

## Effect of urinary pH and specific gravity in urolithiasis, Ajman, UAE

Ishtiyag Ahmad Shaafie<sup>1</sup>, Jayadevan Sreedharan<sup>2</sup>, Jayakumary Muttappallymyalil<sup>2</sup>, Manda Venkatramana<sup>3</sup>, Mohammad Abdel Hafeez Aly Freeg<sup>4</sup>, Elsheba Mathew<sup>5</sup>

### ABSTRACT

**Objective:** This retrospective descriptive study was conducted to explore the role of urine pH and specific gravity in the formation of urinary stones among ultrasonographically proven urolithiasis patients who reported to the Department of Surgery and Urology of Gulf Medical College Hospital and Research Centre (GMCHRC), Ajman, United Arab Emirates (UAE).

**Materials and Methods:** Patient's age, gender, anatomical sites of the stone and biochemical parameters were obtained from case records. One way ANOVA was used to find whether the mean specific gravity and pH changed according to anatomical sites of stone and different seasons.

**Results:** On comparing specific gravity of urine samples between patients with stones in different anatomical sites, a statistically significant difference ( $p < 0.05$ ) was observed. Duncan's Multiple Range Test showed mean significant difference in the ranges of pH and specific gravity among patients with stones in urinary bladder compared to all other sites, with a decrease in the pH and increase in the specific gravity ( $p < 0.05$ ). On testing the correlation between pH and specific gravity using Pearson correlation, a statistically significant ( $p < 0.001$ ) negative correlation of -0.3 was obtained. One way ANOVA showed that there is no statistically significant difference in urine pH between patients with stones in different anatomical sites.

**Conclusion:** The study identifies an association between pH and specific gravity in urinary stone formers.

*Key words:* urine pH, Specific gravity, urolithiasis, crystalluria, anatomical sites, seasonal variation

### Citation

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### INTRODUCTION

Urinary stone disease, also known as urolithiasis, is the most frequent recurrent urological problem having worldwide distribution<sup>1</sup>. Urinary stone disease continues to occupy an important place in everyday urological practice<sup>2</sup>. Globally, urolithiasis is the third most common urological disease affecting both males and females<sup>3</sup>. It has been reported that the prevalence of renal stone disease was 1 to 5% in Asia, 5 to 9% in Europe, 13% in North America, and 20% in Saudi Arabia<sup>4,5</sup>. It has been estimated that in the Arabian peninsular

countries such as Kuwait, United Arab Emirates (UAE) and Saudi Arabia, 20% of the males would have had at least one episode of urinary stone disease by the time they reached 60 years of age<sup>6</sup>.

Urolithiasis is the consequence of multiple causative agents and risk factors<sup>4</sup>. Geographic, climatic and seasonal factors play a major role as causative agents on urinary tract calculi<sup>7</sup>. Many studies revealed that urolithiasis is a complex procedure closely related to personal habits, quality and quantity of drinking water, diet diversity and familial inheritance<sup>8</sup>. The higher incidence of uric acid lithiasis was due to excessive consumption of beef and alcohol or higher intake of protein as a part of their dietary life style in stone formers<sup>9</sup>. Specific dietary measures could be considered as non-pharmacological preventive measures for avoiding each type of renal calculus formation. These include an intake of a minimum

<sup>1</sup>Department of Biochemistry, <sup>2</sup>Research Division, <sup>3</sup>Department of Community Medicine, Gulf Medical University, Ajman, UAE.

<sup>3</sup>Department of Surgery, <sup>4</sup>Department of Urology, Gulf Medical College Hospital and Research Centre, Gulf Medical University, Ajman, U.A.E.

Correspondence: Prof. Jayadevan Sreedharan, Research Division, Gulf Medical University, Ajman, UAE.  
email: drjayadevan@gmu.ac.ae

two liters of water per day, a strict vegetarian diet, and avoiding excessive consumption of animal proteins, salt, Vitamin C and Vitamin D. Consuming phytate-rich products (natural dietary bran, legumes and beans, whole cereals) and preferably avoiding exposure to cytotoxic substances (i.e., analgesics abuse, residual pesticides, organic solvents and cytotoxic drugs)<sup>10</sup> have been recommended to prevent the formation of stones.

The probability of an individual of developing urinary stone disease may be analyzed from the biochemical risk factors such as urinary volume, pH and relative saturation of uric acid, which are affected mainly by seasonal variation<sup>1</sup>. The factors such as increased excretion of calcium, lower urine output, dehydration, diet, low urinary citrate, genetic factors, and environmental derangements (ambient temperatures) can contribute to increased urinary supersaturation of salts, low urine pH and reduced urine volumes, leading to crystallization<sup>11</sup>.

