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Investigation of Crystalluria and Its Association with Urinary Tract Infections

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ABSTRACT

Background: Crystalluria, the presence of crystals in urine, can arise from factors such as dehydration, dietary habits, and metabolic disorders, often linked to urinary tract infections (UTIs). **Objective:** This study aims to identify the predominant types of crystals in patients with UTIs and examine the association between pus cells and crystalluria. Conducted at Alkhidmat Razi Hospital over four months (June-September 2024), it utilized a non-probability purposive sampling technique. **Methods:** A total of 134 UTI patients were enrolled, with 35.1% male and 64.9% female participants. Age groups were categorized into six ranges: 5-15, 15-25, 26-35, 36-45, 46-55, and 56-65 years. The mean age was 34.1±16.4 years. Results indicated that 31% had crystalluria while 69% did not. Notably, 68.7% of samples showed no detectable crystals. **Results:** Calcium oxalate emerged as the most common crystal type, found in 25.4% of cases. Males exhibited higher percentages of crystalluria, with calcium oxalate present in 17.9% of males versus 7.47% of females. Other crystals included amorphous phosphate (2.24% in males and 1.49% in females) and calcium carbonate (0.75% in males only). **Conclusion:** Understanding the specific types of crystals and their impact on UTI severity is vital for treatment strategies. Statistical analysis via SPSS version 25.0 revealed a chi-square p-value of 0.313, indicating no significant association between pus cells and crystalluria.

INTRODUCTION

Urinary tract infections (UTIs) are a significant global health concern, affecting approximately 150 million people annually (Aziz et al., 2023). The prevalence rate of UTIs is estimated to be around 65% (Khatoon et al., 2023), making it the third most frequent illness among humans, after pulmonary and gastrointestinal illnesses (Najar et al., 2009). Females are particularly susceptible, with an estimated 50% experiencing a UTI at least once in their lifetime, and 10-60% having symptomatic UTIs (Czajkowski et al., 2021). The presence of crystals in the urine, known as crystalluria, can indicate various pathological conditions and may also be observed in healthy individuals (Priyadarshani et al., 2018). Crystalluria can result from changes in urine pH and temperature, supersaturation of certain electrolytes and substances, or the intake of specific foods (Katica et al., 2020). The clinical manifestations of crystalluria may include hematuria, oliguria, abdominal and back pain, and a burning sensation during urination (Zeller et al., 2016).

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The type of crystals observed during urinalysis depends on factors such as salt concentration, solubility, and urine pH (Nagarajan Prabhu et al., 2015). Acidic urine typically contains crystals such as calcium oxalate, uric acid, cysteine, and tyrosine, while alkaline urine may contain crystals like triple phosphate (ammonium-magnesium phosphate), calcium carbonate, and ammonium biurate (Fogazzi, 1996). Certain crystals, such as calcium oxalate, uric acid, and cysteine, are associated with serious health disorders and can indicate an increased risk of kidney stone formation (Lee et al., 2022). The presence of these crystals may also be linked to underlying conditions like kidney dysfunction, metabolic disorders, or the ingestion of specific substances (Fogazzi, 1996). The analysis of urinary crystals and other components can provide valuable insights into various disease conditions, including urinary tract infections (Tabassum & Khurshid, 2020). The diagnosis of UTIs typically involves evaluating the number of leukocytes and the presence of bacteriuria in the urine (Czajkowski et al., 2021). The most common causative agents of UTIs are bacteria, such as Escherichia coli, Klebsiella species, Staphylococcus, and Pseudomonas (Mancuso et al., 2023).

Urinary tract infections can be classified as complicated (CUTI) or uncomplicated (uUTI) based on factors such as underlying conditions, anatomical abnormalities, and the presence of risk factors (Mancuso et al., 2023). CUTIs are associated with a higher risk of complications and are often linked to factors like urinary tract blockage, neurological dysfunction, and kidney failure (Shahzad et al., 2022). The recurrence of UTIs, defined as more than two episodes per year, is a significant challenge in the management of these infections (Xie et al., 2022). Recurrent UTIs can have a substantial impact on the quality of life and require timely and effective treatment to reduce the risk of reoccurrence (Khatoon et al., 2023).

