Urinary Sodium to Potassium Ratio in Pediatric Stone Patients

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ABSTRACT

The incidence of pediatric stone disease is on the rise. Dietary elements including high salt intake and reduced water consumption remain the major risk factors for stone formation. Urinary stone profile in pediatric literature remains limited. The purpose of the study is to a) compare the urinary sodium/potassium (Na/K) molar ratio in pediatric stone patients at CHOI to the national average dietary intake and b) correlate the risk factors of stone formation with dietary factors in pediatric stone formers.

Methods: This retrospective cohort study included all Pediatric stone patients who attended outpatient Nephrology clinic from 03/1/2014 to 10/1/2018. Children with known metabolic/genetic causes for stone disease, incomplete 24 hr urinary collection or on medications that affect mineral excretions were excluded from the study. Statistical analysis was done using SAS 9.4. Descriptive data of the study population was provided. Hypothesis testing was done using one sample T test and predictive analysis performed using linear correlation and multiple regression models.

Results: 150 patient charts were screened and 89 included in the study. Average age of the study population was 12.7 years with 58% females and 42% males. Mean Na/K molar ratio in pediatric stone patient was 3.7, statistically significantly higher than the national average of 2.5 using one sample T test ($P < 0.001$). Urinary calcium excretion showed a strong linear correlation with sodium excretion (r 0.545, $P < 0.001$). Multiple regression models using urinary calcium excretion as the dependent variable showed correlation with urinary sodium excretion (P 0.004), urinary volume ($P < 0.0001$) and urinary pH (P 0.001).

Conclusion: 24 hr urinary sodium potassium molar ratio is significantly higher in stone formers indicating higher salt and lower potassium consumption when compared to national average intake. Water intake, salt consumption and alteration of urinary pH remain the main dietary modality to alter calcium excretion and hence reduce stone formation.

KEYWORDS: Sodium; Potassium; Pediatric Stone; Salt Consumption

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BACKGROUND

Pediatric stone disease is on the rise [1,2]. Though historic data had suggested stone disease to be around 1 out of 7600 pediatric inpatients [3] more recent reports have observed an almost fivefold increase in urinary calculi incidence [4]. Some of the proposed theories for increasing pediatric stone incidence include low fluid intake, increasing incidence of obesity, excessive dietary salt intake [5], and an increase in beverage consumption over free water intake. Hypercalciuria, a strong risk factor for stone formation has shown an association with spot urine sodium/potassium ratio. Increasing potassium intake by altering the Ur sodium/potassium ratio has a beneficial effect in reducing calciuria [6].

Literature is limited to the epidemiological data of sodium and potassium intake in pediatric patients with renal calculi. 24-hour urinary collection if done properly serves as a good tool for calculating dietary intake of sodium and potassium. Dietary intake varies with age and sex and the most recent NHANES data (2013-2014) has shown that the average dietary sodium intake is much higher than the federal dietary guidelines of >2300 mg /day and potassium intake much lower than the stated guideline of 4700 mg/day [7]. Though the mean sodium and potassium intake vary with age, sex and is heavily influenced by caloric intake, the estimated urinary sodium to potassium (Ur Na/K) molar ratio remains constant with a national average of around 2.5 [8]. This ratio is much higher than the WHO recommended ratio of 1.

Positive association of elevated first-morning urine spot sodium-potassium ratio with the prevalence of the adult urinary stone disease is been reported in the literature [9]. Spot studies are good tools but can be influenced by the timing of collection and dietary intake before the collection.24-hour urine studies remain the gold standard for measuring dietary sodium and potassium intake but literature on the 24-hour urinary sodium-potassium ratio in pediatric stone formers is limited.

HYPOTHESIS

Primary objective

We hypothesize that children with renal stones will show higher 24-hour urinary sodium to potassium molar ratio when compared to the national average, indicating higher dietary sodium to potassium intake.

Secondary objective

To determine the correlation of traditional risk factors such as hypercalciuria with dietary risk factors as determined by 24-hour urinary collection in pediatric stone patients

Operational definitions

Dietary sodium intake in mg/day = Urinary 24 hour sodium in mmol x 23

Dietary potassium intake in mg/day = Urinary 24 hour potassium in mmol x 39

Urinary 24 hours sodium-potassium molar ratio = Urine 24 hour Na in mmol/Urine 24 hour K in mmol

BMI – BMI is a person's weight in kilograms (kg) divided by his or her height in meters squared.

METHOD/STUDY

Retrospective cohort study.

