

Research Article

Investigation of the Presence of Crystalluria in Cats with Lower Urinary Tract Disease

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Abstract

Crystalluria, the presence of crystals in urine, results from electrolyte and/or substance oversaturation. Feline lower urinary tract disease (FLUTD), where crystalluria is an etiological factor, is diagnosed by exclusion due to its multifactorial nature and overlapping clinical signs. Urinalysis and sediment examination are practical, cost-effective diagnostic tools. This study investigated crystalluria in domestic cats with FLUTD, classified crystal types, and assessed their role in preventing urethral plug formation and obstruction. It included 50 owned cats (28 males, 22 females, median age: 3 years, range: 1–8) presented to the Harran University Veterinary Faculty Animal Hospital between March 2024 and January 2025. All underwent physical, laboratory, and imaging exams and were classified into four crystalluria subgroups: calcium oxalate (CaOx, n = 9), hippuric acid (n = 8), uric acid (n = 8), and struvite (n = 25). Crystalluria was more frequent in tabby cats fed commercial dry food than in those on home-prepared diets. It was also more common in semi-indoor, neutered cats, particularly those that had never mated. The predominant clinical signs were stranguria and hematuria. Median urine pH was 6.75 (range: 4.0–8.5), and urine specific gravity (Sg) was 1.030 (range: 1.030–1.040). In conclusion, the most prevalent crystals in Şanlıurfa cats were struvite, CaOx, hippuric acid, and uric acid. Crystalluria was most common in male, neutered, tabby cats aged ≥ 3 years, weighing ~ 3.5 kg, fed commercial dry food, never mated, and living a semi-indoor lifestyle. Regular urinalysis and veterinary check-ups are advised for at-risk cats to prevent complications like urethral plug formation and obstruction.

Keywords: Cat, cystitis, urinalysis, ultrasound

Introduction

Feline lower urinary tract disease (FLUTD) is characterized by clinical signs such as stranguria, pollakiuria, hematuria, and periuria (Black, 2018). In the United States, an estimated 250,000–500,000 cats are affected annually (Kalkstein et al., 1999). Studies indicate that feline idiopathic cystitis (FIC) accounts for 55–60% of FLUTD cases, followed by urolithiasis (12–22%) (Saevik et al., 2011). Bacterial urinary tract infections are reported in 1.5–20% of cases, while bladder wall neoplasms and neurological disorders are less common, occurring in 0.3–3.6% and 0.2–3% of cases, respectively (Kaul et al., 2019). When no causative agent is identified, the diagnosis of FIC is made if submucosal petechial hemorrhages are observed via cystoscopy or vesicostomy (Westropp and Buffington, 2004). However, in half of non-obstructive FLUTD cases, the underlying cause remains unknown (Forrester and Towell, 2015).

Crystalluria is the presence of crystals in urine, typically resulting from the oversaturation of certain electrolytes and substances. Key contributors include calcium oxalates, urates, and phosphate ions excreted by the kidneys, which exceed the urine's ability to dissolve and retain them (Dorsch et al., 2014). Crystals may become trapped in the matrix, forming a plug. Severe crystalluria can lead to urethral obstruction even without a colloid matrix, though it is often subclinical. However, persistent or severe crystalluria may predispose to urolith formation, increasing the risk of urethral obstruction and cystitis (Kruger et al. 2003; Dorsch et al., 2014).

The diagnosis, treatment, and management of FLUTD-related conditions such as FIC, crystalluria, and bacterial cystitis face two major challenges: the unidentified cause and the lack of randomized controlled trials evaluating treatment options. Similar difficulties exist in human interstitial cystitis. Due to the multifactorial nature of FLUTD and overlapping clinical signs, diagnosis is often by exclusion. Urinalysis and sediment examination are practical, cost-effective tools providing valuable clinical insights. Since the diagnosis of FLUTD is one of exclusion, it often necessitates various, and sometimes costly, diagnostic tests. Therefore, evaluating the demographic characteristics of cats in the region and assessing the diagnostic utility of

routine clinical parameters may help streamline and facilitate the diagnostic process. This study aims to investigate crystalluria in owned cats with FLUTD, classify crystal types, and assess their role in complications such as urethral plug formation and obstruction. Determining the regional prevalence of crystalluria may help mitigate FLUTD risk and guide pet owners in preventive care.

