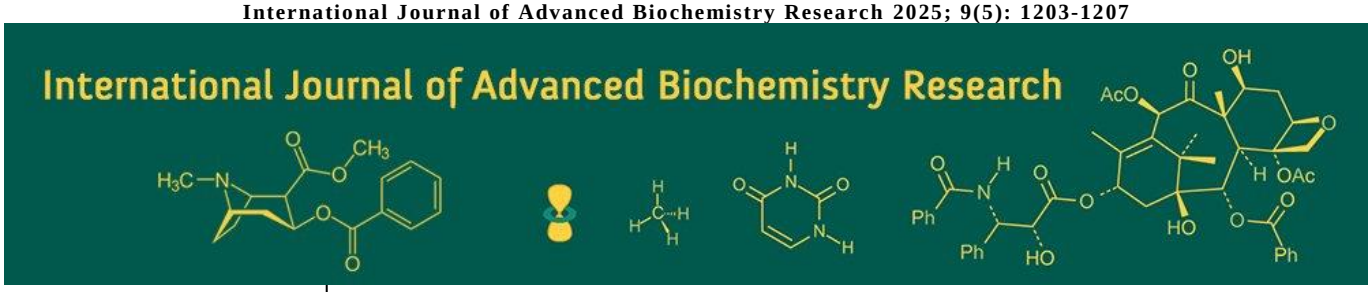

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Biochemical and ultrasonographic evaluation of urethral obstruction induced hydronephrosis in male cats

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Abstract
Hydronephrosis, which results from urethral blockage, is a critical and potentially fatal condition in cats that requires immediate diagnosis and treatment. This study aimed to establish a relationship between the severity of hydronephrosis and changes in the important serum biochemical indicators blood urea nitrogen (BUN) and creatinine as well as describing the ultrasonographic characteristic of different grades of the condition. Seven male cats with confirmed urethral obstruction were comprehensively evaluated through a clinical examination, serum biochemistry and abdominal ultrasonography. The results indicated a statistically significant rise in both BUN and creatinine levels with the progression of hydronephrosis. Mean±SE BUN levels were 43.14±3.65 mg/dL for mild cases, increasing to 68.58±2.99 mg/dL for moderate cases and and reaching a high of 99.75±12.56 mg/dL for severe cases. Similarly, mean creatinine levels were 2.49±0.10 mg/dL, 3.78±0.31 mg/dL and 6.02±0.21 mg/dL for the respective grades. A strongly positive correlation was established between the hydronephrosis grades and biochemical markers. Ultrasonography proved to be an essential tool for precise grading of the renal pathology, revealing a clear progression of renal pelvic dilation and parenchymal thinning as the disease progressed. This study highlights the importance of a comprehensive diagnostic approach that combines biochemical analysis and imaging for the early detection, accurate grading and timely management of hydronephrosis in cats with urethral obstruction, ultimately leading to improved recovery and prognosis.

Keywords: Hydronephrosis, urethral obstruction, cats, blood urea nitrogen (BUN), creatinine and ultrasonography

Introduction
Feline lower urinary tract disease includes a variety of conditions affecting the bladder and urethra with urethral obstruction being a frequently encountered emergency, particularly in male cats due to their naturally narrow urethral passage (Beiter, 2016; George and Grauer, 2016) [3, 7]. This blockage causes a rapid increase in pressure within the urinary tract, which has a significant impact on kidney function. Persistent elevated pressure can cause retrograde dilation of the renal pelvis and calyces, a condition known as hydronephrosis (Rieser, 2005) [11]. If not addressed in time, this condition can lead to irreversible renal damage, characterized by tubular atrophy and interstitial fibrosis, ultimately resulting in either acute or chronic kidney disease (Abdel-Saeed *et al.*, 2021) [1]. The physiological consequences are both rapid and severe. Impaired urine flow compromises the glomerular filtration rate, leading to an accumulation of nitrogenous waste products in the blood. Elevated levels of blood urea nitrogen (BUN) and creatinine, known as azotemia, serve as key indicators of renal dysfunction in obstructed cats (George and Grauer, 2016) [7]. The degree of azotemia typically reflects the duration and intensity of the obstruction. In addition to biochemical alterations, prolonged obstruction also leads to distinct structural changes in the kidney. Initially, there is only minimal pelvic dilation, but as the pressure increases, the renal parenchyma begins to thin (Udainiya *et al.*, 2018) [15]. Ultrasonography is a highly effective, non-invasive diagnostic method for visualizing these progressive changes. It facilitates the evaluation of renal architecture and pelvic dilation, enabling accurate grading of hydronephrosis severity (Saranya *et al.*, 2025) [13].

