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Aetiology of chronic kidney disease and risk factors for disease progression in Chinese subjects: A single-centre retrospective study in Beijing

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Abstract

Aim: To assess the aetiological factors of chronic kidney disease (CKD) and factors associated with disease progression.

Methods: Single-centre retrospective study evaluating thorough electronic medical records of patients diagnosed with CKD at Peking University People's Hospital (April 2010-April 2015). The objectives were to identify the aetiological factors of CKD in Chinese patients and risk factors associated with CKD progression.

Results: Of 15 425 CKD patients, 12 380 had aetiology recorded. The leading aetiologies associated with CKD were chronic glomerulonephritis (CGN; 36.8%), hypertensive nephropathy (HTN; 28.5%) and diabetic nephropathy (DN; 27.1%). CGN was most common in patients with early stage disease (stages 1-2); DN and HTN were common in advanced-stages (stages 3-4). In a longitudinal subcohort of 2923 patients with ≥6-month follow-up, 19.6% experienced CKD progression. Patients with CKD progression were significantly older in age and had a greater number of comorbidities and laboratory anomalies, and were more likely to have DN (40.5%) and CGN (40.5%) than HTN (5.5%) at baseline than patients without progression. In a multivariate analysis, factors associated with disease progression included macro- and micro-albuminuria, anaemia, hyperkalaemia, hyperphosphataemia, metabolic acidosis, CKD stage 4 and type 2 diabetes mellitus (T2DM).

Conclusion: This study identified CGN, DN and HTN as the leading aetiological factors for CKD in Chinese patients. DN was a strong predictor of faster disease progression, with albuminuria (a complication of T2DM) associated with highest risk for disease progression.

KEYWORDS

chronic kidney diseases, diabetic nephropathies, disease progression, glomerulonephritis, hypertensive nephropathy

Zhun Sui and Jiemin Wang contributed equally to this article.

Chronic kidney disease (CKD) is an increasingly common global health concern with an estimated prevalence of 8% to 16% worldwide and a generally poor prognosis.[1] The estimated incidence of CKD in China is 10.8%, accounting for ~120 million patients.[2] The reported prevalence of CKD varies across different regions of China: up to 13.0% in Beijing,[3] 11.8% in Shanghai,[4] 9.5% in Taian[5] and 13.6% in rural and 12.1% in urban Guangdong Province.[6,7]

The aetiology of CKD differs substantially between developed and developing countries, and the mechanisms underlying CKD progression may also differ.[1] Although diabetes mellitus and hypertension are the most common causes of CKD in developed and many developing countries, in some developing countries, such as China, chronic glomerulonephritis (CGN) has been reported as the leading cause, followed by diabetes and hypertension.[1] CGN encompasses primary CGN due to, for example, immunoglobulin A (IgA) nephritis, and CGN secondary to another disease, such as systemic lupus erythematosus (SLE).[8] However, changing lifestyles in China have resulted in increased prevalence of diabetes, hypertension and obesity in recent years.[9] Diabetes (39.5%) and hypertension (24.2%) were reported as the most common aetiological factors associated with CKD in Chinese patients aged >60 years in 2009 to 2010 compared with 1990 to 1991.[10]

Disease progression has serious consequences; determining factors associated with progression may support physicians in identifying high-risk patients. Potential factors associated with disease progression include demographic characteristics (race and ethnicity), comorbidities (hypertension and diabetes), laboratory abnormalities (proteinuria [albuminuria]) and associated complications of CKD (eg, anaemia and hyperkalaemia).[11,12]

The prevalence of advanced-stage (stages 3-4) CKD is reportedly lower in China than in western countries[2]; however, there is a lack of contemporary data describing CKD epidemiology, aetiology and factors associated with CKD progression in China, particularly in urban areas. This cross-sectional retrospective study used high-quality data from Chinese patients in Beijing to identify the aetiological factors associated with CKD and examine contributors to CKD progression. The completeness of the database and longitudinal data available in a subgroup of patients allowed factors ranging from demographic characteristics, laboratory results, comorbidities and complications to be tested for their association with CKD progression.