Material and Method

This study received approval from the Local Ethics Committee for Animal Experiments at Harran University on 04/07/2024 with session 2024/004 and decision number 01-18. All animal owners gave their consent for participation in the study.

Animal Material

This study included 50 owned cats of both sexes presenting with FLUTD-related clinical signs, such as stranguria, pollakiuria, hematuria, and periuria. These cats were admitted to the Harran University Faculty of Veterinary Medicine Animal Hospital for diagnosis and treatment between March 2024 and January 2025. Detailed anamnesis, demographic data, urine dipstick and sediment analysis, and urinary bladder ultrasonographic findings were evaluated.

Clinical Examinations

All cats included in the study underwent a detailed medical history review, demographic data collection, and a comprehensive physical examination. The examination included body temperature measurement, capillary refill time assessment, body weight recording, heart and respiratory rate evaluation, lung and heart auscultation, as well as palpable lymph node and mucosal assessments. Information was recorded on diet, breed, lifestyle (indoor or semi-indoor), neuter status, previous mating history, and whether the cats were adopted or homebred. Additionally, the duration of FLUTD symptoms before hospital admission was documented.

Inclusion/Exclusion Criteria

Cats with a history of any disease other than FLUTD, those currently receiving antibiotics, nonsteroidal anti-inflammatory drugs, antidepressants, and/or appetite stimulants, or those exhibiting abnormalities such as high fever, icterus, dyspnea,

or anemia on clinical examination were excluded from the study. Based on the inclusion and exclusion criteria, a total of 50 cats of different ages, breeds, and sexes with FLUTD were enrolled following detailed anamnesis and physical examination.

Radiographic and Ultrasonographic Examinations

All cats with FLUTD findings underwent urinary bladder ultrasonographic examination with minimal stress and restraint, lasting no more than five minutes. The area was shaved, cleaned with alcohol, and gel was applied before using a 7.5 MHz microconvex transducer (Mindray Z60, China). Bladder integrity, wall thickness, and the presence of sediment and/or stones were assessed. Additionally, radiographic examination was performed in two laterolateral and ventrodorsal views of the abdominal region (Fujifilm CR, Japan).

Collection of Urine Samples, Urine Dipstick and Sediment Examinations

During ultrasonographic examination, urine samples (2–5 mL) were collected via ultrasound-guided cystocentesis using a 22G needle. Urine dipstick analysis (URIT-31) was performed within five minutes to assess pH, specific gravity (SG), leukocytes (WBC), and erythrocytes (RBC). The remaining urine samples (1–2 mL) were centrifuged at 1500 rpm for 10 minutes, and the sediment was examined under a light microscope ($\times 40$ magnification, Olympus, Japan) for the presence of crystalluria.

Forming Subgroups

The 50 cats included in the study were categorized into four subgroups based on the morphological characteristics of crystals detected in urine sediment examination: calcium oxalate (CaOx, $n=9$), hippuric acid ($n=8$), uric acid ($n=8$), and struvite ($n=25$).

Statistical Analyses

Statistical analyses were performed using SPSS version 27.0. The normality of continuous variables was assessed using the Shapiro-Wilk test. For non-normally distributed data, results were expressed as median (min–max). Descriptive statistics were calculated using the same software. Intergroup comparisons were conducted using the Kruskal-Wallis test for non-parametric data, with statistical significance set at $p < 0.05$.

Results

Anamnesis and clinical examination findings

The median duration of clinical signs in the cats included in the study was 3 days (range: 1–5 days). According to anamnesis data, all cats exhibited hematuria, stranguria, and dysuria, indicative of FLUTD. Stranguria was observed in all cats (50, 100%), while some cats (9, 18%) had both stranguria and hematuria, and the rest of the cats (41, 82%) had hematuria accompanied by stranguria.

Sex

Of the 50 cats included in the study, 28 were male (14 neutered, 14 intact), and 22 were female (13 neutered, 9 intact). In the CaOx group, 5 were male and 3 were female; in the hippuric acid group, 4 were male and 4 were female; in the uric acid group, 3 were male and 5 were female; and in the struvite group, 16 were male and 9 were female. Sex distribution of the cats is presented in Figure 1.

