explained by volume depletion (from nausea/vomiting, diarrhea, overdiuresis, malignant ascites, or pleural effusions), sepsis, or cardiac involvement, which sensitize the kidney to nephrotoxins by induction of a prerenal state.[22] Moreover, several reports indicated an association between RCC and other renal diseases, such as acute and chronic glomerulonephritis.[2,3] Previous studies reported that

© 2014 Lippincott Williams & Wilkins

TABLE 3. Multivariate Analysis of Associations Between Comorbidities and ESRD Risk in Patients With and Without RCC

	Non-RCC		RCC	
	Multivariate HRs[†]	(95% CI)	Multivariate HRs[†]	(95% CI)
Female vs. male	0.99	(0.72–1.36)	1.56	(1.08–2.25)***
Age: ≥65 vs. <65	1.77	(1.25–2.49)**	1.95	(1.33–2.85)***
Diabetes	4.01	(2.68–6.02)***	2.06	(1.38–3.08)***
Hypertension	1.96	(1.30–2.97)**	1.22	(0.82–1.81)
Coronary heart disease	1.06	(0.64–1.75)	0.57	(0.29–1.14)
Atrial fibrillation	0.78	(0.23–2.60)	0.51	(0.07–3.85)
Heart failure	0.69	(0.29–1.66)	1.25	(0.49–3.18)
Chronic kidney disease	21.1	(11.4–39.0)***	15.4	(9.25–25.8)***
Hyperlipidemia	1.35	(0.76–2.38)	1.35	(0.70–2.63)

[†]Multivariate HRs were adjusted for age, sex, monthly income, and comorbidities (including diabetes, hypertension, coronary heart disease, heart failure, chronic kidney disease, and hyperlipidemia).
**$P < 0.01$.
***$P < 0.0001$.

membranous glomerulonephritis is the glomerular lesion most often associated with RCC.[9,21] Other studies reported that minimal change nephropathy, immunoglobulin A glomerulonephritis, membranoproliferative glomerulonephritis, and rapidly progressive glomerulonephritis were rarely associated with RCC.[1–3,5,9,15,18,21,26,30] In the present study, we found that RCC is associated with an increased risk for ESRD. This might be explained by the presence of the above factors in our patients with RCC.

We also found that females with RCC had higher risk for ESRD than males with RCC. In Western countries, females with RCC have better survival rates after radical and partial nephrectomy than males, although the reason for this survival advantage is unclear.[29] Lee et al[17] demonstrated that Korean females with RCC had significantly better survival rates than males. Korean females with RCC also had a lower proportion of clear cell histology and a higher proportion of chromophobe histology.[17] Moreover, a study in China

TABLE 4. Interaction of RCC with Age, CKD, and Diabetes in ESRD

Variables			Crude HRs (95% CI)	Multivariate HRs (95% CI)	Interaction *P* value
RCC	CKD[*]	Case no./N			0.002
No	No	146/23,412	1.00	1.00	
Yes	No	100/2887	7.47 (5.79–9.64)***	5.94 (4.54–7.76)***	
No	Yes	14/108	47.6 (27.4–82.7)***	20.9 (11.6–37.8)***	
Yes	Yes	19/53	112 (6.91–180)***	80.2 (48.7–132)***	
	P for trend		<0.0001	<0.0001	
RCC	DM[†]	Case no./N			0.0001
No	No	112/21,709	1.00	1.00	
Yes	No	82/2364	8.78 (6.60–11.7)***	7.31 (5.42–9.85)***	
No	Yes	48/1811	7.12 (5.07–10.0)***	4.30 (2.96–6.24)***	
Yes	Yes	37/576	22.5 (15.5–32.7)***	14.0 (9.33–20.9)***	
	P for trend		<0.0001	<0.0001	
RCC	Age ≥ 65[‡]	Case no./N			0.42
No	No	54/12,904	1.00	1.00	
Yes	No	48/1613	9.25 (6.26–13.6)***	5.83 (3.90–8.72)***	
No	Yes	106/10,616	2.52 (1.82–3.50)***	1.93 (1.37–2.70)***	
Yes	Yes	71/1327	19.0 (13.3–27.1)***	10.1 (6.84–14.8)***	
	P for trend		<0.0001	<0.0001	

[*]Multivariate model, adjusted for sex, monthly income, and comorbidities (including diabetes, chronic kidney disease, hypertension, coronary heart disease, heart failure, and hyperlipidemia).
[†]Multivariate model, adjusted for age, sex, monthly income, and comorbidities (including diabetes, hypertension, coronary heart disease, heart failure, and hyperlipidemia).
[‡]Multivariate model, adjusted for age, sex, monthly income, and comorbidities (including chronic kidney disease, hypertension, coronary heart disease, heart failure, and hyperlipidemia).
***$P < 0.0001$.