1 | METHODS

1.1 | Study design and participants

This was a single-centre, retrospective, observational study performed in the Department of Nephrology, Peking University People's Hospital (PUPH), Beijing (one of Beijing's largest tertiary healthcare facilities) using data from April 2010 to April 2015. Electronic medical records of inpatients and outpatients with newly diagnosed stage 1 to 4 CKD were reviewed for inclusion. Patients aged ≥18 years who met the diagnostic criteria and had demographic and laboratory test (at least one serum creatinine test) data available were included.

SUMMARY AT A GLANCE

This study identified diabetic nephropathy was a strong predictor of faster disease progression, and confirmed albuminuria to be associated with highest risk for disease progression.

CKD was defined as either estimated glomerular filtration rate (eGFR) ≤60 mL/min/1.73 m^2 for ≥3 months, or kidney damage characterised by proteinuria, haematuria or anatomical abnormality (stage 1/2 disease). Patient eGFR was estimated using the 2009 CKD Epidemiology Collaboration equation.[13] The disease was staged based on the National Kidney Foundation Kidney Disease Outcomes Quality Initiative guidelines[14] (see supporting information). For patients with eGFR >60 mL/min/1.73 m^2, presence of additional kidney structure abnormalities (via pathological or imaging evidence) or impaired renal

TABLE 1 Baseline characteristics of the cross-sectional and longitudinal cohorts of patients with CKD

Clinical characteristics	Overall, cross-sectional cohort (n = 15 425)	Longitudinal subcohort (n = 2923)
Sex, n (%)		
Female	6758 (44.0)	1328 (45.4)
Age, years		
Mean (SD)	59 (17)	59 (18)
CKD stages[a], n (%)		
1	4864 (31.5)	1018 (34.8)
2	4217 (27.3)	837 (28.6)
3	3895 (25.2)	859 (29.4)
4	1334 (8.7)	210 (7.2)
5	1115 (7.2)	—
Laboratory tests, mean (SD)		
Serum creatinine[b], mg/dL	1.04 (0.77)	0.88 (0.53)
Serum albumin[c], g/L	40.5 (6.90)	40.53 (7.34)
Serum phosphorus[c], mmol/L	1.16 (0.28)	1.17 (0.21)
Serum calcium[c], mmol/L	2.23 (0.22)	2.21 (0.17)
Potassium[c], mmol/L	4.23 (0.71)	4.30 (0.54)
Haemoglobin[c], g/L	123.7 (27.30)	129.78 (21.87)

Abbreviations: CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; IQR, interquartile range; SD, standard deviation.
[a]Stage 1 with normal or high eGFR (>90 mL/min/1.73 m^2), stage 2 mild CKD (eGFR 60-89 mL/min/1.73 m^2), stage 3 moderate CKD (eGFR 30-59 mL/min/1.73 m^2), stage 4 severe CKD (eGFR 15-29 mL/min/1.73 m^2) and stage 5 end-stage CKD (eGFR <15 mL/min/1.73 m^2).
[b]Data were presented as median (IQR) for its non-normal distribution.
[c]Data were missing from some patients.

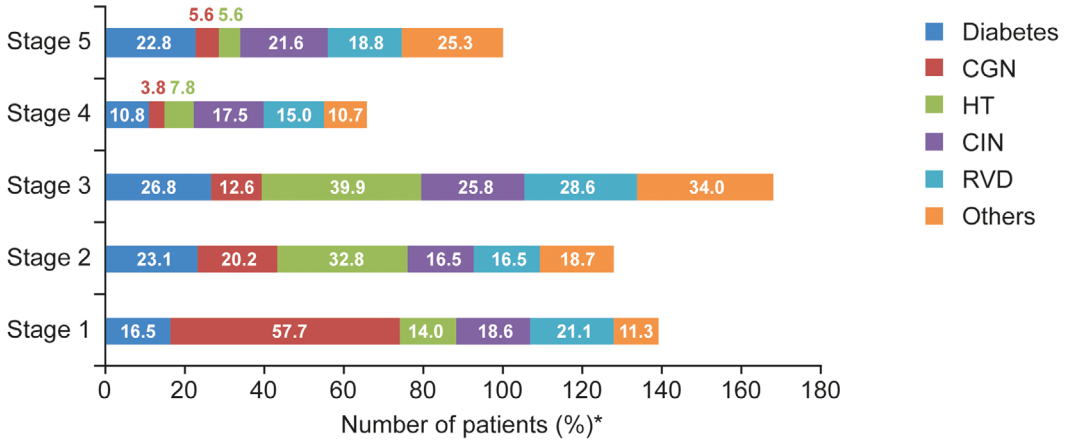
function, such as albuminuria, of >3 months' duration was also required. Patients were excluded if at baseline they had: acute kidney disease that resolved in <3 months, current acute kidney disease, kidney stones, tumour or kidney infection, or were undergoing renal replacement therapy (RRT; including dialysis and renal transplantation).