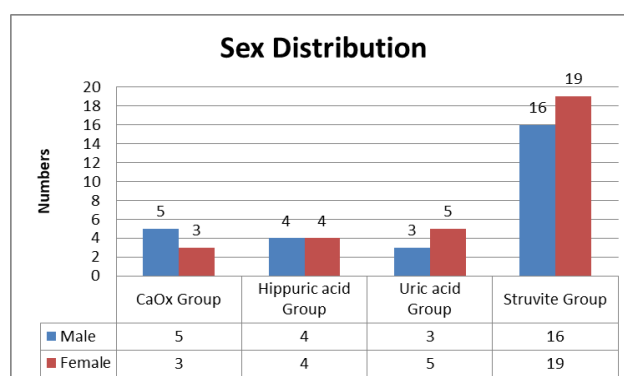


Figure 1. Sex distribution of the cats

Age

The median age of all cats included in the study was 3 (1-8) years. The median ages for each group were as follows: CaOx group, 4 (2-5.5) years; hippuric acid group, 2.5 (1-6.5) years; uric acid group, 3.25 (1-6) years; and struvite group, 3 (1-8) years. Age of the cats is presented in Figure 2.

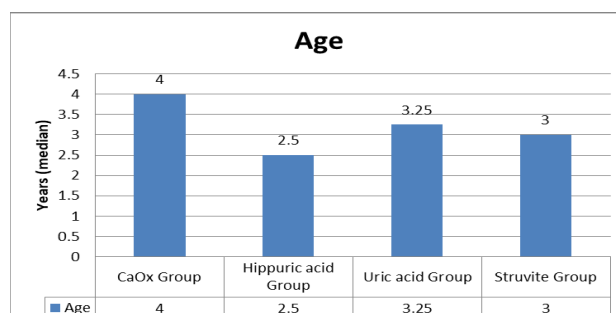


Figure 2. Age distribution of the cats

Body Weight

The median body weight of all cats included in the study was 3.75 (2.1-6) kg. The median body weights for each group were as follows: CaOx

group, 4 (2.5-5.75) kg; hippuric acid group, 3.1 (2.3-6) kg; uric acid group, 3.85 (3.2-5.6) kg; and struvite group, 3.75 (2.1-6) kg. Body weights of the cats are presented in Figure 3.

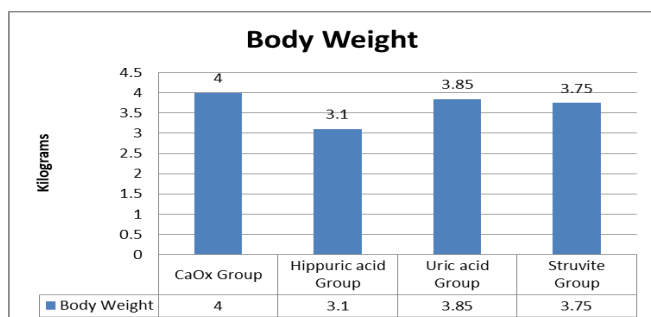


Figure 3. Body weight of the cats

Diet

Of the 50 cats included in the study, 35 were fed commercial dry food, while the remaining 15 were on a home-prepared diet. In the CaOx group, 7 cats were fed commercial dry food and 2 were on a home-prepared diet. All cats in the hippuric acid group (8 cats) were fed a home-prepared diet. In the uric acid group, 5 cats were fed commercial dry food and 3 were on a home-prepared diet. In the struvite group, 23 cats were fed commercial dry food, while 2 were on a home-prepared diet. Diets of the cats are presented in Figure 4.