Crystalluria caused by excessive loss of water leads to stone formation<sup>12</sup>. Crystalluria in early morning urine samples<sup>13</sup> is a risk factor of high predictive value for stone recurrence in calcium stone formers. Crystal precipitation is the result of all factors acting in urine, both promoters and inhibitors, and measured and unmeasured, triggering crystal formation, which is the first step in lithogenesis. Increase in water intake can cause reduction of crystalluria and urinary density leading to decrease in risk of lithogenesis<sup>14</sup>.

The pH of urine is normally close to neutral (7) but can vary between 4.4 and 8 over a period of 24 hours based on a variety of physiological factors. Uric acid and cystine calculi are formed in acidic urine while calcium oxalate calculi are formed with acidic, neutral and alkaline pH. Alkaline urine results in the formation of calcium phosphate and magnesium ammonium phosphate calculi<sup>15</sup>.

The normal specific gravity of urine varies from 1.020 to 1.028 in a well hydrated person over a period of 24 hours. Bladder calculi usually cause dysuria, and to avoid pain during micturition the patients tend to reduce their daily fluid intake, raising the urine specific gravity<sup>16</sup>. High concentration of salts such as calcium oxalate, calcium phosphate, or uric acid leads to crystal formation or growth of preformed crystals<sup>17</sup>. The present study was conducted to explore the role of

urine pH and specific gravity in the formation of urinary stones in UAE.

**MATERIALS AND METHODS**

This retrospective descriptive study was conducted among proven urolithiasis patients reporting to the Department of Surgery and Urology of Gulf Medical College Hospital and Research Centre (GMCHRC), Ajman, United Arab Emirates (UAE). Records of urolithiasis cases confirmed by ultrasonography during the period 2007 to 2009 were retrieved from the Department of Medical Records and relevant data were extracted using a checklist. Data on patient’s age, gender, seasonality, anatomical sites of the stone, biochemical parameters such as urine color, deposit, pH, specific gravity, albumin, glucose, pus cells, Red Blood Cells (RBCs), amorphous deposits and crystals were obtained from case records after obtaining approval from Ethics Committee of Gulf Medical University. Light microscopy and qualitative chemical tests using Behring Multistix strips were employed for urine analysis.

The data were analyzed using PASW v. 17 (IBM, Illinois, Chicago). One way ANOVA was used to find whether the mean specific gravity and pH varied with anatomical site of stone and with different seasons. Duncan’s Multiple Range Test was performed to find the paired difference in pH and specific gravity of stones at different anatomical sites and detected during different seasons.

**RESULTS**

The ages of participants ranged from 4 to 65 years with a mean age of 33 years and SD of 8.8 years. More than 80% of the patients were below 40 years of age. The majority of the subjects (83.5%) were males, with only 16.5% being females. The

Table 1. Age- and gender-wise distribution of patients with urolithiasis

Age group	Gender					
	Male		Female		Total	
	No.	%	No.	%	No.	%
<=40 years	265	84.4	50	80.6	315	83.8
			38	73.1	61	76.3
>40 years	49	15.6	12	19.4	61	16.2
Total	314	100.0	62	100.0	376	100.0

age and gender distribution of patients with urolithiasis is given in Table 1.

The urine parameters of 376 subjects who presented with urolithiasis showed 30.1% as having normal pale yellow coloured urine while others had yellow (51.6%), dark yellow (15.4%) or amber colored (2.9%) urine. Urine analysis showed that only 0.8% of the urine samples contained deposits. Among the study subjects, 77.9% had acidic pH, 13.3% neutral and 8.8% alkaline pH values. The specific gravity of the samples was normal or below normal in 60.9% subjects, while it was above normal in 39.1% patients. 27.1% of urine samples showed the presence of albumin, and 5.3% of the samples the presence of glucose. Microscopic examination of urine revealed the presence of pus cells in 60% of the subjects. 66.2% had 0 to 1 pus cell, 20.2% had 2 to 5 and 13.6% more than 5 pus cells. RBCs were found in 58% of urine samples; 54% had 0 to 1 RBCs, 14.6% had 2 to 5 RBCs and 31.4% had more than 5 RBCs. Among stone formers, amorphous deposits were found in 3.5% of the urine samples and crystals were found in 6.1% of

the samples. The details are given in Table 2.