The objective of this study is to investigate the dominant types of crystals observed among patients with urinary tract infections and to elucidate the association between crystalluria, pus cells, and urine pH.

MATERIALS AND METHODS

This was an experimental cross-sectional study conducted at Alkhidmat Razi Hospital, Rawalpindi. A non-probability purposive sampling technique was used, and the sample size was calculated using the OpenEPI software, which determined it to be 350 participants. The study duration was from June 2024 to September 2024, and the data was analyzed using SPSS software. A performa was used to collect the data, and the study was approved by the Institutional Review Board (IRB) of the laboratory where the research was conducted.

Inclusion Criteria

All patients who presented clinically with urinary tract infection, irrespective of age and gender, were included.

Exclusion Criteria

1. Patients with recent use of antibiotics
2. Individuals with known metabolic disorders unrelated to UTI
3. Patients with indwelling urinary catheters
4. Patients with urological surgeries within the past months

Data Collection: A total of 134 midstream urine samples were collected in sterile containers. The samples included 47 males and 87 females, with ages ranging from 5 to 65 years. Patients' sociodemographic information, clinical findings, and types of crystals were obtained from their history charts and laboratory reports.

Urinalysis: The urinary parameters were measured using the dipstick method by observing the color change and comparing it with the standard within 20 to 30 seconds. The values were recorded separately for further analysis.

Microscopic Examination: A 5-10 ml urine sample was centrifuged at 3000 rpm for 5 minutes. After discarding the supernatant, one drop from the sediment was placed on a clean glass slide and covered with a clean cover slip. The deposits were then studied under a high-power objective lens (40X) to clearly demonstrate the types of crystals and other cellular components in the urine.

RESULTS

The mean age of the patients enrolled in this study was 34.1±16.4 years. The age distribution of the patients showed that the highest percentage (32.8%) was in the 26-35 years age group, followed by 14.9% in the 5-15 years, 36-45 years, and 56-65 years age groups. The lowest percentage (9.0%)

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was observed in the 46-55 years age group (Figures 1).

The gender-wise distribution showed that 35.1% of the participants were male, and 64.9% were female (Figure 2).

The urinalysis parameters revealed that 51.5% of the patients had pale yellow urine, 53.0% had clear urine appearance, 88.1% had no glucose, 75.4% had no blood, 93.3% had negative nitrites, 95.5% had negative ketone bodies, 74.6% had no protein, 78.4% had negative leukocyte esterase, and 95.5% had no casts (Tables 1).

The quantitative urinalysis parameters showed that the highest percentage (30.6%) had a specific gravity range of 1.005-1.010, and the highest percentage (45.5%) had a urine pH range of 5.0-5.9. The majority of the patients (67.2%) had a pus cell range of 6-10, 65.7% had an epithelial cell range of 0-5, and 79.9% had an RBC range of 0-5 (Table 2).

The clinical findings showed that 40 patients had micturition, 49 had burning and stinging while urinating, 9 had abdominal and side pain, 6 had fatigue, and 30 showed no clinical symptoms(Fig 3).

The percentage of crystals among the patients showed that 31% had crystalluria, while 69% had no urinary crystals (Figure 14). The distribution of crystalluria among the UTI patients revealed that calcium oxalate was the most prevalent type, present in 25.4% of the cases, followed by amorphous urate (3.7%), amorphous phosphate (0.7%), calcium carbonate (0.7%), and uric acid (0.7%) (Fig 4).

The gender-wise distribution of crystalluria showed that the types of all crystals found were higher in males. The most predominant type found in both genders was calcium oxalate, with 17.9% in males and 7.47% in females.(Fig 5)

The association between crystalluria and urine pH showed that the majority of the crystals were observed in acidic urine (pH 5.0-6.9), with calcium oxalate being the most prevalent (Table 3).

The association between pus cells and crystalluria showed that the highest frequency of positive crystalluria cases was observed in the range of 6-10 pus cells, with 31 cases. The association was not statistically significant (Table 4).

Figure 1

Shows the age distribution of the study participants.