Variables analysed in the overall CKD cohort were presented as proportions of patients with each CKD aetiology at baseline, as well as aetiology stratified by CKD stage, risk factors for CKD complications and advancing CKD stage. A subcohort of patients from the overall cross-sectional analysis cohort was included in a longitudinal survival analysis to determine the association between CKD aetiology or CKD complications (eg, anaemia, hyperkalaemia, hypokalaemia, hyperphosphataemia and hypocalcaemia) and progression. This subcohort comprised patients with stage 1 to 4 CKD who were followed up for ≥6 months and had ≥3 eGFR measurements separated by a gap of ≥30 days. CKD progression was defined using the 2012 Kidney Disease: Improving Global Outcomes CKD guideline criterion, that is, a drop in eGFR stage category accompanied by a ≥ 25% reduction in eGFR from baseline during the follow-up period, rather than by absolute change in eGFR in mL/min/month.[15] As patients on RRT were excluded from the study, initiation of RRT was taken as an indicator of progression. The observation period ended in April 2015 and was therefore a censoring event.

The study protocol was approved by the ethics committee of the PUPH and performed in accordance with International Conference on Harmonisation Good Clinical Practice (GCP, E6) and the Declaration of Helsinki. As the study was retrospective, requirement of informed consent was waived. Confidentiality of patient data was maintained and the de-identified data were analysed. Mortality data were not assessed.

1.2 | Data collection

The available data included patient demographics, medical history, laboratory tests and prescriptions. Information related to patient's age, sex, CKD aetiology, laboratory parameters, as well as their treatment, was extracted from the database and linked longitudinally for individual patients. Aetiology was extracted from electronic medical records, including CGN, diabetic nephropathy (DN), hypertensive nephropathy (HTN), tubulointerstitial diseases, vascular diseases and others. Comorbidities and complications that are common to CKD were considered, including coronary artery disease (CAD), anaemia, hyperkalaemia, hypokalaemia, hyperphosphataemia, hypocalcaemia and metabolic acidosis (see supporting information for definitions). Baseline was set as the date of the patient's first visit or CKD diagnosis for the cross-sectional analysis. The date of the first available serum creatinine test was used as index date for the longitudinal analysis. All data were collected by study physicians in a prespecified format approved by the ethics committee. The effects of missing data were addressed through data quality checks and propensity score matching.



	Number of patients					
	Overall	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Diabetes	1574	260	363	422	170	359
CGN	2677	1545	541	338	102	151
HT	1739	243	570	694	135	97
CIN	194	36	32	50	34	42
RVD	133	28	22	38	20	25
Others	150	17	28	51	16	38

FIGURE 1 Chronic kidney disease (CKD) aetiology by CKD stage in the overall, cross-sectional cohort. CGN, chronic glomerulonephritis; DN, diabetic nephropathy; HTN, hypertensive nephropathy; CIN, chronic interstitial nephritis; RVD, renal vascular disease

TABLE 2 Baseline characteristics of patients with and without CKD progression after follow-up (mean ~2 years) in the longitudinal analysis subcohort