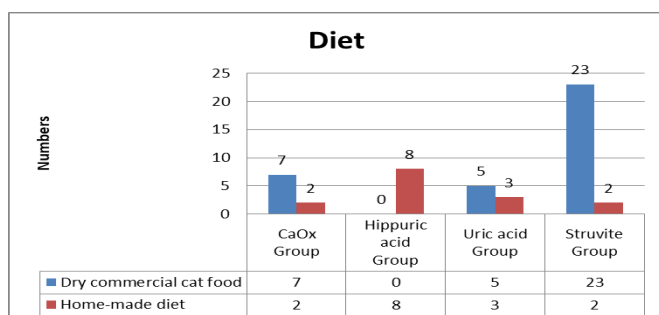


Figure 4. Diet of the cats

Breed

Among the 50 cats included in the study, 18 were Tabby, 8 were Exotic, 6 were Scottish, 1 was Persian, 10 were British, and 7 were Bombay. In the CaOx group, 2 were Tabby, 3 were Exotic, 1 was Scottish, 2 were British, and 1 was Bombay. In the hippuric acid group, 1 was Tabby, 3 were Scottish, 2 were Exotic, 1 was Bombay, and 1 was British. In the uric acid group, 3 were Tabby, 2 were Exotic, 1 was Scottish, 1 was British, and 1 was Bombay. In the struvite group, 12 were Tabby, 6 were British, 4 were Bombay, 1 was Scottish, 1 was Persian, and 1 was Exotic. Breed distribution of the cats is presented in Figure 5.

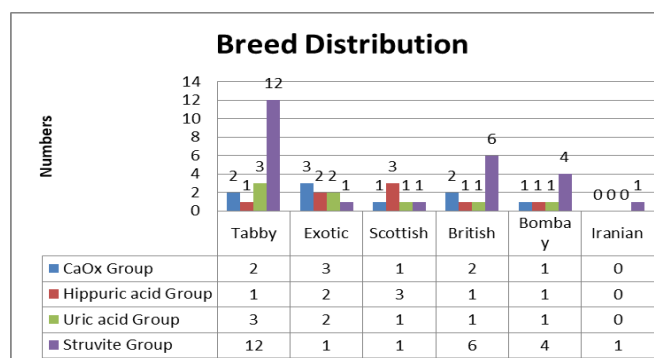


Figure 5. Breed distribution of the cats

Lifestyle

Among the 50 cats included in the study, 23 were indoor, while 27 were semi-indoor or had access to the outdoors. In the CaOx group, 6 were indoor and 3 were semi-indoor. In the hippuric acid group, 2 were indoor and 6 were semi-indoor. In the uric acid group, 3 were indoor and 5 were semi-indoor. In the struvite group, 12 were indoor and 13 were semi-indoor. Lifestyle of the cats is presented in Figure 6.

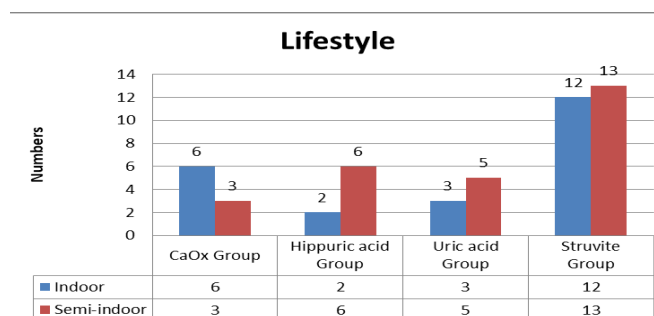


Figure 6. Lifestyle of the cats

Neuter Status

Of the 50 cats included in the study, 27 were neutered and 23 were intact. In the CaOx group, 3 cats were neutered and 6 were intact; in the hippuric acid group, 4 cats were neutered and 4 were intact; in the uric acid group, 6 cats were neutered and 2 were intact; and in the struvite group, 14 cats were neutered and 11 were intact. Neuter status of the cats is presented in Figure 7.

