

# Correlative Analysis Between Severity of Urolithiasis and Laboratory Parameters and Its Implication in Evaluation of the Probable Risk Profile

Rajeev T.P<sup>a</sup>, Yashasvi Singh<sup>a, b</sup>, Sasanka Kumar Barua<sup>a</sup>,  
Debanga Sarma<sup>a</sup>

## Abstract

**Background:** Urolithiasis presents serious hazard which significantly elevates the cost of national health expenditure in almost every part of both the hemispheres. There is high risk of hospitalization with loss of valuable human resource and decreased productivity along with it. Risk factors still evade the exact etiology and search for optimal serum panel is still in its infancy. Urolithiasis incidence has gradually increased in last 3 decades which suggests that some constant metabolic and urinary parameters are implicated in the risk of occurrence of urinary stone. The present study is intended to identify a panel of serum parameters, urinary parameters, radiological characteristics and correlating it with the clinical severity of stone disease.

**Methods:** The present study was conducted at the Department of Urology at GMCH Guwahati. The authors retrospectively analyzed 151 patients undergoing stone surgery from a period of January 2016 to August 2017. Data comprised of all serum and urinary examinations done 1 week preoperatively and radiological scans within 1 month before surgery. Spearman test was used to determine correlation and analysis of variance (ANOVA) was applied for comparison between more than two categories.

**Results:** Stone multiplicity was positively correlated with upper tract stone sides ( $r = 0.530$ ,  $P < 0.01$ ), large stone volume ( $r = 0.172$ ,  $P < 0.02$ ), stone recurrence, urinary infection and urine protein. Upper tract stone sides number was positively correlated with upper tract obstruction sides ( $r = 0.542$ ,  $P < 0.03$ ), large stone volume ( $r = -0.321$ ,  $P < 0.01$ ). Upper tract obstruction sides number was positively correlated with large stone volume ( $r = -0.848$ ,  $P < 0.01$ ).

**Conclusions:** Results demonstrated that urinary tract obstruction and total stone volume significantly correlated with abnormal serum panel, urinary profile and were harbinger of complex stone pattern.

**Keywords:** Hypertension; CKD; Stone multiplicity; Upper tract obstruction

## Introduction

Urolithiasis is an omnipresent pandemic disorder affecting large patient population worldwide and especially in South Asia. About 10% of people will experience nephrolithiasis in their lifetime and about 50-70% of those will have recurrences [1, 2]. Urolithiasis prevalence has been on an upswing in both sexes and in certain areas of the Indian subcontinent like NE India; the lifetime hazard appears to be even higher. A lot of capital has been used in the overall management of urinary stones worldwide but its forestalling has been a spurned field. A recent study based upon the National Health and Nutrition Examination Survey (NHANES) estimated that 19 % of men and 9 % of women will be diagnosed with a kidney stone by the age of 70 years [3]. Recurrence rates of renal stone are approximately 10% per year, 50% over a period of 5 - 10 years and 75% over 20 years period. The incidence rate of nephrolithiasis varies with geographical region of an individual country. Nearly 2 million people in India are affected with urolithiasis every year and many parts of the country have names denoted as a stone belt that is, Gujarat, Maharashtra, Punjab, Rajasthan, Delhi, Haryana and part of states on Northeast side[4]. There are a number of epidemiological arenas consisting of anatomic, metabolic, dietary and urinary factors that incline to the development of urolithiasis. The frequency with which these different risk factors occur in patients with recurrent stone disease and the role of genetic susceptibility are reviewed at the end of this topic. Upper urinary tract stones may lead to hydronephrosis and renal compromise. Nonetheless, hypertension, diabetes mellitus and chronic kidney disease (CKD) were proved to be correlated with nephrolithiasis. Many authors agree and it is our firm belief that stones in patients with CKD should be cleared [5]. However, the risk factor that may influence the calculus kidney damage is still unclear and needs further evaluation.

