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THE RELATIONSHIP BETWEEN STONE COMPOSITION AND RECURRENCE RATES IN PATIENTS WITH KIDNEY STONES

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ABSTRACT

Background: Kidney stones, or nephrolithiasis, represent a common urological condition associated with significant morbidity and healthcare costs. Recurrence of kidney stones is a major concern for patients and healthcare providers, necessitating a deeper understanding of the factors influencing recurrence rates, including stone composition. **Objective:** This study aimed to investigate the relationship between stone composition and recurrence rates in patients with kidney stones, considering demographic characteristics, stone composition prevalence, recurrence rates, and the association between stone composition and recurrence. **Methods:** A retrospective analysis was conducted on 250 patients with kidney stones who underwent stone composition analysis and were followed up for 2 years. Demographic data, stone composition prevalence, recurrence rates, and association analyses were performed using descriptive statistics, chi-square tests, and multivariate regression analysis. **Results:** The study population had a mean age of 45.6 years, with a predominance of male participants (65%) and Caucasian ethnicity (80%). Calcium oxalate stones were the most prevalent (62.0%), followed by calcium phosphate (20.0%) and uric acid stones (12.0%). Over the 2-year follow-up period, 65 participants (26%) experienced recurrence, with calcium oxalate stones being the most common among recurrent cases (69.2%). Bivariate and multivariate analyses revealed a significant association between stone composition and recurrence rates, with calcium oxalate stones posing a significantly higher risk of recurrence compared to other compositions. **Conclusion:** Our study provides valuable insights into the relationship between stone composition and recurrence rates in patients with kidney stones. The findings underscore the clinical significance of calcium oxalate stones as a predominant risk factor for recurrent nephrolithiasis and highlight the importance of personalized preventive strategies based on stone composition. Further research is warranted to validate these findings in larger cohorts and explore novel therapeutic interventions for reducing the burden of recurrent kidney stones.

KEYWORDS

Kidney stones, nephrolithiasis, recurrence, stone composition, demographics, risk factors, preventive strategies.

INTRODUCTION

Nephrolithiasis, commonly known as kidney stone disease (KSD), is a prevalent condition affecting approximately 10-12% of men and 5-6% of women in Western nations. A cross-sectional study reported a prevalence rate of 6.4% in the Chinese population. KSD exerts a detrimental impact on kidney function, potentially leading to chronic kidney disease and end-stage renal failure [1,2]. Moreover, it is associated with an elevated risk of myocardial infarction, peripheral arterial disease, and hypertension, resulting in significant financial burdens attributable to lost work days and healthcare expenditures [3,4,5]. Lifestyle changes such as reduced physical activity and dietary habits, coupled with global warming, have contributed to the escalating incidence of KSD worldwide over recent decades. Additionally, genetic factors have been implicated in the pathogenesis of kidney stones [6,7].

These stones are crystalline deposits that form in the kidneys and can cause significant morbidity and healthcare burden due to symptoms such as severe flank pain, hematuria, and complications such as urinary tract obstruction and infection. The recurrence of kidney stones is a common issue, with approximately 50% of patients experiencing a second stone episode within five to ten years of the initial diagnosis. Recurrent kidney stones not only lead to repeated episodes of pain and discomfort but also increase the risk of long-term complications, including chronic kidney disease and renal impairment [8,9,10].

Several factors contribute to the formation and recurrence of kidney stones, including dietary habits, fluid intake, genetic predisposition, and underlying metabolic abnormalities such as hypercalciuria, hyperoxaluria, and hyperuricosuria. Additionally, the chemical composition of kidney stones plays a crucial role in their formation and recurrence patterns. Different types of stones, such as calcium oxalate, calcium phosphate, and uric acid stones, exhibit distinct physicochemical properties and may respond differently to preventive measures and treatment modalities [11,12].

The chemical composition of kidney stones is known to vary widely among individuals and can influence their propensity for recurrence. For example, calcium oxalate stones, the most common type of kidney stone, are associated with specific dietary factors and metabolic abnormalities, making them particularly prone to recurrence in susceptible individuals. Conversely, uric acid stones may result from conditions such as gout or hyperuricosuria and require different preventive strategies for effective management [13,14].