Inclusion Criteria

All Pediatric stone patients (from 6 to 19 years of age) who attended the outpatient Nephrology clinic at the Children's Hospital of Illinois from 03/1/2014 to 10/1/2018 will be included in the study. EMR search criteria to include kidney stone, renal calculus, hypercalciuria will be used to capture all the stone patients.

Exclusion Criteria

Children who have known metabolic/genetic cause for stone formation such as secondary hyperparathyroidism, Vitamin D toxicity, Hyperoxalaosis, Cystinuria.

Children who were started on thiazide diuretic or potassium citrate supplementation before their first 24-hour urine evaluation for stone risk profile.

Incomplete 24-hour urinary collection as noted by low urine 24-hour creatinine.

Measurements

Demographic data to be collected include age, sex, and BMI. The following data from the 24-hour urinary collection will be collected for analysis – Volume, calcium, oxalate, SS Ca Ox, Citrate, sodium, potassium, Phosphorus, and supersaturation of calcium phosphate.

Statistical Analysis

Data will be analyzed in SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

In the descriptive analysis, mean and standard deviation were used to report continuous variables, while frequency and percentage were calculated for categorical variables.

One sample T-test was used to compare urinary Na/K molar ratio in pediatric stone patients to national mean.

Predictive analysis (linear correlation and multiple regression model) were used to determine the correlation of urinary calcium excretion.

RESULTS

150 charts were reviewed and 89 included in the study after exclusion criteria. The mean age of the study cohort was 12.7 years with 58% being females and 42% males. A detailed descriptive analysis of the study cohort is provided in table 1. One sample T-test (Figure 1) showed that the urinary sodium to potassium molar ratio in the stone cohort is statistically significantly higher than the national average.

Variable	Mean (SD)	Min - Max	Normal range
Age(years)	12.7 (3.4)	5 -18	
Weight(Kg)	49.3 (19.9)	16.8 -108.9	
BMI	21.3 (5.5)	14.3 -36.6	
Urine volume (L/day)	1.2 (0.8)	0.2 -4	
Urine pH	6.5 (0.5)	5.4 -7.6	
Ur Na (mg/day)	3183.6 (1657.3)	460 -8970	2400-4000
Ur K (mg/day)	1529.3 (680.4)	429 -3744	1900 -2700
Ur Na/K (molar ratio)	3.7 (1.7)	1.1 -10.7	2.5
Ur Ca (mg/day)	166 (85.6)	38 -458	
Ur Ca (mg/kg/day)	3.6 (1.7)	1 -8.9	< 4 mg/kg/day
Ur P (g/day)	0.7 (0.3)	0.2 -1.9	0.6 -1.2
Ur citrate (mg/day)	487.1 (226.4)	110 -1325	450-550
Ur Oxalate (mg/day)	26.9 (9.6)	11 -65	20-40
SS CaOx	8.8 (4.8)	1.5 -33.2	6 -10
SS CaP	2.5 (1.4)	0.2 -6.1	0.5 -2

Table 1: Descriptive analysis of the study population.

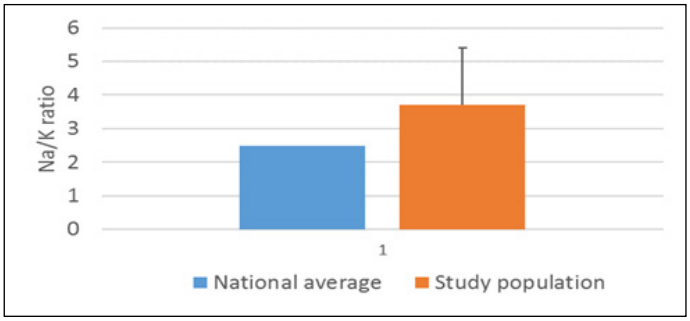

Figure 1: One Sample T test.

Urinary calcium excretion showed a linear correlation with several variables including age, BMI, urinary volume, 24-hour urinary levels of sodium, potassium, citrate, and oxalate. The strongest linear correlation was noted with urinary sodium excretion (r 0.588, $p < 0.0001$) (Figure 2).

