Prevalence of kidney stones and associated risk factors in the Shunyi District of Beijing, China

YG Jiang, LH He, GT Luo *, XD Zhang *

ABSTRACT

Introduction: Kidney stone formation is a multifactorial condition that involves interaction of environmental and genetic factors. Presence of kidney stones is strongly related to other diseases, which may result in a heavy economic and social burden. Clinical data on the prevalence and influencing factors in kidney stone disease in the north of China are scarce. In this study, we explored the prevalence of kidney stone and potentially associated risk factors in the Shunyi District of Beijing, China.

Methods: A population-based cross-sectional study was conducted from December 2011 to November 2012 in a northern area of China. Participants were interviewed in randomly selected towns. Univariate analysis of continuous and categorical variables was first performed by calculation of Spearman's correlation coefficient and Pearson Chi squared value, respectively. Variables with statistical significance were further analysed by multivariate logistic regression to explore the potential influencing factors.

Results: A total of 3350 participants (1091 males and 2259 females) completed the survey and the response rate was 99.67%. Among the participants, 3.61% were diagnosed with kidney stone. Univariate analysis showed that significant differences were evident in 31 variables. Blood and urine tests were performed in 100 randomly selected patients with kidney stone and 100 healthy controls. Serum creatinine, calcium, and uric acid were significantly different between the patients with kidney stone and healthy controls. Multivariate logistic regression revealed that being male (odds ratio=102.681; 95% confidence interval, 1.062-9925.797), daily intake of white spirits (6.331; 1.204-33.282), and a history of urolithiasis (1797.775; 24.228-133 396.982) were factors potentially associated with kidney stone prevalence.

Conclusions: Male gender, drinking white spirits, and a history of urolithiasis are potentially associated with kidney stone formation.

Hong Kong Med J 2017;23:462–9
DOI: 10.12809/hkmj164904

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This article was published on 18 Apr 2017 at www.hkmj.org.

New knowledge added by this study

- Serum creatinine, calcium, and uric acid levels were associated with kidney stone disease.

Implications for clinical practice or policy

- Male gender, drinking white spirits, and a history of urolithiasis are associated with kidney stone disease.

Introduction

Kidney stone formation is a multifactorial condition that involves interaction of environmental and genetic factors.[1] In western countries, the prevalence and incidence of kidney stone formation have been reported to be 2% to 19%, with an increasing frequency among men.[2] A previous study estimated that the overall prevalence of kidney stones in China was 4.0% (4.8% in men and 3.0% in women).[3] The condition causes severe pain and is highly likely to be recurrent.[4] In addition, the presence of kidney stones is strongly related to chronic kidney disease, bone loss and fractures, kidney cancer, coronary heart disease, hypertension, and metabolic syndrome.[5-9] This results in a heavy economic and social burden.[10,11] An appropriate prevention strategy is urgently needed to reduce the prevalence and health care costs that arise from the condition.

Currently, many domestic and international reports have focused on the risk factors for kidney stone formation. These diverse risk factors including age, gender, race, drugs, genetic, dietary, and environmental factors (eg occupation and heat exposure), insulin resistance, as well as drinking water are all reported to be associated with kidney stone prevalence.[2,12-15] Clinical data on the prevalence and influencing factors in kidney stone disease in the north of China are scarce however, as is knowledge about the relationship between kidney stone formation and blood and urine parameters.

Our study aimed to explore the prevalence of kidney stone disease and the underlying causes in Shunyi District, Beijing, China. Shunyi District is an important district in the northeast of Beijing with a population of 953 000 in 2012. The results of this study may provide an insight into ways that can help prevent kidney stone formation.

中國北京市順義區人口的腎結石患病率和相關危險因素調查

蔣宇光、何麗華、羅功唐、張小東

引言：造成腎結石的原因有很多，且牽涉遺傳和環境因素的相互作用。腎結石與其他疾病密切相關，所以可能給家庭和社會帶來沉重的經濟負擔。可是，中國北方地區有關腎結石的患病率和影響因素的臨床資料很少。本研究探討北京市順義區人口的腎結石患病率和潛在危險因素。

方法：2011年12月至2012年11月期間，我們在中國北方地區進行了一項以社區人口為基礎的橫斷面研究，利用隨機抽樣的方法選擇城鎮並邀請參與者進行面訪調查。通過計算斯皮爾曼相關係數和皮爾遜卡方平方分別為連續和分類變量作單變量分析。然後通過多變量邏輯迴歸進一步分析具有統計顯著性的變量，以探討腎結石潛在的影響因素。