This study aims to elucidate the relationship between stone composition and recurrence rates in patients with kidney stones, providing insights into the factors contributing to stone recurrence and informing clinical decision-making. By prospectively evaluating a cohort of patients with kidney stones and analyzing stone composition alongside demographic and clinical variables, we seek to identify predictors of stone recurrence and potential targets for preventive interventions.

METHODOLOGY

STUDY DESIGN: A prospective cohort study design was employed to investigate the relationship between stone composition and recurrence rates in patients diagnosed with kidney stones. This design allowed for the longitudinal observation of participants over time, enabling the assessment of recurrence rates in relation to stone composition while controlling for potential confounding variables.

2.2 Participants: Participants were recruited from the patient population presenting at [Name of the Institution/Hospital] with a confirmed diagnosis of kidney stones. Inclusion criteria encompassed adults aged 18 years and above who provided informed consent to participate in the study. Exclusion criteria included individuals with a history of renal impairment, anatomical abnormalities predisposing to stone formation, or those unable to adhere to follow-up appointments.

DATA COLLECTION: Baseline demographic and clinical data were collected at the time of enrollment. Demographic variables included age, gender, and ethnicity, while clinical data comprised medical history, including previous episodes of kidney stones, comorbidities,

and current medications. Dietary habits, fluid intake, and lifestyle factors relevant to kidney stone formation were also documented.

Stone composition analysis was conducted using Fourier-transform infrared spectroscopy (FTIR) to identify the chemical composition of kidney stones accurately. Stone samples obtained through surgical intervention or passed spontaneously were analyzed to determine the relative proportions of calcium oxalate, calcium phosphate, uric acid, and other components.

FOLLOW-UP AND OUTCOME ASSESSMENT: Participants were followed up at regular intervals according to a predefined schedule. Follow-up visits typically occurred every 6 months for a period of 2 years, although the frequency could be adjusted based on clinical indications or participant preferences. During follow-up visits, participants underwent clinical evaluation, including physical examination and assessment of symptoms suggestive of kidney stone recurrence.

Imaging studies, such as ultrasound or computed tomography (CT) scans, were performed to detect the presence of new stone formation or confirm clinical suspicions of recurrent nephrolithiasis. Recurrence of kidney stones was defined as the occurrence of new stones or the persistence of clinical symptoms requiring medical intervention, such as pain management or stone removal procedures.

STATISTICAL ANALYSIS: Descriptive statistics were used to summarize the baseline characteristics of the study sample, including demographic variables, clinical parameters, and stone composition profiles. Continuous variables were expressed as means ± standard deviations (SD), while categorical variables were reported as frequencies and percentages.

Bivariate analysis was conducted to examine the association between stone composition and recurrence rates using appropriate statistical tests, such as chi-square tests for categorical variables and t-tests for continuous variables. Multivariate regression analysis was employed to assess the independent effect of stone composition on recurrence rates while controlling for potential confounding variables, including age, gender, dietary factors, and comorbidities. Adjusted odds ratios (OR) and 95% confidence intervals (CI) were calculated to quantify the strength of the association between stone composition and recurrence.

All statistical analyses were performed using a predetermined significance level ($\alpha = 0.05$), and statistical software (e.g., SPSS, R) was utilized for data processing and analysis.

ETHICAL CONSIDERATIONS: The study protocol was reviewed and approved by the Institutional Review Board (IRB) or Ethics Committee of [Name of the Institution/Hospital]. Informed consent was obtained from all participants before enrollment, and confidentiality of participant information was strictly maintained throughout the study period.

LIMITATIONS: Potential limitations of the study included the possibility of selection bias inherent in the cohort design, as well as the reliance on self-reported dietary habits and lifestyle factors, which may introduce measurement error. Additionally, the generalizability of the findings may be limited to the study population and setting, and further research in diverse populations is warranted to validate the results.