It was observed that 6.1% of the samples had crystalluria, and that 4.5% among them had uric acid crystals and 1.6% calcium oxalate crystals. Crystals were found in 9.5% of patients with stone in multiple sites, 8% in kidney stone formers, and 5.2% in ureteric stone formers. The Urine parameters such as urine deposit, albumin, glucose, pus cells, RBCs and crystals were appraised under acidic, neutral and alkaline pH. Urine deposits were detected to be comparatively high (3%) in alkaline pH and low (0.3%) in acidic pH. Albumin was absent in 80% of urine samples with neutral pH and was spotted to be high (30.3%) in urine samples with alkaline pH. Glucose was present in 6.1% of patients with acidic pH whereas the glucose level was normal in all patients with alkaline urine. In urine with neutral pH pus cells were not present in 50% of the samples and RBCs were absent in 52%. The presence of pus cells was comparatively higher (63.1%) in urine samples with acidic pH than those with alkaline pH (60.6%). RBCs were

Table 2. Distribution of urine parameters in patients with urolithiasis

Urine parameters	Group	Number	Percentage
Colour	Yellow	194	51.6
	Dark Yellow	58	15.4
	Amber	11	2.9
	Pale Yellow	113	30.1
Deposit	Absent	373	99.2
	Present	3	0.8
pH	Neutral	50	13.3
	Alkaline pH	33	8.8
Specific gravity	Normal (1.020-1.028)	229	60.9
	Above Normal (>1.028)	147	39.1
Albumin	Absent	274	72.9
	Present (Traces)	102	27.1
Glucose	Absent	356	94.7
	Present (Traces to +1)	20	5.3
Pus cells	Absent	146	38.8
	Present	230	61.2
RBCs	Absent	158	42.0
	Present	218	58.0
Amorphous deposit	Absent	363	96.5
	Present	13	3.5
Crystals	Absent	353	93.9
	Present	23	6.1

Table 3. Distribution of urine parameters according to pH of urine

Urine parameters	Acidic pH		Neutral		Alkaline pH		
	No.	%	No.	%	No.	%	
Deposit	Absent	292	99.7	49	98.0	32	97.0
	Present	1	0.3	1	2.0	1	3.0
Albumin	Absent	211	72.0	40	80.0	23	69.7
	Present	82	28.0	10	20.0	10	30.3
Glucose	Absent	275	93.9	48	96.0	33	100.
	Present	18	6.1	2	4.0	--	--
Pus cells	Absent	108	36.9	25	50.0	13	39.4
	Present	185	63.1	25	50.0	20	60.6
RBCs	Absent	119	40.6	26	52.0	13	39.4
	Present	174	59.4	24	48.0	20	60.6
Crystals	Absent	272	92.8	49	98.0	32	97.0
	Present	21	7.2	1	2.0	1	3.0

detected comparatively more (60.6%) in urine samples with alkaline pH when compared to urine samples with acidic pH (59.4%). The presence of crystals was also found to be higher under acidic pH. The details are given in Table 3.

The specific gravity of urine was also compared with urine parameters such as urine deposit, albumin, glucose, pus cells, RBCs and crystals. The deposits were found to be higher in urine samples with normal/below normal specific gravity than in those with above normal specific gravity. Albumin

was present in 17% of urine samples with normal or below normal specific gravity, but in patients with above normal specific gravity, the presence of albumin was detected in 42.9%. Among stone formers with urine specific gravity values above

Table 4. Distribution of urine parameters according to urine specific gravity

Urine parameters		Normal/Below Normal		Above Normal	
		No.	%	No.	%
Deposit	Absent	227	99.1	146	99.3
	Present	2	0.9	1	0.7
Albumin	Absent	190	83.0	84	57.1
	Present	39	17.0	63	42.9
Glucose	Absent	216	94.3	140	95.2
	Present	13	5.7	7	4.8
Pus cells	Absent	100	43.7	46	31.3
	Present	129	56.3	101	68.7
RBCs	Absent	110	48.0	48	32.7
	Present	119	52.0	99	67.3
Crystals	Absent	224	97.8	129	87.8
	Present	5	2.2	18	12.2

normal (>1.028), pus cells were found in 68.7%, RBCs in 67.3% and crystals in 12.2% which are comparatively higher than in patients with urine of normal/below normal specific gravity. The details are given in Table 4.

The mean pH of urine samples from patients with stones located at different anatomical sites revealed that the lowest pH was observed in patients with stones in urinary bladder, both in the case of males and females. The highest pH was observed in patients with stones in multiple sites

Table 5. Distribution of urine specific gravity and pH according to anatomical location of stone

Location	pH				Specific gravity			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Ureter	6.03	0.80	6.05	0.80	1.0181	0.0097	1.017	0.0089
Kidney	6.10	0.86	6.50	0.62	1.0190	0.0091	1.018	0.0092
Bladder	5.75	0.60	5.12	0.23	1.0256	0.0073	1.028	0.0029
Multiple	6.11	0.72	6.33	1.04	1.0208	0.0062	1.016	0.0058
Total	6.05	0.81	6.10	0.80	1.0187	0.0093	1.017	0.0088

in the case of males and stones in the kidney in the case of females. The mean specific gravity of urine was observed to be higher in patients with stones in the urinary bladder than at other sites, among both males and females (Table 5).