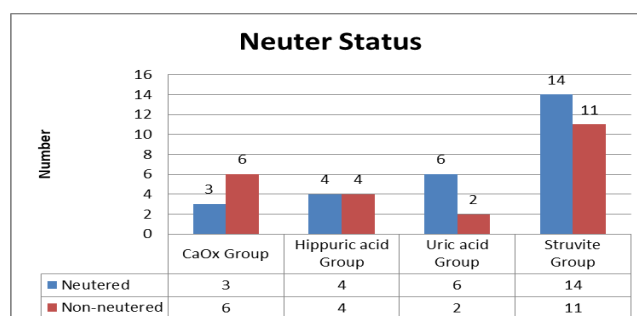


Figure 7. Neuter status of the cats

Adoption/Home-raised

Of the 50 cats included in the study, 19 were adopted from shelters or other homes, and 31 were born at home. Of the CaOx group, 3 were adopted and 6 were born at home; of the hippuric acid group, 2 were adopted and 6 were born at home; of the uric acid group, 4 were adopted and 4 were born at home; and of the struvite group, 10 were adopted and 15 were born at home. Origin of the cats is presented in Figure 8.

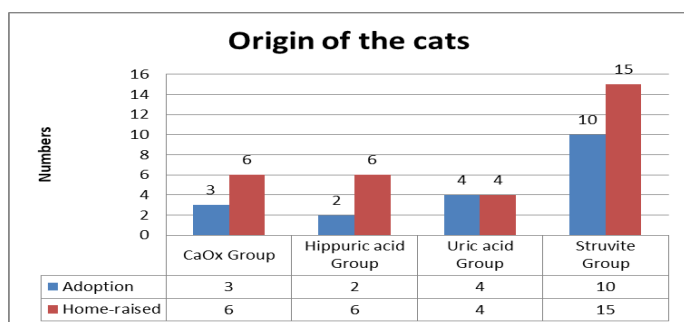


Figure 8. Origin of the cats

Breeding Status

Of the 50 cats included in the study, 10 had a history of mating, while 40 had never mated. In the CaOx group, 1 cat had mated before, and 8 had never mated. In the hippuric acid group, 1 had mated before, and 7 had never mated. In the uric acid group, 1 had mated before, and 7 had never mated. In the struvite group, 7 had mated before, and 18 had never mated. Breeding status of the cats is presented in Figure 9.

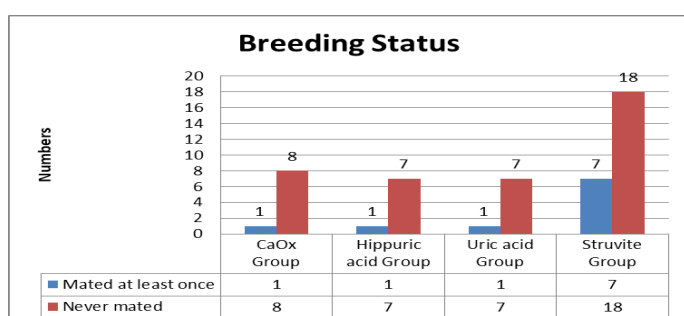


Figure 9. Breeding status of the cats

FLUTD Findings

All cats in the CaOx group exhibited periuria and stranguria, with hematuria present in 7 cats and dysuria in 2 cats. Similarly, all cats in the hippuric acid group had periuria and stranguria, accompanied by hematuria in 4 cats and dysuria in 4 cats. In the uric acid group, all cats also exhibited periuria and stranguria, with hematuria observed in 7 cats and dysuria in 1 cat. In the struvite group,

all cats had stranguria, which was accompanied by pyuria in 6 cats, periuria in 19 cats, dysuria in 2 cats, and hematuria in 23 cats. FLUTD findings of the cats are presented in Figure 10.