Nearly 75 % of patients with nephrolithiasis form calcium stones mostly comprising of calcium oxalate or calcium phosphate to some extent, while uric acid stones make up less than 10 percent of all stones [6]. Renal stones consist of a variety of

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<sup>a</sup>Department of Urology, 3rd Floor, GMCH Complex, GMC Hostel Road, Bhangagarh, Guwahati, 781032, Assam, India

<sup>b</sup>Corresponding Author: Yashasvi Singh, Department of Urology, 3rd Floor, GMCH Complex, GMC Hostel Road, Bhangagarh, Guwahati, 781032, Assam, India. Email: Yashasvisingh075@gmail.com

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crystalline and non-crystalline materials, knowledge of which influences clinical decision. Analysis of 24 h urine composition provides data on the possible contents of a stone but does not perfectly predict stone type. The frequent crystalline materials found in kidney stones are calcium oxalate, calcium phosphate, uric acid, and struvite though mutual coexistence for them in most cases has become an undeniable fact. Non-crystalline materials found in stones include blood and protein. The aim of this study is to establish a correlation between different calculus clinical patterns and laboratory parameters in patients with urolithiasis, in order to further explore the mechanism of these parameters changes after stone formation and also to find out some risk factors of kidney damage after urolithiasis occurs.

## Methods

This retrospective study included 151 patients with urolithiasis who underwent surgery for renal, ureteric and vesical stones at the Department of Urology and Renal Transplantation between January 2016 to August 2017 and were in follow-up for at least 6 months in the Urology OPD. Diagnosis of stone diseases and their clinical implication were assessed by USG W/A, intravenous urogram (IVU), Non-contrast CT kidney-ureter-bladder scanning (NCCT KUB) and contrast-enhanced computed tomography (CECT (W/A + pelvis + urography) ) when required accordingly. “Stone multiplicity” was construed as multiple urinary tract stones present, disregarding their locations. “Upper urinary tract obstruction” was characteristically present when ureteric calculi or hydronephrosis caused by renal calculi were diagnosed. “Large stone bulk” was defined as stone’s size greater than 2 cm in diameter. Data on patient’s age at presentation, gender, co-morbidities, past medical and surgical history were recorded. Diagnosis of uncontrolled hypertension and diabetes mellitus was based on medical history and current use of medication. Height and weight were measured and body mass index was calculated.

All hematological and biochemical test results were obtained preoperatively, within 1 week before primary surgery. Authors evaluated the serum levels of urea, creatinine, sodium, potassium, magnesium, calcium, phosphorus, alkaline phosphate, uric acid and albumin. Patients were asked to collect morning urine samples which were examined for pH, specific gravity, protein and bacteria. Patients with borderline renal function and objective evidence of CKD on USG W/A upfront underwent 99 m Tc-DTPA renal scan. Split GFR below 20% than that of the contralateral kidney was considered as “mild damage” and above 20% as “moderate damage”. Ipsilateral kidney’s GFR below 10 mL/min was considered as “severe damage”. Discrete and continuous variables were compared using Chi-square test, Student’s *t*-test and post-hoc analysis respectively and correlation coefficient was calculated using the Pearson’s R analysis. P values less than 0.05 were considered statistically significant. SPSS version 21.0 was used to evaluate all statistical analysis.

## Results

The median age for the entire cohort was  $55.15 \pm 14.26$  years

**Table 1.** Distribution Pattern of Categorical and Clinical Parameters With Overall Distribution

Age (years)	Mean $\pm$ SD	55.15 $\pm$ 14.26
Gender	Male/female	87/64
Recurrence	Yes/no	50/101
BMI	Mean $\pm$ SD	25.21 $\pm$ 3.26
HTN	Present/absent	48/103
DM	Present/absent	29/122
CKD	Present/absent	44/107
DM + CKD	Present/absent	12/139
Stone multiplicity	Present/absent	85/66
Upper tract stone site	0/1/2	32/62/57
Upper tract obstruction side	0/1/2	16/65/67
Large stone bulk	Present/absent	41/110
Ipsilateral kidney damage	Mild/moderate/severe	48/80/23