© 2014 Lippincott Williams & Wilkins

indicated that females with RCC had lower stage and grade tumors than males.[7] Thus, it is possible that females with RCC had higher risk for ESRD simply because they had a survival advantage over males with RCC.

Limited information is available concerning the prognostic effect of renal survival for patients with RCC. Our study shows that CKD, diabetes, and old age are statistically significant independent prognostic factors for poor renal outcome. Advanced age and diabetes are well-known risk factors for the progression of CKD.[16] Thus, as expected, our multivariate analysis found that old age and diabetes are associated with ESRD in patients with RCC. After adjusting for these confounding variables, we found that the presence of CKD is also associated with higher risk for ESRD in patients with RCC. This has not been previously reported for patients with RCC.

The current study has several limitations. First, we used a retrospective cohort design by the analysis of existing claims data. The results of clinical tests, anthropometric and laboratory examinations, and health behavior of the patients were not available in the claims data. Thus, we were unable to examine the association of abnormal levels of laboratory markers, such as hemoglobin or albumin, with ESRD. However, the existing claims data enabled us to perform a natural history study on other comorbidities that may be associated with renal outcome. Second, we were unable to assess patients with RCC who received clinical diagnoses of RCC but were not given surgery. The operation techniques, such as open and laparoscopic surgery, and the status of adjuvant chemotherapy were not evaluated, and this might have affected the subsequent renal outcome following the diagnosis of RCC. Third, information on the aggressiveness of RCC was not available in the inpatient claims database. Thus, we were unable to measure whether the RCC aggressiveness is associated with ESRD. In addition, episodes of acute kidney injury during the follow-up period might have affected the accuracy of accumulated incidence in the study and control cohorts. However, the strength of this study is its use of a nationwide population-based sample that effectively enabled us to collect representative patients with ESRD. Further studies of this issue should be conducted with long-term follow-up in order to elucidate the mechanism of ESRD development in patients with RCC based on additional biological and clinical information.

In conclusion, RCC is an independent risk factor for ESRD, and the relationship between them is stronger in females than in males. The diagnosis and treatment of CKD after the diagnosis of RCC, as well as surveillance of renal function and adjustment of drug regimens that may impair renal function, brings together the nephrologist and a team of specialists who are all caring for this group of patients. We expect that such a multimodal approach will increase the survival rate and improve the quality of life of patients with RCC.