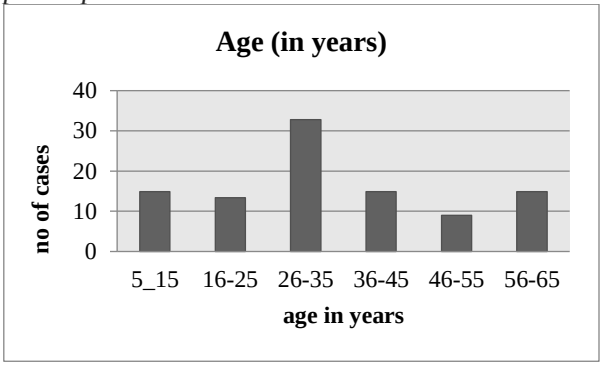

Figure 2

Shows Gender wise distribution of the study participants.

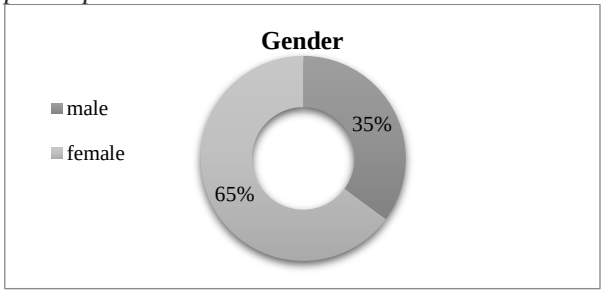

Table 1

Urinalysis parameters of UTI patients

Characteristics	Groups	Frequency N	Percentage%
COLOUR OF URINE	yellow	44	32.8
	pale yellow	69	51.5
	Light yellow	12	9.0
	dark yellow	9	6.7
APPEARANCE OF URINE	clear	71	53.0
	turbid	30	22.4
	slightly turbid	33	24.6
GLUCOSE	yes	16	11.9
	no	118	88.1
BLOOD	positive	33	24.6
	negative	101	75.4
NITRITIES	positive	9	6.7
	negative	125	93.3
KETONE BODIES	positive	6	4.5
	negative	128	95.5
PROTEIN	+	11	8.2
	++	4	3.0
	+++	3	2.2
	trace	16	11.9
	negative	100	74.6

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LEUCOCYTE ESTERASE	negative	105	78.4
	+	7	5.2
	++	8	6.0
	+++	9	6.7
	++++	5	3.7
CAST	granular cast	5	3.7
	hyaline cast	1	.7
	no	128	95.5

Table 2
Quantitative variables of urinalysis of patients having UTI

Parameters	Ranges	Frequency n	Percentage%
SPECIFIC GRAVITY	1.005-1.010	41	30.6
	1.011-1.015	22	16.4
	1.016-1.020	26	19.4
	1.021-1.025	20	14.9
	1.026-1.030	25	18.7
PH	5.0-5.9	61	45.5
	6-6.9	54	40.3
	7-7.9	16	11.9
	8-8.9	3	2.2
PUS CELLS	6-10	90	67.2
	11-15	17	12.7
	16-20	7	5.2
	21-25	4	3.0
	numerous	16	11.9
EPITHELIAL CELLS	0-5	88	65.7
	5-10	29	21.6
	11-15	12	9.0
	16-20	4	3.0
	numerous	1	.7
RED BLOOD CELLS	0-5	107	79.9
	5-10	13	9.7
	11-15	4	3.0
	16-20	3	2.2
	numerous	7	5.2