taking into account all the four respective groups but irrespective of gender group ( $P = 0.034$ ). Median age was maximal for the ureteric stone group (Table 1). While examining the biochemical parameters it was seen that median value of serum urea was maximum in ureteric stone group but the overall distribution did not reach significant level ( $P = 0.950$ ). Serum creatinine was analyzed in all the four groups as a constant variable both pre and postoperatively, and was maximal in the vesical calculus group when compared with other groups ( $P = 0.029$ ) (Table 2). Protein metabolism that was specifically mapped upon in view of the dietary habits and serum albumin level was found to be significantly associated in all the four groups ( $P = 0.012$ ). Though serum calcium concentration holds an important position in urolithiasis development, our analysis could not get a significant association except in obstruction ( $P = 0.001$ ) group and large stone bulk group ( $P = 0.002$ ) for the same. Serum sodium ( $P = 0.032$ ) and magnesium ( $P = 0.045$ ) both were significantly associated with stone formation among all the four groups. Among these parameters, male and the aged were significantly associated with bladder calculi. Renal calculi were associated with recurrence, UTI and higher urinary protein, whereas ureteral calculi were associated with higher serum sodium level. The combination of renal and ureteric calculi was associated with higher serum creatinine. One third of the patient in the entire cohort had recurrence in the follow-up period (6 months) with maximum number of cases in the kidney stone group with significant association (Chi square value = 4.706,  $P = 0.019$ ) and correlation ( $r = 3.08$ ,  $P = 0.042$ ). Hypertension was as significantly associated (Chi square value = 8.528,  $P = 0.001$ ) and correlated ( $r = 5.67$ ,  $P = 0.036$ ) as recurrence in the four stone categories and was present in 31.79% cases. CKD was present in 29.14% cases when presented in isolation ( $P = 0.043$ ), and in 7.94% cases when combined with DM II ( $P = 0.404$ ) which was not significant when present in combination (Table 3). Its correlation with the stone distribution groups did reach significant level ( $P = 0.027$ ) when analyzed statistically. Multiple stones were observed in 56.29% cases and were significantly associated (Chi square

**Table 2.** Median Values of Continuous Variables With Corresponding P Values (Chi-Square Analysis/Pearson's R Analysis)

Variable	Group				P value
	Kidney	Ureter	Kidney + Ureter	Bladder	
Age	56.42	58.19	48.61	52.09	0.034
BMI	25.7	24.65	24.61	24.56	0.574
Serum urea	5.66	6.01	5.9	5.87	0.95
Serum uric acid	0.36	0.35	0.33	0.36	0.541
Serum creatinine	93.52	88.51	69.45	95.06	0.029
Serum ALP	75.08	76.38	82.92	64.67	0.067
Serum albumin	42.69	41.07	41.72	41.86	0.012
Serum Na	144	143.73	143.13	142	0.032
Serum K	3.96	3.95	4.02	3.97	0.893
Serum Ca	2.28	2.29	2.26	2.28	0.683
Serum Mg	0.88	0.89	0.87	0.93	0.045
Serum PO <sub>4</sub>	1.16	1.08	1.16	1.13	0.339
Urine specific gravity	1.021	1.019	1.019	1.022	0.587
Urine pH	5.93	6.02	5.82	5.84	0.801

value = 8.348,  $P = 0.039$ ) and correlated ( $r = -4.09$ ,  $P = 0.027$ ) with the stone groups. Multiple stones were managed in the same sitting if present on the same side and there was a gap of 3 to 6 months when present on the opposite side.