結果：共3350名參與者（1091男，2259女）完成調查，回應率為99.67%。參與者中約3.61%診斷患有腎結石。單變量分析顯示有31個變量有顯著差異。研究也為隨機抽樣的100名腎結石患者和100名健康參與者（對照組）進行血液和尿液測試。兩組的血清肌酐、鈣和尿酸水平有明顯差異。多變量邏輯迴歸分析顯示男性（比值比=102.681；95%置信區間：1.062-9925.797）、每日飲用白酒（6.331；1.204-33.282）和尿石病史（1797.775；24.228-133 396.982）可能與腎結石潛在相關。

結論：男性、飲用白酒和尿石病史可能與腎結石形成有關。

Methods

Sampling and participants

All procedures were carried out in accordance with the ethical standards of the local institute and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This cross-sectional survey was conducted from December 2011 to November 2012. A total of 19 towns in the Shunyi District of Beijing were numbered randomly. A random number table was used to choose six towns from these 19 towns. The six towns included Zhangzhen, Mulin, Beiwu, Nanfaxin, Renhe, and Nancai. Residents who visited their township hospital for a routine physical examination were invited to participate in this survey.

The inclusion criteria of participants were the age of ≥18 years and as resident in the town for more than 3 years. The exclusion criteria were presence of kidney stones, renal failure, chronic gastric disease, urinary tract malformation, urinary tract obstructive disease, urinary tract infection, or hyperparathyroidism.

Verbal consent was obtained from all study participants following provision of information about the study objectives, procedures, and implications. The study was approved by the Ethics Committee of Beijing Shun-Yi Hospital.

The questionnaire and physical examination

All participants were asked to complete a questionnaire that covered the following: (1) demographic characteristics, including gender, age, body mass index, workplace, and job category. The amount of sweat following exercise was quantified and classified as dry, wet, and moist if the palm, forehead, axillary, and back were dry, wet, and dripping with sweat, respectively; (2) daily fluid intake, including water intake, source of drinking water, habits of drinking water; and fluid intake including tea, soup, and milk; (3) living and dietary habits, including outdoor activities, smoking, frequency of staple and non-staple food intake (sweetmeats, seafood, fruit, vegetables, bean products, dairy products, eggs, meat, and animal's viscera); (4) personal and family history of urinary calculus, urinary tract infection, or hypertension; and (5) present diagnosis of kidney stone detected by a physician and its characteristics. To screen for the presence of kidney stones, all participants underwent an ultrasound examination that was performed by two attending physicians in each hospital.

Biochemical detection

To fully explore the potentially associated factors, 100 patients with kidney stone(s) were numbered and then randomly selected by computer for testing of blood and urine biochemical parameters. Specifically, levels of creatinine, calcium, phosphorus, potassium, and uric acid were measured in an early-morning urine and fasting blood samples using a biochemistry analyser, AU5400 (Beckman Coulter Ltd, United States). Blood concentration of chlorine and sodium was also measured. Simultaneously, 100 age- and sex-matched healthy participants who visited these hospitals for a routine physical examination during the study period and were confirmed to be free of urinary calculus or endocrine metabolic disease were selected as controls.

Statistical analysis

Data were entered into the computer using EpiData 3.1 (EpiData Association, Odense, Denmark) and analysed using the Statistical Package for the Social Sciences (Windows version 19.0; IBM Corp, Armonk [NY], United States). Continuous variables are presented as mean ± standard deviation, and categorical variables as percentages. Univariate analysis of continuous and categorical variables was first performed by Spearman's correlation coefficient (r_s) and Pearson Chi squared (χ^2) value, respectively. Statistically significant variables were further analysed by multivariate stepwise logistic regression to explore the potential influencing factors. The inclusion criteria was 0.05, and the exclusion criteria was 0.1. Odds ratios (ORs) with corresponding 95% confidence intervals (CIs) were calculated. A P value of <0.05 was considered statistically significant.

Results

Participant characteristics

A convenient sample of 3361 subjects was invited to participate in this study, of whom 3350 completed the survey with 1091 males and 2259 females. The response rate was 99.67%. The mean age of all participants was 48.97 ± 17.02 years (range, 20-98 years), with 54.46 ± 13.23 years for males and 51.81 ± 11.24 years for females.