Demographics	Non-progressing (n = 2349)	Progressing (n = 574)	*P*-value[a]
Sex			
Female, %	44.8	48.1	.155
Age, years	57 (18)	60 (16)	.001
Comorbidities, %			
Hypertension	84.3	96.9	<.001
T2DM	43.9	50.8	.004
CAD	34.1	44.3	<.001
Stroke	10.0	18.3	<.001
Heart failure	3.2	13.6	<.001
Malignancies	6.4	6.7	.777
CKD stages, %			All <.001
1	37.6	23.4	
2	27.5	33.2	
3	29.4	29.4	
4	5.5	14.0	
Aetiology, %			All .005
Diabetic nephropathy	36.1	40.5	
CGN	46.4	40.5	
Hypertensive nephropathy	9.7	5.5	
CIN	1.4	2.6	
RVD	2.2	4.2	
Others[b]	4.3	6.8	
Laboratory tests			
Serum albumin, g/L	40.84 (7.43)	39.27 (6.81)	<.001
Albuminuria, %			All <.001
Normal	21.9	6.8	
Microalbuminuria	29.9	21.0	
Macroalbuminuria	48.2	72.2	
Serum phosphorus, mmol/L	1.16 (0.21)	1.19 (0.22)	.008
Serum calcium, mmol/L	2.21 (0.17)	2.19 (0.18)	.001
Potassium, mmol/L	4.29 (0.51)	4.34 (0.64)	.044
Haemoglobin, g/L	131.7 (21.6)	121.9 (21.2)	<.001
CO_2, mmol/L	25.2 (3.2)	24.6 (3.4)	<.001
Cholesterol, mmol/L	5.08 (1.81)	4.98 (1.54)	.245
Triglycerides, mmol/L	1.85 (1.40)	1.87 (1.31)	.720
LDL, mmol/L	2.99 (1.36)	2.94 (1.17)	.404
HDL, mmol/L	1.16 (0.37)	1.10 (0.35)	<.001

Abbreviations: CAD, coronary artery disease; CGN, chronic glomerulonephritis; CIN, chronic interstitial nephritis; CKD, chronic kidney disease; HDL, high-density lipoprotein; LDL, low-density lipoprotein; RVD, renal vascular disease; T2DM, type 2 diabetes mellitus.

[a]Comparisons of continuous variables (age, serum creatinine, serum albumin, serum phosphorus, serum calcium, potassium, haemoglobin, CO_2, cholesterol, triglycerides, LDL and HDL) between two groups were performed using the *t* test. The Chi-squared test was used to compare the categorical variables (sex, CKD stage, aetiology and albuminuria).

[b]Including, inherited disease, polycystic kidney disease and obstructive kidney disease.

1.3 | Statistical analysis

Continuous variables were reported as mean ± SD, unless otherwise specified. Comparisons of continuous variables between two groups were performed using *t* tests, Wilcoxon signed rank tests and analysis of variance tests where appropriate. The Chi-squared test was used to compare the categorical variables. In the longitudinal CKD subcohort, Kaplan-Meier curves were estimated to determine the association between CKD progression with both disease stage based on eGFR and albuminuria. Multivariate logistic regression analysis was used to assess the association of risk factors with CKD complications, cardiovascular disease and other outcomes. Hazard ratio estimates along with a 95% confidence interval for time to progression of disease were assessed in a multivariate Cox proportional hazards model, built by stepwise selection of patient covariates (age, sex, comorbidities, CKD stage and laboratory test results) from all available