Upper tract stone sites incorporated 41.06% cases on a single site and 37.75% cases on two sites which was significantly associated (Chi square value = 14.743,  $P = 0.033$ ) and correlated ( $r = -4.09$ ,  $P = 0.027$ ) with the same. Hydronephrosis of the upper tract resulting from obstruction occurred in 43.04% on one side and 44.37% on both the sides and it was significantly associated (Chi square value = 14.81,  $P = 0.049$ ) and correlated ( $r = 2.69$ ,  $P = 0.022$ ) with the four stone groups. Large stone bulk was seen in 27.15% and was not significantly associated and correlated with the same compelling on the importance of delay in presentation to the OPD. The time lag in presentation augmented the ipsilateral kidney damage which towered at 52.98% for moderate damage and 15.23% for severe damage and was significantly associated (Chi square value = 14.27,  $P = 0.048$ ) and correlated ( $r = 3.10$ ,  $P = 0.038$ ) with the groups in consideration.

The correlation determination for stone multiplicity with other clinical variables revealed that stone multiplicity was positively correlated with upper tract stone sides ( $r = 0.730$ ,  $P < 0.01$ ), large stone volume ( $r = 0.272$ ,  $P < 0.02$ ), stone recurrence ( $r = 0.632$ ,  $P = 0.001$ ), CKD ( $r = 0.062$ ,  $P = 0.001$ ), urine albumin ( $r = 2.63$ ,  $P = 0.012$ ) and urine infection ( $r = 1.80$ ,  $P = 0.001$ ). Upper tract stone sides number was positively correlated with age ( $r = 2.32$ ,  $P = 0.002$ ), upper tract obstruction sides ( $r = 0.742$ ,  $P < 0.01$ ), serum creatinine ( $r = 4.67$ ,  $P = 0.002$ ), serum sodium, and urinary infection, large stone volume ( $r = -0.321$ ,  $P < 0.01$ ), urine specific gravity ( $r = 1.87$ ,  $P = 0.04$ ) and urine infection ( $r = 8.06$ ,  $P = 0.003$ ). Upper tract stone obstruction sides number was positively correlated with age ( $r = 5.56$ ,  $P = 0.033$ ), BMI ( $r = 9.87$ ,  $P = 0.044$ ), serum potassium ( $r = 6.44$ ,  $P = 0.021$ ), serum creatinine ( $r = 1.56$ ,  $P =$

0.039), serum calcium ( $r = 5.06$ ,  $P = 0.001$ ), serum phosphate ( $r = 6.86$ ,  $P = 0.042$ ), urine albumin ( $r = 0.443$ ,  $P = 0.002$ ) and urinary infection ( $r = 0.443$ ,  $P = 0.01$ ), whereas negatively correlated with large stone volume ( $r = -0.748$ ,  $P < 0.01$ ) and serum magnesium ( $r = -4.67$ ,  $P = 0.038$ ). Large stone volume was positively correlated with age ( $r = 0.879$ ,  $P = 0.033$ ), urine albumin ( $r = 3.65$ ,  $P = 0.011$ ), serum phosphate ( $r = 0.401$ ,  $P = 0.001$ ), serum calcium ( $r = 0.801$ ,  $P = 0.002$ ) and CKD ( $r = 0.441$ ,  $P = 0.023$ ). Ipsilateral kidney damage was positively correlated with age, recurrence, CKD, hypertension, serum urea and serum creatinine, serum albumin (Table 4).

## Discussion

In our patient population, bilateral upper tract calculi are correlated with higher serum sodium. Increased daily sodium intake tends to increase serum and urinary sodium in a significant manner which not only increases the net calcium excretion in the urine, but also increases urinary pH and decreases citrate excretion at the same time. Keeping the aforementioned aspect in consideration, the urinary concentration of calcium phosphate and monosodium urate also increased significantly. Thus, a high sodium intake was directly responsible for the crystallization of calcium salts in urine. Moreover, in our study, upper urinary tract obstruction side number was correlated with higher serum potassium, calcium and phosphate level, as well as lower magnesium level.

Calcium urolithiasis has hypercalcemia and hypercalcemia both as compelling and estimable factors requiring urgent and immediate action. Hypercalcemia exists when serum calcium level increases, together with measuring and calculation of physiologically active calcium when there is difference in the pH of blood or serum albumin [7]. In serum, calcium is either bound to albumin or is found in its free form (ionized).