REFERENCES

1. Abouchacra S, Duguid WP, Somerville PJ. Renal cell carcinoma presenting as nephrotic syndrome complicated by acute renal failure. *Clin Nephrol*. 1993;39:340–342.
2. Abu-Romeh SH, al-Adnani MS, Asfar S. Renal cell carcinoma presenting with acute renal failure and IgA glomerulonephritis. *Nephron*. 1988;50:169–170.
3. Ahmed M, Solangi K, Abbi R, et al. Nephrotic syndrome, renal failure, and renal malignancy: an unusual tumor-associated glomerulonephritis. *J Am Soc Nephrol*. 1997;8:848–852.
4. Anderson RG, Bueschen AJ, Lloyd LK, et al. Short-term and long-term changes in renal function after donor nephrectomy. *J Urol*. 1991;145:11–13.
5. Auguet T, Lorenzo A, Colomer E, et al. Recovery of minimal change nephrotic syndrome and acute renal failure in a patient withRenal cell carcinoma. *Am J Nephrol*. 1998;18:433–435.
6. Barlow LJ, Korets R, Laudano M, et al. Predicting renal functional outcomes after surgery for renal cortical tumours: a multifactorial analysis. *BJU Int*. 2010;106:489–492.
7. Chen J, Shi B, Zhang D, et al. The clinical characteristics of renal cell carcinoma in female patients. *Int J Urol*. 2009;16:554–557.
8. Cho A, Lee JE, Kwon GY, et al. Post-operative acute kidney injury in patients with renal cell carcinoma is a potent risk factor for new-onset chronic kidney disease after radical nephrectomy. *Nephrol Dial Transplant*. 2011;26:3496–3501.
9. Cudkowicz ME, Sayegh MH, Rennke HG. Membranous nephropathy in a patient with renal cell carcinoma. *Am J Kidney Dis*. 1991;17:349–351.
10. Donin NM, Suh LK, Barlow L, et al. Tumour diameter and decreased preoperative estimated glomerular filtration rate are independently correlated in patients with renal cell carcinoma. *BJU Int*. 2012;109:379–383.
11. Funahashi Y, Hattori R, Yamamoto T, et al. Change in contralateral renal parenchymal volume 1 week after unilateral nephrectomy. *Urology*. 2009;74:708–712.
12. Haroun MK, Jaar BG, Hoffman SC, et al. Risk factors for chronic kidney disease: a prospective study of 23,534 men and women in Washington County, Maryland. *J Am Soc Nephrol*. 2003;14:2934–2941.
13. Huang WC, Levey AS, Serio AM, et al. Chronic kidney disease after nephrectomy in patients with renal cortical tumours: a retrospective cohort study. *Lancet Oncol*. 2006;7:735–740.
14. Jeon HG, Jeong IG, Lee JW, et al. Prognostic factors for chronic kidney disease after curative surgery in patients with small renal tumors. *Urology*. 2009;74:1064–1068.
15. Kagan A, Sinay-Trieman L, Czernobilsky B, et al. Is the association between crescentic glomerulonephritis and renal cell carcinoma coincidental?*Nephron*. 1993;65:642–643.
16. Kuo HW, Tsai SS, Tiao MM, et al. Epidemiological features of CKD in Taiwan. *Am J Kidney Dis*. 2007;49:46–55.
17. Lee S, Jeon HG, Kwak C, et al. Gender-specific clinicopathological features and survival in patients with renal cell carcinoma (RCC). *BJU Int*. 2012;110:E28–E33.
18. Lee SJ, Richards NT. Nephrotic syndrome cured by renal biopsy. *Nephrol Dial Transplant*. 1992;7:265–266.
19. Maisonneuve P, Agodoa L, Gellert R, et al. Cancer in patients on dialysis for end-stage renal disease: an international collaborative study. *Lancet*. 1999;354:93–99.
20. Mandel J, Kjellstrand CM. Long-term results of dialysis and transplantation in patients with end-stage renal failure from hypernephroma. *Nephron*. 1986;44:111–114.
21. Nishibara G, Sukemi T, Ikeda Y, et al. Nephrotic syndrome due to membranous nephropathy associated with renal cell carcinoma. *Clin Nephrol*. 1996;45:424.
22. Perazella MA, Moeckel GW. Nephrotoxicity from chemotherapeutic agents: clinical manifestations, pathobiology, and prevention/therapy. *Semin Nephrol*. 2010;30:570–581.

© 2014 Lippincott Williams & Wilkins

23. Pettus JA, Jang TL, Thompson RH, et al. Effect of baseline glomerular filtration rate on survival in patients undergoing partial or radical nephrectomy for renal cortical tumors. *Mayo Clin Proc*. 2008;83:1101–1106.
24. Prassopoulos P, Cavouras D, Gourtsoyiannis N. Pre- and post-nephrectomy kidney enlargement in patients with contralateral renal cancer. *Eur Urol*. 1993;24:58–61.
25. Shirasaki Y, Tsushima T, Saika T, et al. Kidney function after nephrectomy for renal cell carcinoma. *Urology*. 2004;64:43–47.
26. Sommer M, Schmidt R, Lambrecht E, et al. Rapidly progressive glomerulonephritis in a patient with advanced renal cell carcinoma. *Nephrol Dial Transplant*. 1998;13:2107–2109.
27. Stewart JH, Buccianti G, Agodoa L, et al. Cancers of the kidney and urinary tract in patients on dialysis for end-stage renal disease: analysis of data from the United States, Europe, and Australia and New Zealand. *J Am Soc Nephrol*. 2003;14:197–207.
28. Vincenti F, Amend WJ, Kaysen G, et al. Long-term renal function in kidney donors. Sustained compensatory hyperfiltration with no adverse effects. *Transplantation*. 1983;36:626–629.
29. Woldrich JM, Mallin K, Ritchey J, et al. Sex differences in renal cell cancer presentation and survival: an analysis of the National Cancer Database, 1993-2004. *J Urol*. 2008;179:1709–1713.
30. Woodrow G, Innes A, Ansell ID, et al. Renal cell carcinoma presenting as nephrotic syndrome. *Nephron*. 1995;69:166–169.

© *2014 Lippincott Williams & Wilkins*