Figure 3
Shows clinical findings of UTI diagnosed patients

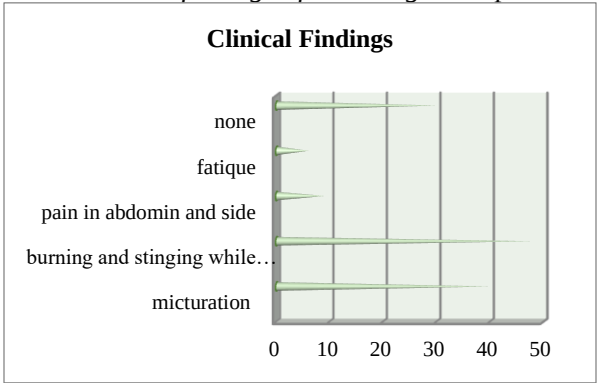

Figure 4
shows percentage of crystals among total patients

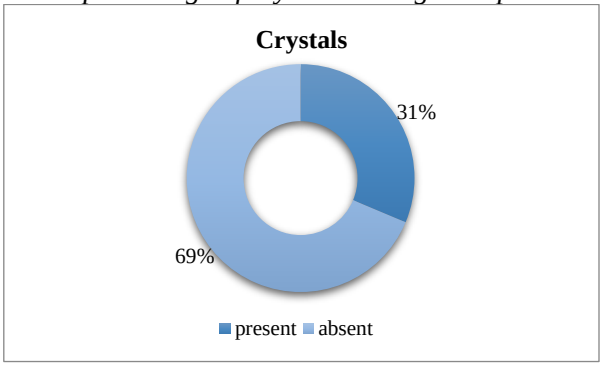

Figure 5
shows percentage of crystalluria among UTI patients

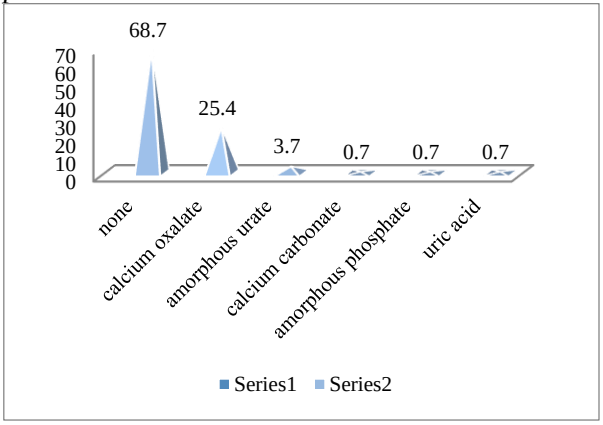

Figure 6
shows gender wise distribution of crystalluria among UTI patients

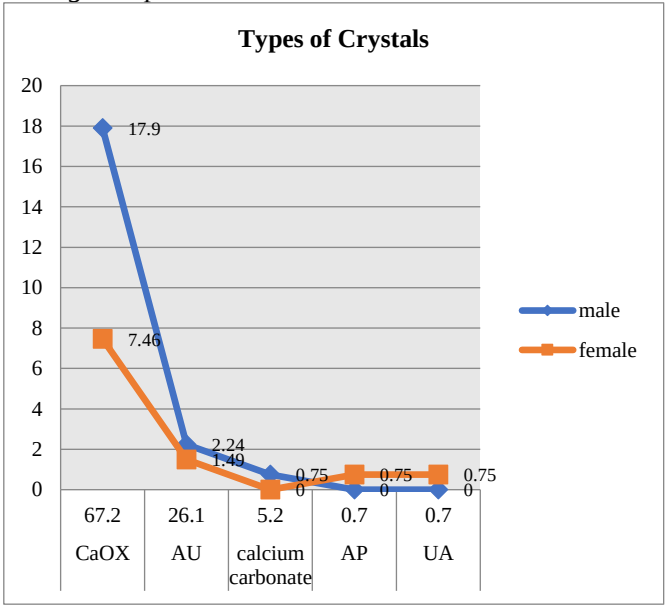

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Table 4
shows association of pus with crystalluria

		Pus cells					Total	P-value
		6-10	11-15	16-20	21-25	numerous		
Crystalluria	Positive	31	6	1	2	2	42	
	negative	59	11	6	2	14	92	
Total		90	17	7	4	16	134	0.313

Table 5
Shows association of crystals with specific gravity

	SPECIFIC GRAVITY				
crystals	1.005-1.010	1.011-1.015	1.016-1.020	1.021-1.025	1.026-1.030
Calcium oxalate	7	5	8	8	6
Amorphous urate	1	1	2	0	1
Calcium carbonate	0	1	0	0	0
Amorphous phosphate	1	0	0	0	0
Uric acid	0	0	1	0	0
Total	9	7	11	8	7

DISCUSSION

Urinary tract infections are the most prevalent infections that impact individual of all ages globally. Throughout the study duration total of 134 urine samples of UTI diagnosed patients were examined for examination of predominant types of crystals in urine. In this study the mean age of the patients enrolled in this study was 34.1±16.4 years. In this study N=47(35.1%) participants were male while N=87(64.9%) majority were females. The age groups are classified into 6 categories which are 5-15, 15-25, 26-35, 36-45, 46-55, and 56-65 years. This study showed that highest percentage of UTI infection is observed age group between 26-35 years (32.8%) as shown in fig 2. The similar results were shown by research study that urinary tract infections are more common in adults having age group between 20-50 years old(Obaid & Juma, 2015).