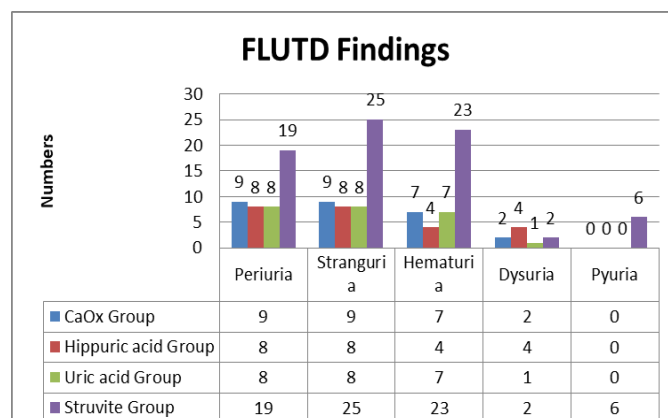


Figure 10. FLUTD findings of the cats

Urine dipstick analysis results

For all cats included in the study, the median urine pH was 6.75 (4–8.5), and the median urine specific gravity (Sg) was 1.030 (1.030–1.040). The urine pH of the CaOx group was 5 (4.5–6.5), with a urine Sg of 1.035 (1.030–1.040). In the hippuric acid group, the urine pH was 5.5 (5–6) and the urine Sg was 1.032 (1.030–1.040). The uric acid group had a urine pH of 4.25 (4–5) and a urine Sg of 1.035 (1.030–1.040). In the struvite group, the urine pH was 8 (7–8.5) and the urine Sg was 1.035 (1.030–1.040). While there was no significant difference in urine Sg levels ($p = 0.616$), urine pH levels varied significantly, with the lowest values in the CaOx group and the highest in the struvite group ($p < 0.0001$).

Discussion

Crystalluria is defined as the presence of crystals in the urine, typically resulting from the oversaturation of certain electrolytes and substances. The key factors triggering crystalluria include the accumulation of calcium oxalate, urate, and phosphate ions, which are excreted by the kidneys and exceed the urine's dissolving capacity. In the presence of crystalluria, crystals can become trapped in the matrix, leading to plug formation. While severe crystalluria can result in urethral obstruction even in the absence of a colloid matrix, it often remains subclinical or causes mild clinical signs in many cats. However, when persistent and severe, crystalluria can contribute to urolith formation, ultimately leading to urethral

obstruction and cystitis. In this study, cats with FLUTD findings were examined for crystalluria and categorized based on crystal type, with their demographic data evaluated comparatively. Struvite was identified as the most common crystal type. The cats with crystalluria were, on average, over 3 years old, had a body weight of 3.5 kg, were male, consumed commercial dry food, were of tabby breed, neutered, had never mated, and had access to the outdoors (semi-indoor). Considering these demographic characteristics could aid in identifying at-risk cats, enabling early screening and preventive measures to reduce further health complications.

Typical findings associated with FLUTD include pollakiuria, periuria, stranguria, and/or hematuria (Black, 2018). Clinical examination may reveal pain in the pelvic region and thickening of the urinary bladder wall on abdominal palpation, while other physical examination findings are usually unremarkable (Stella et al., 2011; Buffington and Chew, 2013). In cats with non-obstructive FIC that is not complicated by other diseases, serum biochemistry and CBC findings remain within normal limits. Therefore, urine analysis plays a crucial role in diagnosis. Hematuria and proteinuria are commonly detected, while pyuria or bacteriuria may be present but are not pathognomonic. The prevalence and severity of crystalluria vary; in a study of 62 cats with non-obstructive FIC, crystalluria was reported in 50% of affected cats (Kruger et al., 1991; Kruger et al., 1996). Urine in these cases is typically acidic and concentrated (Kruger et al., 1996). In the present study, when cats were categorized based on crystal type, all cats in the CaOx group exhibited periuria and stranguria, with hematuria detected in 7 cats and dysuria in 2 cats. Similarly, all cats in the hippuric acid group had periuria and stranguria, with hematuria in 4 cats and dysuria in 4 cats. In the uric acid group, periuria and stranguria were also present in all cats, accompanied by hematuria in 7 cats and dysuria in 1 cat. In contrast, all cats in the struvite group exhibited stranguria, with pyuria in 6 cats, periuria in 19 cats, dysuria in 2 cats, and hematuria in 23 cats. These variations in clinical findings may be influenced by multiple factors, including environmental temperature, neurological influences, diet, and cats' stress responses to different environments (Cannon and Alstadt, 2015).