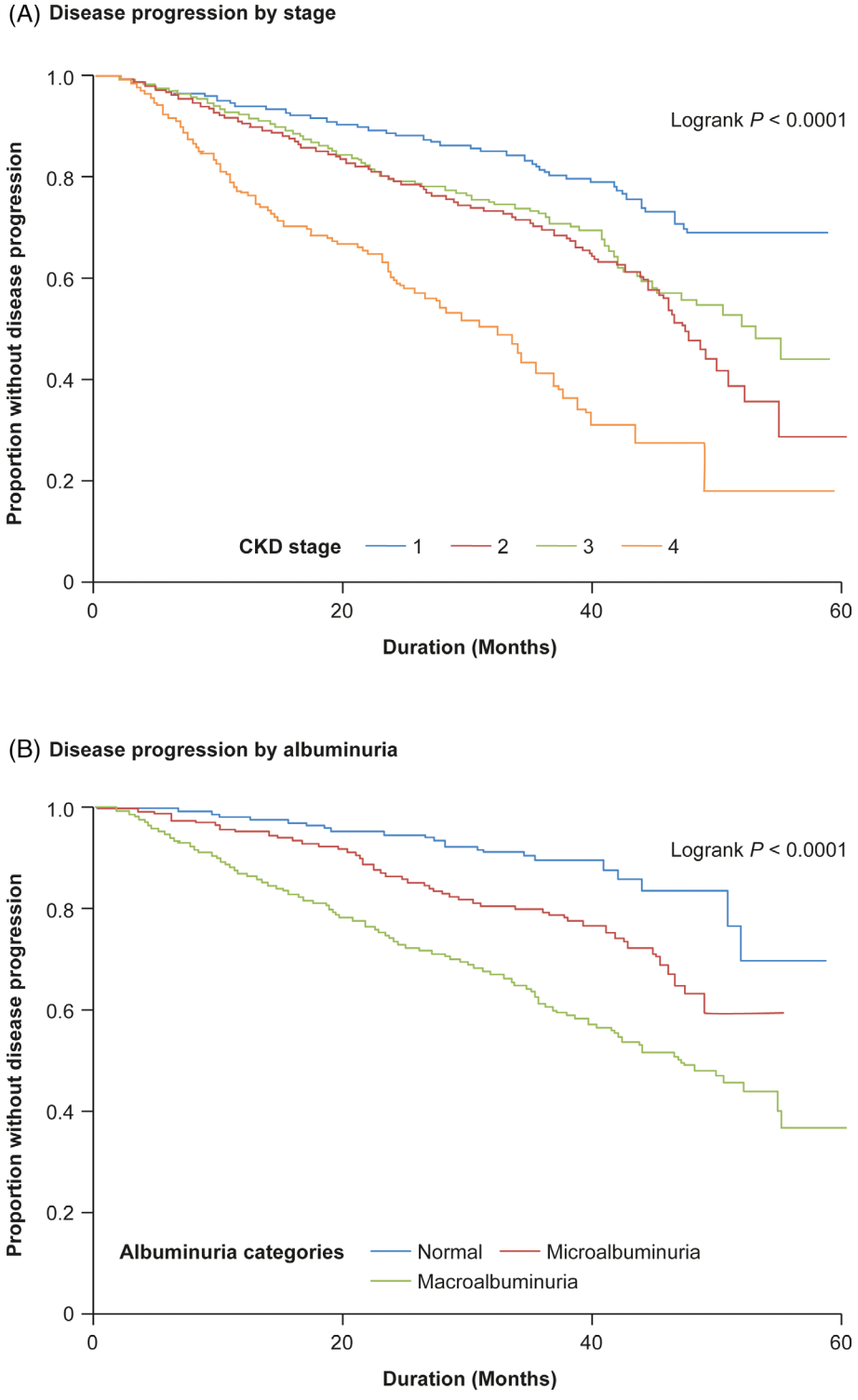


FIGURE 2 Kaplan-Meier survival plot of disease progression by A, disease stage and B, albuminuria in the longitudinal subcohort. CKD, chronic kidney disease

baseline variables. We attempted to mitigate confounders by indication by having the control group (ie, patients without CKD progression) as similar as possible to the exposed group (ie, patients with CKD progression); however, we did not collect measures such as urine volume or blood pressure, which may lead to continued unadjusted confounding. Interactions between variables and follow-up periods were not studied. Patients with many missing data points were excluded from the longitudinal analyses, however, selection bias analyses showed no difference in patient characteristics of mean age, duration of CKD, serum creatinine, HbA1c, the prevalence of DN and hypertension between those included and excluded from the analyses (data not shown). Results were regarded as significant at the level of $P \leq .05$. Statistical analysis was performed using the Statistical Analysis System version 9.4 for Windows.

2 | RESULTS

2.1 | Baseline characteristics

In total, 16 131 patients were diagnosed with CKD from 20 510 available patients in the PUPH database overall. Among them, 701 were excluded for RRT and 5 were excluded for missing demographic and medical history, resulting in a total of 15 425 patients (mean age, 59 ± 17 years; 44.0% females) in the final cross-sectional analysis (Table 1). In these patients, advanced disease stage was generally associated with increased incidence of common CKD comorbidities, including hyperkalaemia and anaemia (Supplementary Table 1).

2.2 | Aetiology of CKD at baseline

Of the overall population of 15 425 patients, there were 12 380 with known CKD aetiology, assessed by clinical diagnosis at baseline (Supplementary Table 2). CGN (36.8%), HTN (28.5%) and DN (27.1%) accounted for >90% of all cases of CKD. Among patients with primary glomerulonephritis (n = 3733), IgA nephropathy was the major pathological type (27.3%). SLE was the most common factor associated with secondary glomerulonephritis (n = 348/817; 42.6%).