This visual assessment complements biochemical findings and provides a complete view of the renal damage. While the individual diagnostic roles of biochemical markers and ultrasonography are well-established, their combined utility requires further investigation. The present study aimed to establish a correlation between serum BUN and creatinine levels and the ultrasonographic grading of hydronephrosis in male cats with urethral obstruction. By integrating these diagnostic approaches, it sought to enhance the understanding of disease progression and improve diagnostic protocols for more effective patient management.

Materials and Methods

Case Selection

Seven male pet cats (n = 7) showing clinical signs of urethral obstruction were presented to the Veterinary Clinical Complex, College of Veterinary Sciences, SVPUA&T, Meerut and included in this study. Clinical signs observed were stranguria, anuria, pollakiuria, hematuria and abdominal discomfort. Inclusion was based on physical examination findings of a distended, non-expressible bladder and failure to pass a urethral catheter.

Clinical Examination

A standardized clinical evaluation was performed on each cat, which involved a detailed history and physical examination. Vital parameters such as rectal temperature, heart rate, respiratory rate, mucous membrane color and capillary refill time were measured to assess the hydration and perfusion status of the cat. Abdominal palpation was conducted to determine the size, firmness and pain response of the urinary bladder.

Biochemical Analysis

Blood samples were collected aseptically from each cat following the clinical examination and prior to any therapeutic intervention. Immediately following collection, the samples were centrifuged to separate the serum for further analysis. Serum blood urea nitrogen (BUN) and creatinine levels were measured using an automated biochemistry analyzer as per the standard operational protocols. The results were carefully documented for comparison across the different ultrasonographic grades of hydronephrosis.

Ultrasonographic Evaluation

Abdominal ultrasonography was performed on all cats using an ultrasound machine equipped with a high-frequency linear transducer to assess renal structure and detect hydronephrosis. The cats were placed in dorsal recumbency and the ventral abdomen was clipped and prepared with coupling gel. Both kidneys were systematically scanned following established protocols. Hydronephrosis was classified into three grades using a modified ultrasonographic system based on renal pelvic dilation and parenchymal changes (Nyland *et al.*, 1995; Barr and Gaschen, 2011) [9, 2]:

Grade 1 (Mild): Characterized by slight renal pelvic dilation with preserved parenchymal thickness and a near-normal corticomedullary definition.

Grade 2 (Moderate): Involves more pronounced pelvic dilation accompanied by reduced corticomedullary distinction and mild to moderate thinning of the renal parenchyma.

Grade 3 (Severe): Exhibited extensive dilation of both the renal pelvis and calyces leading to severe cortical thinning, a loss of corticomedullary architecture and significant distortion of the shape of the kidneys.

All ultrasonographic examinations were performed by a single experienced veterinary radiologist to maintain consistency and reduce inter-observer variability.

Results

Clinical Presentation

The clinical presentation of all seven cats was consistent with classical signs of urethral obstruction, including significant stranguria, vocalization and a palpable, firm and painful urinary bladder. Owners reported anuria in every case with the duration ranging from 12 to 48 hours before presentation. Several cats also displayed signs of systemic illness such as lethargy, anorexia and vomiting, particularly those with higher grades of hydronephrosis. Dehydration was apparent in several cases, based on a prolonged capillary refill time and reduced skin turgor.