**Table 3.** Significant Association and Correlation Parameters of Categorical Variables and Clinical Parameter Groups

Variable	Chi square coefficient	P value	Pearson r coefficient	P value
Gender	7.28	0.063	-0.015	0.859
Recurrence	4.706	0.019	3.08	0.042
HTN	8.528	0.001	5.67	0.036
DM II	5.635	0.302	0.01	0.907
CKD	8.66	0.043	7.42	0.027
DM + CKD	2.92	0.404	-0.002	0.979
Multiple stones	8.348	0.039	-4.09	0.027
Upper tract stone side	14.743	0.033	-0.858	0.041
Upper tract obstruction side	14.81	0.049	0.269	0.022
Large stone bulk	2.072	0.558	0.021	0.798
Ipsilateral kidney damage	14.27	0.048	3.1	0.038

It is the ionized calcium which is of concern because ionized calcium is the physiologically active form of calcium as calcium bound to albumin is inactive. Standard lab tests usually measure the total calcium. When albumin is low, patients have lower total calcium on lab tests. Hence, patients with lower serum albumin tended to have higher serum active calcium level.

When the serum is alkaline, hydrogen ions bound to negatively charged albumin are released. These binding spots on albumin open for ionized calcium to bind, which reduces the amount of physiologically active calcium. Hypercalcemia and hypercalciuria increase the incidence of calcium stones, by increasing the urinary saturation of calcium salts and by binding negative-

**Table 4.** Clinical Parameter Groups and Corresponding Biochemical and Epidemiological Variables With Corresponding Correlation Values

Variable	Multiplicity		Stone side		Ipsilateral kidney damage		Large stone bulk		Obstruction side	
	Pearson's r value	P value	Pearson's r value	P value	Pearson's r value	P value	Pearson's r value	P value	Pearson's r value	P value
Gender	-0.87	0.081	-0.7	0.99	-0.081	0.56	0.212	0.43	-0.55	0.011
Age	0.65	0.239	2.32	0.02	4.55	0.001	0.879	0.004	5.56	0.033
Recurrence	0.632	0.001	8.06	0.035	0.632	0.021	1.12	0.09	0.56	0.129
BMI	0.59	0.265	3.67	0.86	0.89	0.1	0.974	0.134	9.87	0.044
DM	0.561	0.435	2.86	0.77	0.661	0.101	0.45	0.172	0.36	0.067
CKD	0.062	0.001	3.44	0.26	0.762	0.002	0.441	0.023	8.06	0.055
HTN	0.98	0.765	4.56	0.14	0.98	0.001	1.02	0.56	0.67	0.113
Serum Na	5.13	0.003	0.87	0.87	0.113	0.81	0.167	0.87	0.86	0.088
Serum K	5.92	0.96	4.36	0.66	0.223	0.448	0.012	0.36	6.44	0.021
Urea	8.34	0.57	5.06	0.24	0.458	0.01	0.183	0.26	0.97	0.954
Creatinine	13.74	0.16	4.67	0.002	0.886	0.001	0.393	0.47	1.56	0.039
Serum ALP	14.81	0.24	1.86	0.56	0.093	0.331	0.948	0.86	0.87	0.113
Serum albumin	1.072	0.062	1.44	0.97	0.088	0.001	0.11	0.44	9.36	0.121
Serum Ca	14.27	0.85	3.97	0.26	0.068	0.098	0.801	0.002	5.06	0.001
Serum Mg	0.183	0.112	5.56	0.09	0.29	0.1	-0.631	0.072	-4.67	0.038
Serum PO4	0.293	0.18	0.56	0.06	0.243	0.295	0.401	0.001	6.86	0.042
Specific gravity	1.95	0.095	1.87	0.04	0.416	0.233	0.198	0.98	0.44	0.098
pH	2.11	0.088	0.36	0.081	0.665	0.376	0.1	0.11	0.775	0.1
Urine infection	1.8	0.001	8.06	0.003	0.885	0.431	0.442	0.689	0.443	0.01
Urine albumin	2.63	0.012	0.445	0.997	0.005	0.981	3.65	0.011	0.091	0.002