2.3 | Aetiology of CKD by stage

Stratification analysis of CKD aetiology by disease stage showed that a greater proportion of patients with CGN (n = 2677) had early stage (stage 1/2) CKD (n = 2086 [77.9%]) than those with DN (n = 623/1574 [39.6%]) and HTN (n = 813/1739 [46.8%]) (Figure 1). The proportion of patients with DN showed a strong positive correlation with increasing disease stage up to stage 3 (16.5% for stage 1, 23.1% for stage 2, 26.8% for stage 3, decreasing to 10.8% for stage 4 and 22.8% for stage 5), whereas CGN was most associated with CKD in stage 1 (57.7%), decreasing to 5.6% in stage 5 (Figure 1).

2.4 | Patient covariates and CKD complications

Multivariate logistic regression analyses, conducted to identify factors associated with CKD complications and severity, indicated that the odds of experiencing a hyperkalaemic event were greater among those with a history of heart failure (HF) and appeared to be correlated with more advanced CKD stage. Anaemia was correlated with increasing CKD stage, in particular stage 5. HF, CAD, CKD severity, stroke and albuminuria were associated with hypocalcaemia. Diabetes, HF and more advanced CKD stage were all associated with hyperphosphataemia. Acidosis was most commonly noted in patients with HF and in those with more advanced CKD stage (Supplementary Table 3).

2.5 | Longitudinal analysis of CKD progression

The mean follow-up duration in the 2923 patients included in the longitudinal analysis of CKD progression was almost 2 years (22

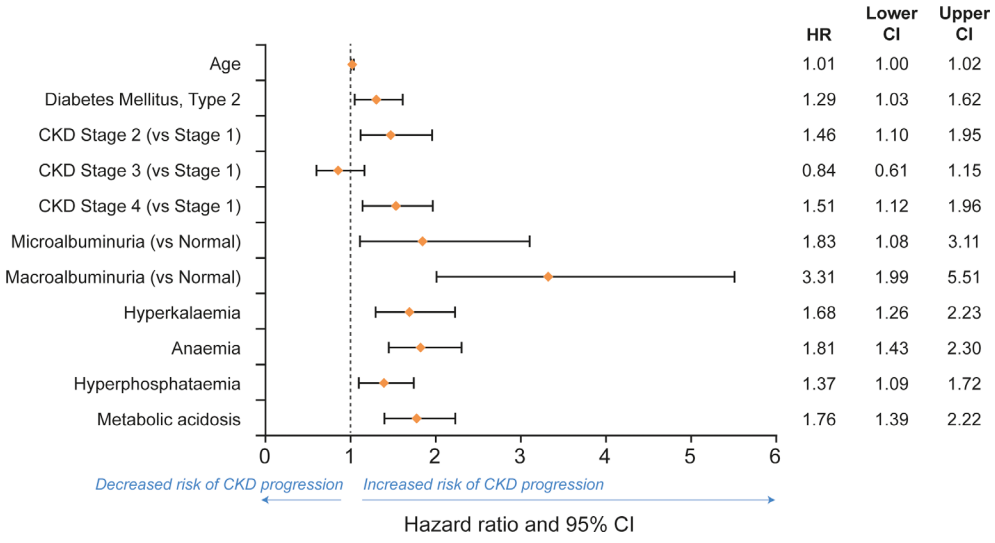


FIGURE 3 Baseline characteristics associated with disease progression on multivariate analysis in the longitudinal subcohort (n = 1595 in final model). Hazard ratio (HR) with 95% confidence interval (CI). CKD, chronic kidney disease

± 13 months). CKD progression was observed in 574 (19.6%) patients. In general, patients with CKD progression were slightly older than those without progression (mean age 60 vs 57 years; $P = .001$), and had significantly more comorbidities at baseline (hypertension, type 2 diabetes mellitus [T2DM], CAD, stroke and HF; all $P < .01$) (Table 2). There were also significant differences in terms of laboratory parameters in those who progressed compared with those who did not (all $P < .05$) (Table 2). Higher CKD stage was significantly associated with disease progression ($P < .001$).

Kaplan-Meier survival analyses showed that CKD progression was associated with CKD stage ($P < .0001$) and albuminuria level ($P < .0001$) at baseline (Figure 2).

In total, after excluding those with many missing data points, 1595 patients from the longitudinal subcohort were included in multivariate Cox proportional hazards modelling to evaluate which baseline characteristics and CKD complications were associated with disease progression (Figure 3). Macroalbuminuria and microalbuminuria were the strongest predictors of CKD progression. The presence of common CKD complications was also associated with progression, including anaemia, metabolic acidosis and hyperkalaemia. Despite the findings of the Kaplan-Meier survival analysis, the associations between CKD progression and stage were not consistent across stages, as a significant association was found for stages 2/4, but not stage 3 (Figure 3). Presence of T2DM was significantly associated with progression.