Biochemical findings

Biochemical analysis revealed an evident correlation between the severity of hydronephrosis and changes in biochemical markers. Serum BUN and creatinine levels consistently increased in parallel with advancing grades of hydronephrosis. For mild hydronephrosis cases (n=2), the mean BUN was 43.14±3.65 mg/dL and the mean creatinine was 2.49±0.10 mg/dL. Moderate hydronephrosis (n=3) showed a significant increase in values with a mean BUN of 68.58±2.99 mg/dL and mean creatinine of 3.78±0.31 mg/dL. The most substantial elevations were noted in the severe hydronephrosis cases (n=2), where the mean BUN reached 99.75±12.56 mg/dL and creatinine averaged 6.02±0.21 mg/dL. These findings were further supported by individual case data such as the highest values recorded in a cat with severe hydronephrosis (S.N. 7), with BUN at 112.32 mg/dL and creatinine at 6.24 mg/dL. The overall mean for all seven cases was BUN 70.22±9.27 mg/dL and creatinine 4.05±0.56 mg/dL.

Ultrasonographic Findings

Ultrasonographic evaluation consistently confirmed the presence of hydronephrosis in all the cats with varying degrees of severity that corresponded to the established grading system:

Grade 1 (Mild Hydronephrosis, n=2): Cats S.No. 1 and 2 showed a slight dilation of the renal pelvis. As depicted in Figure 1 (a), their corticomedullary definition was well-preserved, parenchymal thickness appeared normal and renal size remained within normal limits.

Grade 2 (Moderate Hydronephrosis, n=3): As seen in Figure 1 (b), cats S.No. 3, 4 and 5 demonstrated more pronounced pelvic dilation. This was accompanied by a partial loss of corticomedullary distinction and mild to moderate thinning of the renal parenchyma. The kidneys appeared mildly enlarged with early signs of architectural distortion.

Grade 3 (Severe Hydronephrosis, n=2): Cats S.No. 6 and 7 exhibited extensive pelvic and calyceal dilation, forming large, anechoic, fluid-filled structures. Figure 1 (c) clearly shows this grade, where the renal cortex was severely thinned. The corticomedullary architecture was nearly absent and the kidneys were markedly enlarged and structurally deformed.

Collectively, these data strongly indicate that the degree of biochemical alteration is directly related to the ultrasonographic grade of hydronephrosis.

Discussion

Feline urethral obstruction is a medical emergency that precipitates a cascade of events leading to severe renal dysfunction (Beiter, 2016) [3]. This study offers powerful evidence of a strong positive correlation between the ultrasonographic grade of hydronephrosis and the severity of biochemical derangements, specifically elevated BUN and creatinine levels, in the affected cats. These findings emphasize the fundamental relationship between structural damage to the kidneys and the functional impairment that defines post-renal azotemia.

The pathophysiology of hydronephrosis is characterized by a significant elevation in intraluminal pressure, which is transmitted to the renal pelvis, opposing glomerular filtration pressure and resulting in a rapid reduction in glomerular filtration rate (Rieser, 2005) [11]. As a result, the capacity of kidney to excrete metabolic waste products is severely hampered causing them to accumulate in the blood (George and Grauer, 2016) [7]. Our observation of a progressive increase in BUN and creatinine levels across the grades of hydronephrosis aligns perfectly with this established physiological model, a pattern consistently documented in both experimental and clinical studies of obstructive nephropathy (Boancă *et al.*, 2024; George and Grauer, 2016) [4, 7].