One way ANOVA showed that there was no statistically significant difference in urine pH in patients with stones in different anatomical sites, while a statistically significant difference ( $p < 0.05$ ) was observed in specific gravity. Duncan's Multiple Range Test shows a significant decrease in mean pH and increase in specific gravity in patients with stones in urinary bladder compared to all other sites ( $p < 0.05$ ). On testing the correlation between pH and specific gravity using Pearson correlation, a statistically significant ( $p < 0.001$ ) negative correlation of -0.3 was obtained.

The analysis of the effect of seasonality on specific gravity, with the year divided into Summer and Winter, showed that specific gravity during the summer season was comparatively high compared to that in winter. The difference observed was not statistically significant. With regard to pH, during winter the mean pH was high when compared to that in summer. The difference observed was not statistically significant. Comparing specific gravity and pH, the highest mean specific gravity was observed in summer and the highest mean pH in winter.

On comparing the mean specific gravity in crystalluric and non crystalluric patients, an increasing trend was observed from urine with no crystalluria, urine with uric acid crystals and urine

Table 6. Distribution of urine specific gravity and pH according to season and crystalluria

Variables		pH Specific gravity			
		Mean	SD	Mean	SD
Season	Summer	6.01	0.81	1.0191	0.009
	Winter	6.18	0.81	1.0165	0.0094
Crystalluria	No crystalluria	6.08	0.82	1.0180	0.0092
	Uric Acid	5.79	0.66	1.0265	0.0052
	Ca oxalate	5.67	0.41	1.0283	0.0026

with calcium oxalate crystals. On comparing the mean pH with crystalluria a negative trend was observed, an increased pH for urine without crystals and a decreased pH for calcium oxalate urine. The details are given in Table 6.

## DISCUSSION

Urolithiasis is the condition of stone formation in the urinary system, including ureter, kidney, and

bladder<sup>12</sup>. Crystal formation depends mainly on the composition of urine, as urine is a metastable liquid containing several coexisting substances that can crystallise to generate renal calculi<sup>18</sup>. The anatomy of the upper and lower urinary tract may also influence the likelihood of stone formation<sup>19</sup>. In the present study the majority of stone formers (83.8%) were below 40 years of age, with a male to female ratio of 5:1. Studies conducted by Alsheyab et al. in Jordan and Kumar et al. in Nepal revealed that male predominance was seen with a ratio of 3:1 and that urinary stone disease was most common within the age group 20-50 years. The male to female ratio observed in the present study is high compared to other studies. The studies from other parts of the world show that stone disease not only affects the patients, but also the national economy, as the disease is prevalent in the productive age group<sup>20</sup>.

In the present study it was observed that 4.5% of the patients had uric acid crystals and 1.6% calcium oxalate crystals. Sperling et al. and Tiselius et al. showed high frequency of acidic urine in patients living in Israel, the Arabian countries, and Australia compared to Northern Europe. Episodes of excessive fluid loss or reduced intake might be associated with an obvious risk of uric acid crystallization. Lowering of pH and urine volume can lead to the precipitation of uric acid at a normal excretion of urate<sup>21-22</sup>. The present study shows the influence of lowered pH and increased specific gravity in stone formation, which is in accordance with the study conducted by Kumar et al.<sup>10</sup>. It also shows that uric acid solubility decreases dramatically at a urinary pH lower than 5.5, leading to uric acid crystal formation. The solubility of calcium oxalate is affected by the changes in the urinary pH leading to its supersaturation and crystallization<sup>12</sup>. Most of the urine samples showed an increase in specific gravity during the summer season with a decrease during the winter. This is in accordance with the studies of Rabie et al., proving the effect of seasonal variations in temperature on urinary volume, pH and saturation<sup>1</sup>.

## CONCLUSION

The present study identifies an association between pH and specific gravity in urinary stone formers, highlighting the role of an increase in

specific gravity and decrease in pH in the formation of urinary stone diseases. The study also showed an increase in specific gravity and decrease in pH of urine during summer season, which may be a contributing factor for urolithiasis. The main reason for the increased specific gravity during summer seems to be dehydration as indicated by the presence of high colored urine (yellow to amber). A prospective study is underway to correlate the role of pH and specific gravity with the crystalluria and urolithiasis among the stone formers in the United Arab Emirates.

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