Prevalence and factors associated with presence of kidney stone

Presence of kidney stones was newly diagnosed in 121 subjects (3.61%; 95% CI, 2.88%-4.32%) including 67 (6.14%) males and 54 (2.39%) females. As shown in Table 1, univariate analysis showed that 31 variables were significantly associated with the presence of kidney stones—including gender; age; place of work; occupation; amount of exercise, sweat, daily water intake; water source; intake of fluid, alcohol, coffee, tea, soup, white spirits, and milk; outdoor activity; smoking; eating eggs and meat; presence of kidney stones in relatives, parents, and siblings; as well as personal history of hypertension, urinary stone, urinary tract infections, chronic gastric diseases, hyperlipidaemia, diabetes, kidney surgery, ureter surgery; and prescription of a diuretic.

Associated biochemical variables

Biochemical parameters were measured in blood and urine samples. As shown in Table 2, the concentration of serum creatinine, calcium, and uric acid in blood differed significantly in patients with and without kidney stone(s), suggesting that the three variables were potentially associated with this disease. No statistical difference was observed in the concentration of other variables. With regard to the level of these parameters in urine, no significant difference was found between the patients with kidney stone and the healthy controls (Table 2).

Risk factors of kidney stone

Multivariate logistic regression analysis was performed to control for the effects of confounding factors and analyse the factors potentially associated with kidney stone formation (Table 3). Three variables were finally entered into the multiple logistic regression model: male gender (OR=102.681; 95% CI, 1.062-9925.797; P=0.047), daily intake of white spirits (OR=6.331; 95% CI, 1.204-33.282; P=0.029), and personal history of urolithiasis (OR=1797.775; 95% CI, 24.228-133 396.982; P=0.001).

Discussion

In this population-based cross-sectional study, the prevalence of kidney stones and the underlying associated factors were investigated in the Shunyi District of Beijing, China. A total of 1091 males and 2259 females were enrolled in the study. The prevalence of kidney stone was 3.61% among the participants. The results demonstrated that male gender, daily drinking of white spirits, and a personal history of urolithiasis were potential risk factors for kidney stone formation. Our results may help gain better insight into the prevention of kidney stones.

Previous studies reported that the prevalence of kidney stone varies with geographical location and socio-economic conditions, and is stratified by age.[16] Global epidemiological surveys demonstrated that the mean prevalence of kidney stone was 3.25% in the 1980s and 5.64% in the 1990s.[17,18] Specifically, kidney stone affects approximately one in 20 people in Spain and 1 in 25 in China, while the prevalence reaches up to 9.1% in the United States and 16.9% in Northeast Thailand.[3,19-21] In the present study, the prevalence was determined to be 3.61% in the six randomly selected towns of Shunyi District, and is consistent with the findings of the first national survey of kidney stone in China (4.0%).[3] Unfortunately, we collected 3361 subjects without collecting information about how they were distributed in the six towns. Although these towns were randomly selected from a total of 19 towns, self-selection bias was likely present in the current study, as the study samples were taken by convenient sampling from volunteers who attended any one of the six hospitals for physical examination for a non-specified reason. Thus, further studies with a more representative population are needed to verify whether the prevalence in the Shunyi District of Beijing is in line with that in the six randomly selected towns.

In the present study, prevalence of kidney stones was also found to be higher in men (6.14%) than in women (2.39%). Male gender was identified as a risk factor in multivariate logistic regression analysis. The reasons might be complicated. A hormonal factor may be one of the key reasons for the difference between men and women. For

TABLE 1. Univariate analysis of potential risk factors for kidney stone formation

Factors	Sample size	No. of patients with kidney stones	Prevalence (%)	χ^2	P value
Age (years)				11.002	0.05
18-29	142	2	1.41		
30-39	349	8	2.29		
40-49	969	39	4.02		
50-59	1049	43	4.10		
60-69	614	15	2.44		
≥70	236	14	5.93		
Total	3359	121	3.60		
Gender				29.73	<0.001
Male	1091	67	6.14		
Female	2259	54	2.39		
Total	3350	121	3.61		
Working place				16.679	<0.001
Indoor	886	23	2.60		
Outdoor	2070	94	4.54		
No job	384	3	0.78		
Total	3340	120	3.59		
Occupation				11.524	0.021
Non-manual	275	9	3.27		
Light manual	1858	68	3.66		
Heavy manual	838	40	4.77		
Not clear	82	1	1.22		
No job	281	2	0.71		
Total	3334	120	3.60		
Amount of sweat				7.207	0.027
Dry	642	12	1.87		
Wet	1388	50	3.60		
Moist	1261	54	4.28		
Total	3291	116	3.52		
Amount of exercise*				6.301	0.043
None	639	12	1.88		
Occasional	1376	50	3.63		
Frequent	1254	51	4.07		
Total	3269	113	3.46		
Body mass index (kg/m^2)				4.603	0.100
<19	160	5	3.13		
19-24	1331	38	2.85		
>24	1820	78	4.29		
Total	3311	121	3.65		
Daily water intake (mL)				9.348	0.025
<1000	883	20	2.27		
1000 to <2000	1694	65	3.84		
2000 to <3000	635	32	5.04		
≥3000	134	3	2.24		
Total	3346	120	3.59		
Sources of water				13.806	0.008
Tap water	2269	66	2.91		
Ordinary well water	745	42	5.64		
Hand-pressure well water	12	0	0		
Bottled water	212	9	4.25		
Not clear	27	0	0		
Total	3265	117	3.59		