3 | DISCUSSION

To the best of our knowledge, this is the first contemporary study conducted in any region of China to determine both the leading aetiological factors of CKD and the predominant risk factors associated with CKD progression in Chinese patients. Most studies to date were conducted before 2015 and have examined CKD aetiology alone, with few investigating risk factors for CKD progression.[16-19] We showed that CGN was the most frequent aetiological factor in our population and found that CKD progression was more common in patients with T2DM and those with advanced stages of CKD.

Most studies in China have reported CGN as an important aetiological factor of CKD. In this study of patients in Beijing, the leading aetiologies associated with CKD were CGN (36.8%), HTN (28.5%) and DN (27.1%). An observational study of 2420 non-dialysis patients with CKD in Shanghai reported the same leading underlying conditions associated with CKD; however, with a much higher prevalence of CGN (57%), and lower prevalence of HTN (14%) and DN (13%).[17] The patient populations in that study and ours comprised inpatients and outpatients at secondary or tertiary hospitals, rather than patients from the general population. Nevertheless, our data are in agreement with previous reports that CGN and DN are the leading aetiologies associated with CKD in China.[16,20-22]

These findings differ from observations from the United States, United Kingdom and Japan, where the leading causes of CKD were DN and HTN.[1] Diabetes was the leading factor associated with CKD (>40%) in the United States, with CGN contributing to <5% of cases; in the United Kingdom, diabetes contributed to >20% of all CKD cases.[1] The differences may be due in part to differences in T2DM prevalence. However, the situation is changing in China. Although CGN remained the leading aetiological factor associated with CKD in our study, the incidence of T2DM and hypertension in China has increased dramatically in recent years.[23] Recent studies in Chinese patients with CKD and anaemia conducted between 2015 and 2016 report up to 31% and up to 88% of patients with a history of T2DM and hypertension, respectively.[24,25] A higher percentage of patients with CKD due to T2DM vs CGN was reported from China between 2011 and 2015.[16] A nationwide study in 2015 by the China Kidney Disease Network (CK-NET) also reported DN as the most common (27%) aetiology of CKD.[26] However, most patients with stage recorded had stage 4 or 5 CKD. In our study, the leading aetiology of CKD for patients with stage 5 CKD was DN (22.8%), whereas CGN was the most common aetiology for those with stage 1 CKD. In our study, approximately 58% of patients had CKD stage 1 or 2 at baseline; thus, the discrepancy in these findings may be representative of the patient population studied. Furthermore, the CK-NET study highlighted aetiological differences between rural and urban Chinese populations; over one-half of urban patients were diagnosed with DN or HTN, whereas the leading causes for CKD in the rural population were obstructive nephropathy or CGN.[26] A low prevalence (2.9%) of diabetic kidney disease has also been independently reported in rural Chinese residents.[27] While our study was conducted in a single centre in Beijing, the centre serves patients from both urban and rural areas. Our study was not designed to compare aetiologies between urban and rural populations; however, further analyses would be of interest in future studies to inform local public health policies. The public health burden of CKD has increased in China, with the increasing prevalence of T2DM and hypertension likely to result in a CKD epidemic[2]; however, it may take another decade for T2DM and hypertension to substantially affect this burden, and the intervening period presents an opportunity to slow the increase in CKD related to hypertension and T2DM.

CKD in T2DM may not always present as typical DN—it can be a result of DN, be due to other causes, such as diffuse microvascular atherosclerosis, or both.[28] These other potential underlying factors makes it difficult to ascertain how much loss of renal function is due to T2DM per se. Annual assessment of kidney function is therefore recommended in patients with T2DM without known renal disease, and screening for CKD should have the same priority as, and be integrated with, screening for hypertension and T2DM.[29]

CKD progression is an important clinical event with substantial morbidity, and is associated with a number of risk factors, including proteinuria, hypertension, diabetes, race and ethnicity.[11] By analysing the characteristics of patients with CKD, we found that the proportions of patients with advanced CKD were highest among those with DN or HTN. The most likely explanation is that CGN is less likely to progress or progresses more slowly than the renal damage caused by diabetes or hypertension, particularly if these conditions remain undetected or untreated. This observation may also partially explain the lower prevalence of advanced-stage CKD in China compared with

other regions, such as the United States and Canada, and Europe,[30,31] that is, because there are fewer patients with DN or HTN.