ly charged inhibitors of stone formation [8]. Increased level of serum calcium should lead to analysis of both ionized calcium and intact PTH with the aim to button in on patients who might have undiagnosed hyperparathyroidism [9]. A study [10] stated that stone patients have a relative risk of hypercalcemia and hypercalciuria nine to 18 times more than non-stone formers, respectively. Nonetheless, by definition of hypercalcemia (serum calcium > 2.75 mmol/L), only two patients (0.03%) in our cohort were diagnosed as real hypercalcemia, which consistent with the research of a prospective study [11]. In a large prospective study, calcium intake was measured and high dietary intake was inversely correlated with kidney stone risk (relative risk: 0.56) [12]. In another large prospective cohort study of men, the relative risk of stone formation for highest and lowest quintiles of calcium intake was 0.69 [13]. Higher calcium intake decreased the risk of stones in females by up to 28% in a prospective cohort study [14]. Some studies indicated that serum phosphate level was a significant risk factor of calcium urolithiasis [15, 16]. The renal phosphate leak theory explains calcium nephrolithiasis in recurrent stone cases by implicating that the defect of renal tubules will prevent phosphate reabsorption [17]. The result is hyperphosphaturia, with low serum phosphate level, causing an increase in the GIT absorption of calcium, which results in an increased renal load of calcium resulting in hypercalciuria. Nonetheless, the value of renal phosphate leak theory in the formation of calcium nephrolithiasis is questionable. Few studies showed no consistent compelling association of patient's serum phosphate level with stone recurrence [18].

When the urinary parameters of patients with idiopathic hypercalciuria were equated to those with normocalciuria, patients with former were found to have increased urinary sodium and sodium intake [19]. In a randomized study comparing low calcium and sodium diet and animal protein, the low sodium and animal protein diet resulted in fewer stone recurrences [20]. Increased sodium diet was related to 61% increase in nephrolithiasis risk in a large prospective study of women [21]. In a randomized study of 210 patients with hypercalciuria with calcium stones, a low sodium diet culminated in lower urinary sodium, as well as lower urinary calcium and oxalate excretion and resulted in normalization of urine calcium excretion for one third of patients [22].

Negative correlation between upper urinary tract obstruction side number and serum magnesium was observed in our series. Some authors indicated that magnesium can lower the risk of stone formation by diverse mechanisms. Magnesium chelates urinary oxalate, producing a soluble magnesium-oxalate complex than calcium oxalate and thus increases urinary citrate level [23]. A low urinary magnesium level has been seen in calcium stone formers with hypercalciuria. Clinically, oral supplementation of magnesium citrate increases urinary magnesium and citrate excretion. Magnesium supplement in deficient patients proved to decrease the recurrence rate of urolithiasis [24].

Serum potassium was observed to be positively correlated with upper urinary tract obstruction side number. Upper urinary tract obstruction invariably leads to hydronephrosis and renal insufficiency if ignored for long period of time. When renal function deteriorates, the ability to effectively regulate

serum potassium via the  $\text{Na}^+/\text{K}^+$ -ATPase and multiple other mechanisms declines significantly. Although atoning mechanism exists, serum potassium will elevate continuously after it reaches its limits.

Our analysis showed that older patients were correlated with larger stone volume, higher risk of bilateral upper urinary tract calculi and obstruction, and severe ipsilateral kidney damage. Past studies have proved that older patients with stone formation had more condition related to metabolic syndromes than younger patients [25, 26]. The clubbing between metabolic syndrome and nephrolithiasis has been established by some past studies [27, 28]. One different scenario leading to the aforementioned condition is the steady decline in renal function that occurs with advanced age, as super-saturation and nephrolithiasis have been attributed to renal tubular cell damage [29]. Furthermore, older patients inclined to have more peculiar presentations of urolithiasis, which cause delay in the diagnosis and management [30]. This may explain why bilateral upper urinary tract calculi and larger stone volume were more frequent in older patients. In conclusion, older patients with urolithiasis usually have larger and more complex stone disease. A random spot urine sample was used for urine culture to establish organisms producing urease. The concomitant finding of high urine pH (> 7.5) in few cases indicated that the patient might have formed an infection stone (magnesium ammonium phosphate + carbonate apatite). Low urine pH presents a risk for uric acid precipitation and subsequent stone formation [31].