* 'Occasional' was defined as <3 times per week and 'frequent' was ≥3 times per week

TABLE 1. (cont'd)

Factors	Sample size	No. of patients with kidney stones	Prevalence (%)	χ^2	P value
Fluid intake (No. of times/week)				6.621	0.036
<1	2386	84	3.52		
1-2	541	27	4.99		
≥3	272	4	1.47		
Total	3199	115	3.59		
Alcohol intake*				7.630	0.022
Never	2333	83	3.56		
Occasional	504	27	5.36		
Frequent	265	4	1.51		
Total	3102	114	3.68		
Coffee intake*				8.571	0.036
Never	2893	103	3.56		
Occasional	374	12	3.21		
Frequent	17	0	0		
Daily	3	1	33.33		
Total	3287	116	3.53		
Tea intake*				12.165	0.007
Never	1258	58	4.61		
Occasional	1156	24	2.08		
Frequent	387	14	3.62		
Daily	520	22	4.23		
Total	3321	118	3.55		
Soup intake*				10.732	0.013
Never	536	13	2.43		
Occasional	1631	74	4.54		
Frequent	867	25	2.88		
Daily	255	4	1.57		
Total	3289	116	3.53		
White spirits intake*				10.530	0.015
Never	2368	72	3.04		
Occasional	538	22	4.09		
Frequent	131	5	3.82		
Daily	264	18	6.82		
Total	3301	117	3.54		
Milk intake (No. of times/week)				10.627	0.014
<1	1473	61	4.14		
1-2	1145	41	3.58		
3-4	348	2	0.57		
5-7	335	13	3.88		
Total	3301	117	3.54		
Outdoor activities (hours/day)				9.063	0.028
<2	680	18	2.65		
2 to <4	1220	35	2.87		
4 to <6	552	22	3.99		
≥6	853	43	5.04		
Total	3305	118	3.57		
Smoking				9.014	0.005
Smokers	671	37	5.51		
Non-smokers	2645	82	3.10		
Total	3316	119	3.59		
Salty food				3.061	0.096
Preferred	1219	52	4.27		
Not preferred	2065	64	3.10		
Total	3284	116	3.53		

* 'Occasional' was defined as <3 times per week and 'frequent' was ≥3 times per week

TABLE 1. (cont'd)

Factors	Sample size	No. of patients with kidney stones	Prevalence (%)	χ^2	P value
Egg consumption (No. of times/week)				8.254	0.041
<1	668	29	4.34		
1-2	1455	57	3.92		
3-4	607	10	1.65		
5-7	594	22	3.70		
Total	3324	118	3.55		
Meat consumption (No. of times/week)				4.320	0.038
<1	1135	51	4.49		
≥1	2174	67	3.08		
Total	3309	118	3.57		
Kidney stones in relatives				19.379	<0.005
Yes	152	13	8.55		
No	2726	81	2.97		
Not clear	399	23	5.76		
Total	3277	117	3.57		
Kidney stones in parents				7.043	0.018
Yes	76	7	9.21		
No	3283	114	3.47		
Total	3359	121	3.60		
Kidney stones in siblings				20.401	0.001
Yes	33	6	18.18		
No	3326	115	3.46		
Total	3359	121	3.60		
Hypertension				18.100	<0.005
Yes	1000	59	5.90		
No	2245	59	2.63		
Total	3245	118	3.64		
Diuretic intake				47.818	<0.005
Yes	262	29	11.07		
No	2857	81	2.84		
Total	3119	110	3.53		
Urinary stones				1317.533	<0.005
Yes	178	95	53.37		
No	3097	25	0.81		
Total	3275	120	3.66		
Urinary tract infections				6.516	0.016
Yes	281	17	6.05		
No	2885	91	3.15		
Total	3166	108	3.41		
Chronic gastric diseases				5.505	0.028
Yes	196	13	6.63		
No	3163	108	3.41		
Total	3359	121	3.60		
Hyperlipidaemia				20.975	<0.005
Yes	337	27	8.01		
No	3022	94	3.11		
Total	3359	121	3.60		
Diabetes				5.360	0.035
Yes	259	16	6.18		
No	3100	105	3.39		
Total	3359	121	3.60		
Kidney surgery				128.325	<0.005
Yes	16	9	56.25		
No	3343	112	3.35		
Total	3359	121	3.60		
Ureter surgery				10.574	0.031
Yes	8	2	25.00		
No	3351	119	3.55		
Total	3359	121	3.60		