The ideal urine pH range for cats is 6.2–6.5. When pH deviates from this range, the risk of ammonium phosphate and calcium oxalate crystal formation increases, directly contributing to crystalluria (Naarden and Corbee, 2020). In this study, the median urine pH of all cats was 6.75 (range: 4–8.5), while the median urine specific gravity (Sg) was 1.030 (range: 1.03–1.040). Urine Sg reflects the kidney's ability to concentrate or dilute urine, depending on the body's hydration status and renal function. A normal urine Sg for cats typically falls between 1.020 and 1.040. Higher values indicate concentrated urine, which is often seen in healthy cats but may also suggest dehydration or conditions that promote crystal formation. Lower values can indicate renal dysfunction or excessive water intake (Kruger et al., 1996). Consistent with previous reports, struvite crystals were associated with higher urine pH, while calcium oxalate and uric acid crystals were linked to more acidic urine (Buffington and Chew, 2013). In the CaOx group, urine pH was 5 (4.5–6.5) and urine Sg was 1.035 (1.030–1.040). In the hippuric acid group, urine pH was 5.5 (5–6) and urine Sg was 1.032 (1.030–1.040). In the uric acid group, urine pH was 4.25 (4–5) and urine Sg was 1.035 (1.030–1.040). In the struvite group, urine pH was 8 (7–8.5) and urine Sg was 1.035 (1.030–1.040). While no statistically significant difference was observed in urine Sg levels ($p > 0.616$), urine pH was significantly lower in the CaOx group and highest in the struvite group ($p < 0.0001$). These findings highlight the critical role of urine pH and Sg in crystalluria. Maintaining an appropriate dietary regimen can help regulate urine composition, reducing the risk of urolithiasis and crystal formation. Since urine Sg indicates urine concentration, monitoring this parameter alongside pH can provide valuable insights into hydration status and metabolic health. Dietary and fluid intake adjustments should be key considerations for cats at risk (Westropp et al., 2019).

Non-obstructive FLUTD affects male and female cats equally, although the risk is higher in neutered animals. Non-obstructive FIC is most commonly observed in cats aged 2–6 years that have lived exclusively indoors and have been fed dry food. Comorbid metabolic diseases, such as obesity, are also associated with FIC (Buffington, 2011; Chew and Buffington, 2013). Relapses occur in 17.1–65% of cats with FIC, and the incidence of relapse

decreases with increasing age (Kruger et al., 2003; Kaul et al., 2019). In the present study, the median age of all cats included was 3 years (range: 1–8). The median age of the CaOx group was 4 years (2–5.5), the hippuric acid group was 2.5 years (1–6.5), the uric acid group was 3.25 years (1–6), and the struvite group was 3 years (1–8). Additionally, the median body weight of all cats was 3.75 kg (2.1–6). The median body weight of the CaOx group was 4 kg (2.5–5.75), the hippuric acid group was 3.1 kg (2.3–6), the uric acid group was 3.85 kg (3.2–5.6), and the struvite group was 3.75 kg (2.1–6). Although the mean ages of the cats in this study were consistent with previous reports, none of the cats were clinically overweight or obese. However, at ages and body weights where the incidence of FLUTD increases (Kaul et al., 2019), performing at least urine dipstick and urine sediment examinations in cats with similar demographic characteristics may help prevent further complications. These diagnostic tools offer the advantages of being cost-effective and providing rapid results, allowing for the timely initiation of treatment and management programs (Buffington, 2011).

The urine volume of cats fed exclusively dry food is 40% lower than that of cats fed only wet food. Reduced urine volume may lead to increased urine concentration, which can aggravate urothelial damage. As a result, neurogenic inflammation begins, accompanied by crystalluria (Kruger et al., 2015). In this study, the median urine pH of all cats was 6.75 (range: 4–8.5), and the median urine Sg was 1.030 (range: 1.03–1.040). Additionally, it was determined that 35 out of 50 cats were fed commercial dry food, while the remaining 15 were fed a home-prepared diet. In the CaOx group, 7 cats were fed commercial dry food and 2 were fed a home-prepared diet. In the hippuric acid group, all 8 cats were fed a home-prepared diet. In the uric acid group, 5 cats were fed commercial dry food and 3 were fed a home-prepared diet. In the struvite group, 23 cats were fed commercial dry food, while 2 were fed a home-prepared diet. These findings can be explained by the low urine volume observed in cats fed only commercial dry food and the urothelial damage, inflammation, and crystalluria that may result from the concentrated urine produced under these conditions (Kruger et al., 2003; Kruger et al., 2015; Kaul et al., 2019). Moreover, due to the variability and unmonitored nature of home-prepared diets in semi-indoor cats, dietary intake could not be precisely assessed (Kruger et al., 2015). Moreover, these findings

align with the understanding that a major cause of FLUTD is a homogeneous diet, an imbalance in the calcium-phosphorus ratio, and excessive magnesium intake, all of which contribute to urine crystallization (Lekcharoensuk et al., 2001).