Compared to HTN and CGN, a higher percentage of patients with DN in the longitudinal cohort had CKD progression. Other investigators have reported a lower proportion of DN patients with advanced CKD, but the high prevalence of cardiovascular disease and other comorbidities in these patients may mean they do not survive to reach advanced-stages of CKD.[32] The survival analysis also demonstrated the importance of CKD stage and the presence of albuminuria, particularly macroalbuminuria, in progression of CKD to end-stage renal disease. CKD complications, such as anaemia, metabolic acidosis and hyperkalaemia, were also found to be predictive of disease progression. Experimental data suggest that hypoxia resulting from anaemia of CKD may contribute to tubulointerstitial damage associated with CKD progression and renal failure.[33] The association between metabolic acidosis and CKD progression may in part be due to the adaptive response of surviving nephrons to the loss of their neighbouring damaged nephrons, that is, increased ammonium excretion resulting in activation of the complement and renin-angiotensin systems, all of which may contribute to tubulointerstitial inflammation and chronic kidney damage.[34] Hyperkalaemia has been linked to metabolic acidosis,[35] and may indirectly contribute to CKD progression by feeding into the adaptive response and also by dictating the withdrawal of nephroprotective renin-angiotensin-aldosterone system inhibitors. The risk factors for CKD progression identified in this Chinese population are consistent with those reported for patients in western countries.[32] While this study examined the characteristics of patients with or without progressive CKD, detailed clinical parameters, such as blood pressure, weight, body mass index, glucose, haemoglobin A1C or smoking history, were not collected; therefore, the phenotype of patients with CKD progression identified here is limited to aetiology, comorbidities and laboratory parameters. Nonetheless, these observations may help to identify patients at greatest risk of disease progression and aid its prevention.

This retrospective study identified the leading aetiological indicators for CKD in a Chinese patient population, as well as factors associated with more rapid renal deterioration. The findings provide insights for identifying patients at high risk of CKD and the potential prevention of disease progression in Chinese patients. The strengths of this study include that it was conducted in a real-world setting and included data collected in a cross-sectional manner from more than 15 000 patients drawn from a population treated at a single academic medical centre, among which a subcohort could be followed up over time. Longitudinal data are still rare in China, and our data were rich in detail. Nevertheless, the single-centre nature of the study may limit the generalizability of its findings to other settings, regions and populations. As expected in a real-world setting, patients were lost from the dataset over time, which may have resulted in some selection bias in the longitudinal analyses, as well as residual confounding. The longitudinal analysis included patients with a minimum of 6 months of follow-up to increase the statistical power of the analyses. However, results may differ with a longer minimum follow-up of 1 year and should be investigated in future studies. Furthermore, the interaction between cause of CKD progression and follow-up period requires further study. Mortality data were not assessed in this analysis and could therefore not be accounted for in the longitudinal analyses. As this was a natural history study and not designed to evaluate an intervention, this retrospective design was deemed suitable.

In this retrospective observational study, the leading aetiologies associated with CKD in the Chinese patient population were CGN (36.8%), HTN (28.5%) and DN (27.1%). Multivariate analysis showed that those with albuminuria, CKD stage 4 at presentation, anaemia, hyperkalaemia, hyperphosphataemia or metabolic acidosis were at increased risk of CKD progression. Identifying those most at risk of progression may help to inform decision-making and facilitate interventions to slow or prevent further renal deterioration in these patients, which is of importance as the prevalence of T2DM increases in China.

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ETHICS STATEMENT

The study protocol was approved by the ethics committee of the Peking University People's Hospital and performed in accordance with International Conference on Harmonisation Good Clinical Practice (GCP, E6) and Declaration of Helsinki. As the study was retrospective, requirement of informed consent was waived. Confidentiality of the patient data was maintained.

DATA ACCESSIBILITY

Data underlying the findings described in this manuscript may be obtained in accordance with AstraZeneca's data sharing policy described at https://astrazenecagrouptrials.pharmacm.com/ST/Submission/Disclosure.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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