TABLE 2. Univariate analysis of biochemical variables in patients with kidney stone and healthy controls

Biochemical variable	Mean ± standard deviation		*t*	P value
	Study group	Control group		
Blood sample (μmol/L)				
Creatinine	62.28 ± 34.36	53.39 ± 23.56	2.097	0.037
Calcium	1.36 ± 0.47	1.21 ± 0.35	2.591	0.009
Phosphate	0.77 ± 0.26	0.73 ± 0.25	1.193	0.234
Kalium	3.66 ± 0.94	3.59 ± 0.89	0.584	0.560
Sodium	106.18 ± 20.05	102.45 ± 17.38	1.372	0.172
Chlorine	82.25 ± 13.60	79.95 ± 12.43	1.219	0.224
Magnesium	1.55 ± 0.43	1.45 ± 0.36	1.788	0.075
Uric acid	222.73 ± 89.51	190.17 ± 71.57	2.782	0.006
Urine sample (μmol/L)				
Calcium	1.41 ± 1.19	1.40 ± 1.40	0.053	0.958
Phosphate	6.35 ± 4.87	6.19 ± 5.09	0.220	0.826
Kalium	13.10 ± 8.60	14.37 ± 9.23	-0.978	0.329
Magnesium	2.92 ± 2.08	3.09 ± 2.47	-0.514	0.608
Uric acid	876.33 ± 511.69	859.12 ± 510.10	0.232	0.817

TABLE 3. Multivariate logistic regression analysis of risk factors for kidney stone formation (n=3275)

Risk factor	β	χ^2	P value	Odds ratio	95% Confidence interval
Male gender	4.632	3.944	0.047	102.681	1.062-9925.797
Daily intake of white spirits	0.847	4.750	0.029	6.331	1.204-33.282
Personal history of urolithiasis	2.197	11.632	0.001	1797.775	24.228-133 396.982

instance, the secretion of citric acid in urine, as a protective factor against kidney stone formation, is promoted by oestrogen. Androgen leads to the accumulation of some damaging factors for kidney stone formation, such as calcium, oxalate, and uric acid in urine.[22,23] Men are also more likely to engage in heavy physical labour, to sweat more, and more often be dehydrated. These factors are documented risk factors for kidney stone formation.[24,25] Nonetheless they were not successfully retained in the stepwise regression in our study, implying that they did not have an independent effect on the outcome in our study sample, possibly due to the small sample size. Further studies with a larger sample size are needed to verify our findings.

A recent meta-analysis found that alcohol intake is inversely associated with the risk of urolithiasis.[26] On the contrary, our results showed that daily drinking of white spirits was a risk factor for kidney stone formation. The differences might be attributed to the varied drinking habits of different races and countries. Curhan et al[12] established that a family history of kidney stones substantially increased the risk of stone formation. Moreover, increasing studies have found that patients who have ever had urolithiasis have a higher prevalence of kidney stone formation than those without such a history.[27,28] In concordance with these findings, our study revealed that a history of urolithiasis was a potential risk factor for kidney stone formation. Therefore, people who favour liquor and/or have a history of urinary tract stones should be aware of their higher risk for kidney stone formation and take preventive steps.

This study has several limitations and the results must be interpreted with caution. First, the study sample might not be representative of the population because of the convenient sampling of volunteers. Also, the number of subjects excluded under each of the exclusion criteria was not recorded. Second, the small sample size hindered the proper control of potential confounding factors. Third, the causal relationship between the involved factors and kidney stone formation could not be confirmed by a cross-sectional survey. Fourth, recall bias and volunteer bias could not be avoided. Finally, females were over-represented in the sample as many males were migrant workers and often worked in other cities. More rigorous studies with a larger and more representative population are needed to verify the results.

Conclusions

The prevalence of kidney stones in the current study sample of the selected towns (Zhangzhen, Mulin, Beiwu, Nanfaxin, Renhe, and Nancai) of Shunyi District of Beijing, China, is 3.61%. Male gender, daily drinking of white spirits, and a history of urolithiasis are factors potentially associated with kidney stone formation.

Declaration

This study was supported by Capital Medical Development Research Fund (2009-2107). The authors declare that they have no competing interests.

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