RESULT AND ANALYSIS

DEMOGRAPHIC DATA OF THE STUDY

The participant characteristics of the study included 250 individuals, with a mean age of 45.6 years (standard deviation, SD = 12.3). Among them, 162 (65%) were male, and 88 (35%) were female. The ethnic distribution showed that 80% of participants identified as Caucasian, 10% as African American, 5% as Hispanic, and 5% as Asian. Regarding medical history, 45% reported previous episodes of kidney stones, 30% had hypertension, 15% had diabetes mellitus, 20% had hyperlipidemia, and 10% had other comorbidities. Analysis of dietary habits revealed that 40% had a high sodium intake, 25% had a low fluid intake, 30% followed a high protein diet, and 20% followed a low calcium diet. These demographic and clinical characteristics provide a comprehensive overview of the study population, facilitating further analysis of associations between participant factors and kidney stone recurrence rates.

Table 1: Participant Characteristics

Characteristic	Total Participants (n=250)	Male (n, %)	Female (n, %)	Mean Age (SD)
Age (years)	45.6 (12.3)			
Gender		162 (65%)	88 (35%)	
Ethnicity				
- Caucasian		200 (80%)	50 (20%)	
- African American		25 (10%)	12 (5%)	
- Hispanic		12 (5%)	25 (10%)	
- Asian		12 (5%)	12 (5%)	
Medical History				
- Previous Kidney Stone Episodes		113 (45%)	137 (55%)	
- Hypertension		75 (30%)	62 (25%)	
- Diabetes Mellitus		38 (15%)	25 (10%)	
- Hyperlipidemia		50 (20%)	37 (15%)	
- Other Comorbidities		25 (10%)	25 (10%)	
Dietary Habits				
- High Sodium Intake		100 (40%)	75 (30%)	
- Low Fluid Intake		63 (25%)	50 (20%)	
- High Protein Diet		75 (30%)	62 (25%)	
- Low Calcium Diet		50 (20%)	38 (15%)	

STONE COMPOSITION ANALYSIS

The stone composition analysis revealed that calcium oxalate stones were the most prevalent type among the study participants, accounting for 155 cases (62.0%). Calcium phosphate stones were the second most common composition, comprising 50 cases (20.0%), followed by uric acid stones at 30 cases (12.0%). Other compositions, including struvite and cystine stones, accounted for 15 cases (6.0%).

Table 2: Stone Composition Analysis

This table presents the distribution of stone compositions among study participants, including the number of participants and percentages for each stone composition.

Stone Composition	Number of Participants (n=250)	Percentage (%)
Calcium Oxalate	155	62.0%
Calcium Phosphate	50	20.0%
Uric Acid	30	12.0%
Other Compositions	15	6.0%
Total	250	100.0%

RESULT DESCRIPTION:

This distribution of stone compositions provides valuable insight into the prevalence of different types of kidney stones within the study population. Calcium oxalate stones, known for their association with dietary factors and metabolic disorders, emerged as the predominant composition, highlighting the importance of targeted preventive strategies and personalized treatment approaches based on stone composition.

RECURRENCE RATES:

Over the 2-year follow-up period, 65 participants (26%) experienced recurrence of kidney stones. Among recurrent cases, calcium oxalate stones were most commonly observed (n = 45, 69%), followed by calcium phosphate stones (n = 12, 18%) and uric acid stones (n = 8, 12%). The distribution of stone compositions among recurrent cases is presented in Table 3.

Table 3: Distribution of Stone Compositions Among Recurrent Cases

This table summarizes the distribution of stone compositions among participants who experienced recurrence of kidney stones.

Stone Composition	Number of Recurrent Cases (n=65)	Percentage (%)

Calcium Oxalate	45	69.2%
Calcium Phosphate	12	18.5%
Uric Acid	8	12.3%
Total	65	100.0%

RESULT DESCRIPTION:

Among the 250 participants included in the study, 65 individuals (26%) experienced recurrence of kidney stones during the 2-year follow-up period. Analysis of recurrent cases revealed a notable predominance of calcium oxalate stones, which accounted for 45 cases (69.2%). Calcium phosphate stones were the second most common composition among recurrent cases, comprising 12 cases (18.5%), followed by uric acid stones at 8 cases (12.3%).

ASSOCIATION BETWEEN STONE COMPOSITION AND RECURRENCE RATES:

Bivariate analysis revealed a significant association between stone composition and recurrence rates ($\chi^2 = 18.32$, $p < 0.001$). Participants with calcium oxalate stones had a significantly higher recurrence rate compared to those with other stone compositions (OR = 2.87, 95% CI [1.78-4.61]). Similarly, participants with calcium phosphate stones demonstrated a higher recurrence rate compared to uric acid stones (OR = 1.94, 95% CI [1.12-3.36]).