The crystals in urine are known as crystalluria. In this study different types of crystals such as calcium oxalate, amorphous phosphate, amorphous urate, uric acid, and calcium carbonate were found. Among total number of patients 31% had crystalluria while 69% had no detectable urinary crystals. Among the samples with crystalluria, calcium oxalate was the most prevalent type, present in 25.4% of the cases. Amorphous urate and amorphous phosphate crystals were found in 3.7% and 0.7% of the samples. Calcium carbonate and uric acid were found in 0.7 % and 0.7% of the samples. Amorphous phosphate, calcium carbonate and uric acid were the least prevalent types. The types of all crystals found were higher in male as compare to females as shown in fig 16. The male were more prone to crystalluria is supports by the research study of (Priyadarshani, Amarasinghe, & Gunawardana, 2018). Higher tendency for crystals deposition in males is also in agreement with by another research study conducted by (Prabhu et al., 2015).

According to this study the most prevalent type of crystal found among total UTI population is calcium oxalate (CaoX) followed by amorphous phosphate. Among the samples with crystalluria, calcium oxalate was the most prevalent type, present in 25.4% of the cases. Amorphous urate and amorphous phosphate crystals were found in 3.7% and 0.7% of the samples. Calcium carbonate and uric acid were found in 0.7 % and 0.7% of the samples. Amorphous phosphate, calcium carbonate and uric acid were the least prevalent types.

PH is an important indicator for the formation and identification of urinary crystals. However, depending on urine acid base status, PH of urine varies from acidic to basic ranges from as low to high (5.0 to 8.0). In my study the majority of the samples were acidic and low number was observed for alkaline samples. The majority of crystals that were seen are in acidic urine (5.0-6.9) that higher number observed for calcium oxalate followed by amorphous urate and least common were, uric acid as in table. In neutral PH range between 7-7.9 only one crystal is seen and alkaline urine range between 8-8.9 also only one crystal is seen. The highly correlated result findings are also found in the

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research study of (Obaid & Juma, 2015) in which calcium oxalate, amorphous phosphate was seen in acidic urine. The other research study of (Hassan, 2011) shows higher levels of occurrence of uric acid 96.03% and calcium oxalate 3.97%, uric acid percentage is higher than our study.

Urine specific gravity varies according to presence of crystals in it. According to my study the higher number of crystals were seen between specific gravity range of 1.016-1.020 and 1.021-1.025 the predominant type observed was calcium oxalate. In this study the number of RBCs, epithelial cells were observed in some samples and pus cells are highly positive in range 6-10 which participants had positive crystalluria. These finding are in agreement with the study of (Obaid & Juma, 2015) in which most crystals were present in range between 1.020-1.025.

The pus cells are a vital indicator of UTI. In this study the p value 0.313 (i.e. p>0.05) shows that there's no significant association between variables of pus cells and crystalluria.

CONCLUSION

Crystalluria is defined as the crystals present in the urine. In this study the majority of the UTI samples (68.7%) did not contain any detectable crystals. Among the samples with crystalluria, calcium oxalate was the most prevalent type, present in (25.4%) of the cases. Amorphous urate and amorphous phosphate crystals were found in (3.7%) and (0.7%) of the samples. Calcium carbonate and uric acid were found in (0.7 %) and (0.7%) of the samples. Amorphous phosphate, calcium carbonate and uric acid were the least prevalent types. These findings suggest that the crystal can occur during UTIs although, it is not present in most of the cases but when it occurs the most common type is calcium oxalate. In this study the p value 0.313 (i.e. p>0.05) for the association of pus cells and crystalluria showed that there is no significant association between pus cells and crystalluria.

Limitation of Study

This study had a relatively short duration, spanning only four months, which may have limited our ability to gather comprehensive data on these patients and potentially introduced some degree of error into our findings. The limited sample size in this study may have contributed to less precise results. This limitation can limit the depth of research results and limit the ability to identify important information or relationships that can be clearly identified across multiple sources.

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