Although cats with FLUTD may not exhibit detectable clinical signs, underlying abnormalities can affect urothelial integrity, bladder permeability, glycosaminoglycan secretion, adrenal function, and the central nervous system. There may be no direct correlation between clinical findings, cystoscopic bladder appearance, and histological changes. Histopathological findings often include urothelial damage, submucosal hemorrhage and edema, submucosal vasodilation with marginal neutrophils, increased mast cell infiltration, fibrosis, and an elevated sensory nerve fiber count (Buffington and Chew, 2017). FLUTD encompasses various conditions affecting the bladder and urethra in cats, with the type of urinary crystals playing a significant role in clinical presentation and disease severity. Unlike calcium oxalate uroliths, struvite stones can often be dissolved through dietary management, making early detection particularly beneficial. Struvite crystalluria can lead to urolith formation, causing frequent urination, straining to urinate, hematuria, and inappropriate urination outside the litter box. In severe cases, particularly in male cats, urethral obstruction may develop, requiring immediate veterinary intervention (Piyarungsri et al., 2020). Calcium oxalate crystals generally form in acidic to neutral urine and are not directly linked to dietary magnesium levels. These crystals can aggregate into uroliths, producing clinical signs similar to struvite stones, including hematuria, dysuria, and potential urinary obstruction. Unlike struvite stones, calcium oxalate uroliths do not dissolve with dietary management and typically require surgical removal (Lund et al., 2013). Ammonium urate crystals, though less common, may develop in cats with metabolic disorders or liver diseases. These crystals contribute to urolith formation, leading to hematuria and dysuria. Diagnosis and treatment generally involve addressing the underlying condition predisposing the cat to ammonium urate crystalluria (Defauw et al., 2011). Beyond toxicological contexts, hippuric acid crystals are rarely observed in feline urine. Their formation is influenced by dietary factors, particularly the ingestion of substances metabolized into benzoic acid, which conjugates with glycine to form hippuric acid. However, as typical feline diets contain minimal amounts of these precursors, hippuric acid crystalluria remains uncommon in healthy cats (Kramer et al., 1984). In summary, urinary crystal type significantly

influences the clinical manifestations of FLUTD. Identifying the specific crystal type is essential for selecting an appropriate treatment strategy, which may involve dietary modifications, increased water intake, medications, or surgical intervention. The crystalluria patterns observed in this study, except for hippuric acid crystals, align with previously reported predisposing factors. The presence of hippuric acid crystals in this study may be attributed to dietary variation. These findings highlight the importance of regular veterinary check-ups and urinalysis for early crystalluria detection and management, ultimately reducing the risk of severe urinary tract complications in the feline population of the region (Dorsch et al., 2014).

In this study, 50 owned cats presented to the Harran University Veterinary Faculty Animal Hospital between March 2024 and January 2025 with clinical signs suggestive of FLUTD were systematically evaluated through comprehensive physical and laboratory examinations, with a primary focus on crystalluria. Struvite was the most frequently detected crystal type (n = 25), followed by calcium oxalate (CaOx, n = 9), hippuric acid (n = 8), and uric acid (n = 8). Demographic analysis indicated that cats with crystalluria were predominantly male, neutered, tabby, and three years of age or older, with an average body weight of 3.5 kg. Most were fed commercial dry food, had never mated, and exhibited a semi-indoor lifestyle. The association between crystalluria and these demographic factors reinforces the influence of diet and environmental conditions on urinary health in cats. Given the potential for crystalluria to progress to more severe complications, such as urethral obstruction, early identification and targeted interventions—including dietary modifications and routine urinalysis—are essential for effective management. These findings highlight the need for further research into the role of dietary composition, hydration strategies, and lifestyle factors in the pathophysiology and prevention of feline lower urinary tract disorders.

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