In our study, urinary tract infection (UTI) was positively correlated with multiple stone, bilateral upper urinary tract stone and obstruction, and larger stone volume. UTI has been proved to be associated with the formation of stones, the most common composition being struvite (magnesium ammonium phosphate). Urease producing bacteria divides urea into ammonia, resulting in an alkaline urinary pH with subsequent struvite stone formation. Nevertheless, not all stones associated with UTI are composed of struvite and not all are associated with urea-splitting organisms [32, 33]. It is uncharted whether non-struvite infected stones result from infection itself or become secondary infected after formation. It has been observed that pathogenic bacteria from stones could initiate renal inflammation leading to crystal aggregation and subsequent nephrolithiasis. Moreover, the presence of bacteria could alter the local microenvironment by metabolic activity which further promotes lithogenesis [34, 35]. Rather than calculating the total estimated GFR from serum creatinine, authors measured the split GFR through Tc-99m DTPA renal scan which enabled them to accurately evaluate the ipsilateral kidney damage level caused by nephrolithiasis. Thus, authors were able to identify the correlation between ipsilateral kidney damage, nephrolithiasis and various biochemical parameters.

In present study, older age, recurrence disease, hypertension (HTN) was positively correlated with the level of ipsilateral kidney damage. There is a proven firm association between HTN and stone formation, as numerous studies have pointed HTN as an independent predictor of nephrolithiasis [36]. Few studies suggest that dysregulation in renal calcium metabolism existed in patients with HTN, leading to increased hypercalciuria [37]. Additionally *vice versa*, in patients with

nephrolithiasis, the incidence of HTN has been seen to be more than that of patients without nephrolithiasis [38]. It has been observed that uncontrolled hypertensive patients with nephrolithiasis have a greater risk for CKD as HTN is formidably associated with CKD. Recurrent stone formation history was proved to be significantly correlated with ipsilateral kidney damage. Amongst 171 patients with idiopathic calcium stones in a recent study [39], the 30 patients with reduced GFR (eGFR < 80 mL/min/1.73 m<sup>2</sup>) had significant incidence of recurrent disease with nearly one stone per patient per year.

In our study, negative correlation was observed between ipsilateral kidney damage and serum albumin level. Urine protein level was positively correlated with larger stone bulk and stone multiplicity. Although no correlation was observed between ipsilateral kidney damage and urine protein level, lower serum albumin level was frequently found in CKD patient mainly caused by proteinuria. It was observed in few studies that proteinuria was a surrogate outcome in CKD, with changes in proteinuria recommended as a surrogate for renal disease progression [40]. A study reported [1] atrophic kidney cortex (< 5 mm), proteinuria (> 300 mg/d), large stone bulk (> 1,500 mm<sup>2</sup>), pediatric age group and recurrent UTI, were predictors of poor renal outcome in upper urinary tract stone formation patients with CKD. This goes hand in hand with our observations. The authors identify several limitations of the current study. We did not categorize patients according to stone compositions because they were not regularly identified in our cohort. The invaluable 24 h urine analysis for super-saturation profile, which includes urinary calcium, phosphate, citrate, oxalate, etc., was also not involved in our study.

## Conclusions

Our analysis demonstrated upper urinary tract obstruction was more likely to correlate with abnormal electrolyte metabolism in terms of serum calcium, magnesium and phosphate. Older age and UTI were positively associated with larger stone volume and complex stone patterns. Ipsilateral kidney damage associated with upper tract obstruction is correlated with old age, recurrence, hypertension and low serum albumin.

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