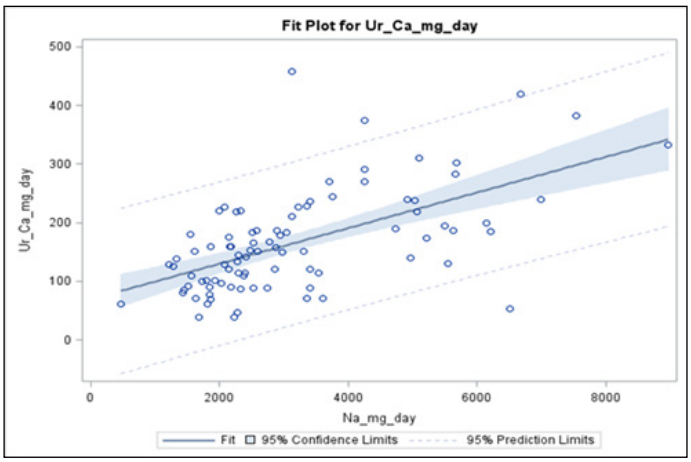

Figure 2: Linear correlation between urine calcium and sodium levels.

Multiple regression model (Table 2) showed urine volume, urine sodium excretion, and urine Ph to be the main determinants of urinary calcium excretion.

Source	DF	F value	p value
Ur Na (mg/day)	1	8.62	0.004
Ur Volume	1	23.32	<.0001
Urine Ph	1	13.2	0.001

DISCUSSION

Once thought to be a rare disease in the pediatric population, a more recent body of literature suggests an increasing incidence and prevalence of childhood nephrolithiasis [10]. Though no systemic, nationwide pediatric epidemiological data is available, several single institutional studies have reported an almost five-fold increase in stone admissions when

compared to historical data [2,4]. Reasons for the increase in pediatric nephrolithiasis remains unclear though a variety of factors have been attributed to the increasing incidence.

Pediatric obesity has been increasing in prevalence over the past decade with almost a triple fold increase noted in NHANES data [11]. Adult data have shown a strong correlation between BMI and urinary excretion of risk factors for calculi such as sodium and uric acid excretion [12]. The evidence in pediatric literature is mixed with certain studies showing a relationship between body mass and calculus [2,13] while others failing to demonstrate a link [14].

Fluid intake and hydration remains the cornerstone in clinical practice for the prevention of de novo or recurrent stone formation. Literature again is limited in the pediatric world to correlate urolithiasis with amount and type of fluid consumption. Studies in the adult stone population have shown both amount of fluids [15] as well as the type of beverage consumption such as increased sugary fluids [16-18] to be important factors in stone formation and recurrence.

One other plausible theory for an increased incidence of pediatric stone disease has been linked to climate changes, whether seasonal or as a part of the global warming trend that could cause a relative state of dehydration. Data from United States military personnel deployed in dry climates show a mean time to stone formation of only 90 days [19]. Similarly, a high incidence of stone disease is noted in areas such as the southern United States due to higher mean annual temperature [20].

Dietary sodium intake is an important modifiable risk factor for preventing stone formation. As sodium and calcium excretion are handled in parallel at the proximal tubules, an increased sodium intake will cause a net increased excretion of both sodium and calcium in the urine [21]. Several studies in the adult literature [22-24] have shown that patients adhering to a low salt diet had a reduction in hypercalciuria and subsequent stone formation. The predominant source of the excess salt intake is from processed foods and restaurant foods rather than from added table salt [5,25].

This cross-sectional study from a retrospective chart review of all pediatric stone patients who were evaluated in the outpatient pediatric nephrology clinic from 2014 to 2018 showed a statistically significantly higher urinary sodium-potassium molar ratio in pediatric stone patients when compared to the national average. Though linear regression analysis showed a correlation of urinary calcium excretion with different patient and dietary risk factors including BMI, multiple regression models showed urine volume, urine sodium excretion and urine Ph to be the main determinants for urine calcium excretion.

Limitations of the study include the small size of the study population and the fact that the cross-sectional nature of the study does not allow to determine causation.

CONCLUSION

Recent epidemiological data based on hospital admissions and single-center experience show that pediatric stone disease has been increasing in incidence and prevalence. A variety of factors including the increased incidence of pediatric obesity, changes in fluid consumption, dietary intake of sodium, and environmental changes have been proposed reasons for the increase. The experience in our outpatient pediatric nephrology clinic shows dietary factors to be one of the most important factors in pediatric stone formers. The urinary sodium to potassium molar ratio is much higher than the national average indicating a much higher sodium intake in our pediatric stone patients. Future longitudinal studies should look at the role of dietary intervention (role of potassium-based salts, dietitian consult during clinic visits, smart apps that can track amount and type of fluid intake) in reducing risk of recurrent stone formation.

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