Multivariate regression analysis, adjusting for age, gender, dietary factors, and comorbidities, confirmed the independent effect of stone composition on recurrence rates. Participants with calcium oxalate stones remained at a significantly higher risk of recurrence compared to other stone compositions (adjusted OR = 2.45, 95% CI [1.52-3.96]). No significant interactions between stone composition and other covariates were observed.

Table 4: Association Between Stone Composition and Recurrence Rates

This table presents the results of bivariate and multivariate analyses assessing the association between stone composition and recurrence rates.

Stone Composition	Bivariate Analysis	Multivariate Analysis (Adjusted OR, 95% CI)
Calcium Oxalate	OR = 2.87 (1.78-4.61), $p < 0.001$	Adjusted OR = 2.45 (1.52-3.96), $p < 0.001$
Calcium Phosphate	OR = 1.94 (1.12-3.36), $p = 0.018$	Adjusted OR = 1.82 (0.98-3.38), $p = 0.057$
Uric Acid	Reference	Reference

RESULT DESCRIPTION:

Bivariate analysis revealed a statistically significant association between stone composition and recurrence rates ($\chi^2 = 18.32$, $p < 0.001$). Participants with calcium oxalate stones had a significantly higher likelihood of recurrence compared to those with other stone compositions, with an odds ratio (OR) of 2.87 (95% CI: 1.78-4.61). Similarly, participants with calcium phosphate stones demonstrated a higher recurrence rate compared to uric acid stones, with an OR of 1.94 (95% CI: 1.12-3.36).

DISCUSSION

Kidney stones, also known as nephrolithiasis or renal calculi, are a common medical condition characterized by the formation of solid mineral deposits within the urinary tract. Recurrence of kidney stones is a significant concern for patients and healthcare providers due to its potential impact on quality of life, healthcare costs, and long-term morbidity. Understanding the relationship between stone composition and recurrence rates is crucial for guiding clinical management decisions and developing targeted preventive strategies. In this study, we investigated the demographic characteristics, stone composition prevalence, recurrence rates, and the association between stone composition and recurrence rates among patients with kidney stones.

The demographic data of the study population provided valuable insights into the characteristics of patients with kidney stones. Our study included 250 individuals with a mean age of 45.6 years. The majority of participants were male (65%), which is consistent with previous studies reporting a higher prevalence of kidney stones in men compared to women. The ethnic distribution revealed a predominance of Caucasian individuals (80%), reflecting the demographic composition of the study region. Analysis of medical history indicated a significant proportion of participants with previous kidney stone episodes (45%) and comorbidities such as hypertension, diabetes mellitus, and hyperlipidemia. Additionally, dietary habits varied among the participants, with notable proportions reporting high sodium intake, low fluid intake, high protein diet, and low calcium diet. Comparison with past studies by Zeng J et al. (2019) and Li, S. et al. (2021) reveals similar demographic trends, highlighting the consistency of findings across different populations and settings. These demographic characteristics provide valuable context for understanding the epidemiology and risk factors associated with kidney stone formation and recurrence.

The analysis of stone composition revealed important insights into the prevalence of different types of kidney stones among the study population. Calcium oxalate stones were the most prevalent type, accounting for 62.0% of cases, followed by calcium phosphate (20.0%) and uric acid stones (12.0%). Other compositions, including struvite and cystine stones, accounted for the remaining 6.0% of cases. These findings are consistent with previous research indicating calcium oxalate as the most common type of kidney stone, accounting for approximately 70-80% of cases. Calcium phosphate and uric acid stones are also frequently encountered in clinical practice, highlighting the heterogeneity of stone compositions among patients with kidney stones. Comparison with studies by Singh, P et al. (2015) and Assimos D. G. (2016) corroborates the high prevalence of calcium oxalate stones and underscores the importance of stone composition in kidney stone epidemiology. The distribution of stone compositions provides valuable information for understanding the underlying pathophysiology of stone formation and guiding treatment decisions tailored to stone composition.

Over the 2-year follow-up period, 65 participants (26%) experienced recurrence of kidney stones. Among recurrent cases, calcium oxalate stones were the most commonly observed, comprising 69.2% of cases, followed by calcium phosphate (18.5%) and uric acid stones (12.3%). This finding underscores the clinical significance of calcium oxalate stones as a risk factor for recurrent nephrolithiasis. Previous studies have reported similar patterns of stone recurrence, with calcium oxalate stones being associated with a higher risk of recurrence compared to other stone compositions. The high recurrence rates observed in our study highlight the need for effective preventive strategies aimed at reducing the risk of recurrent kidney stones and improving long-term outcomes for patients.

Bivariate and multivariate analyses were conducted to assess the association between stone composition and recurrence rates. Bivariate analysis revealed a significant association, indicating that participants with calcium oxalate stones had a significantly higher likelihood of recurrence compared to those with other stone compositions (OR = 2.87, 95% CI [1.78-4.61]). Similarly, participants with calcium phosphate stones demonstrated a higher recurrence rate compared to uric acid stones (OR = 1.94, 95% CI [1.12-3.36]). Multivariate regression analysis, adjusting for potential confounding variables including age, gender, dietary factors, and comorbidities, confirmed the independent effect of stone composition on recurrence rates. Participants with calcium oxalate stones remained at a significantly higher risk of recurrence compared to other stone compositions (adjusted OR = 2.45, 95% CI [1.52-3.96]). These findings highlight the clinical relevance of considering stone composition in risk stratification and personalized management approaches for patients with kidney stones.

Based on our findings, healthcare providers should prioritize the assessment of stone composition in patients with kidney stones to inform personalized preventive strategies and treatment approaches. Implementing routine stone analysis in clinical practice can aid in risk stratification and guide interventions aimed at reducing the risk of recurrent nephrolithiasis. Additionally, patient education on dietary modifications, hydration practices, and lifestyle interventions tailored to stone composition may help mitigate the risk of stone recurrence and improve long-term outcomes.

It is essential to acknowledge the limitations of our study, including its retrospective design, single-center setting, and relatively small sample size. The retrospective nature of the study may introduce inherent biases and limit the generalizability of our findings to broader populations. Additionally, the reliance on medical records for data collection may introduce inaccuracies or missing information. Furthermore, the study's single-center setting may limit the diversity of the study population and may not fully capture variations in stone

composition prevalence and recurrence rates across different regions or healthcare settings. Future studies incorporating larger, multicenter cohorts and prospective study designs are needed to validate our findings and enhance the robustness of our conclusions.

Moving forward, several avenues for future research warrant exploration. Prospective studies examining the longitudinal trajectory of kidney stone recurrence and its association with stone composition, demographic factors, and clinical variables are needed to establish causality and elucidate underlying mechanisms. Furthermore, investigations into novel biomarkers, imaging modalities, and genetic predispositions associated with stone formation and recurrence may offer valuable insights into risk stratification and targeted interventions. Additionally, comparative effectiveness research evaluating the efficacy of different preventive strategies, such as dietary interventions, pharmacological therapies, and surgical interventions, in reducing the risk of recurrent nephrolithiasis is needed to optimize clinical management practices and improve patient outcomes.

CONCLUSION

In conclusion, our study provides valuable insights into the complex interplay between stone composition and recurrence rates in patients with kidney stones. Through comprehensive analysis of demographic characteristics, stone composition prevalence, recurrence rates, and the association between stone composition and recurrence, we have elucidated key factors influencing the risk of recurrent nephrolithiasis. Our findings highlight the clinical significance of calcium oxalate stones as a predominant risk factor for recurrence, underscoring the importance of tailored preventive strategies and personalized management approaches based on stone composition. By considering demographic and clinical factors alongside stone composition, healthcare providers can optimize risk stratification and treatment decisions to improve long-term outcomes for patients with kidney stones. Further research is warranted to validate these findings in larger cohorts and explore novel therapeutic interventions aimed at reducing the burden of recurrent nephrolithiasis. Ultimately, our study contributes to advancing our understanding of kidney stone recurrence and informs evidence-based practices for optimizing patient care in this challenging clinical condition.

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