An important finding in our study is that even cats with mild hydronephrosis exhibited measurable elevations in biochemical markers (mean BUN 43.14±3.65 mg/dL, creatinine 2.49±0.10 mg/dL). This finding highlights that even subtle urinary outflow obstruction can initiate functional compromise, emphasizing the necessity of rapid diagnosis and intervention (Saranya *et al.*, 2025) [13]. If left untreated, this early compromise can quickly progress to severe azotemia and uremia as shown by the high mean BUN (99.75±12.56 mg/dL) and creatinine (6.02±0.21 mg/dL) values in our severely affected cats, which are characteristic of an acute uremic crisis often encountered in emergency due to delayed owner recognition or presentation (Rieser, 2005) [11].

These findings have significant clinical implications. In a clinical practice, a cat suspected of urethral obstruction should undergo immediate biochemical analysis for BUN and creatinine, ideally in conjunction with an abdominal ultrasonographic examination. This combined diagnostic approach permits a quick and accurate evaluation of the impact of obstruction on both the renal function and structure, which is essential for guiding treatment decisions. For example, cats with mild-to-moderate hydronephrosis and corresponding biochemical changes may have a better prognosis for full renal recovery after successful de-obstruction compared to those with severe, long-standing hydronephrosis and profound azotemia (Boancă *et al.*, 2024; Saha, 2023) [4, 12].

Ultrasonography proved to be an crucial, non-invasive diagnostic tool in this study, facilitating the accurate grading of hydronephrosis based on specific morphological criteria. The observed progression, from slight pelvic dilation in mild cases to extensive dilation with severe cortical thinning and loss of corticomedullary differentiation in severe cases, is consistent with the disease progression of obstructive nephropathy (Abdel-Saeed *et al.*, 2021; Udainiya *et al.*, 2018) [1, 15]. The ability of ultrasonography to directly visualize these architectural distortions makes it a superior method for assessing the anatomical extent of renal damage compared to biochemical markers alone that only reflect overall glomerular filtration rate. Therefore, an integrated approach combining both modalities offers the most comprehensive diagnostic picture.

The strong correlation between biochemical markers and ultrasonographic findings demonstrates a clear association between structural kidney damage and functional compromise. As the structural pathology in the kidney progresses, the corresponding functional impairment as indicated by the biochemical markers also intensifies. This has significant clinical relevance, suggesting that even subtle ultrasonographic changes in the renal pelvis should prompt a thorough evaluation of renal function, even if biochemical parameters are only mildly elevated. The early detection of these changes is crucial for enabling timely intervention before permanent damage occurs.

Despite the valuable insights gained, certain limitations of this study must be acknowledged. The primary limitation is the small sample size (n=7), which, while demonstrating strong correlations, restricts the generalizability of the findings and the limits the ability to draw statistically significant conclusions. A larger cohort would enable more valid comparisons between groups and potentially uncover more subtle associations. The design of this study was also cross-sectional, assessing cats at a single point in time. Long-term, prospective studies monitoring biochemical and ultrasonographic parameters after deobstruction would provide valuable insights on the reversibility of hydronephrosis and renal outcomes.

Although these limitations exist, the consistent and strong correlations observed in this study reinforce the need for a multi-modal diagnostic approach (Drobatz *et al.*, 2003) [6]. Future research should prioritize larger prospective studies and the exploration of novel biomarkers such as the renal resistive index via Doppler ultrasonography, to gain further insight into renal perfusion changes associated with hydronephrosis (Segev *et al.*, 2011; Langston *et al.*, 2003) [14, 8]. The early identification and prompt management of urethral obstruction are essential for preventing irreversible renal damage and improving patient quality of life (Cooper and Forrester, 2019; Osborne *et al.*, 2011) [5, 10].

Table 1: Case wise grading of hydronephrosis and their biochemical parameters

S.N.	Grade of hydronephrosis	BUN (mg/dL)	CRE (mg/dL)
1.	Mild	46.80	2.60
2.	Mild	39.49	2.39
3.	Moderate	67.51	3.98
4.	Moderate	64.02	3.16
5.	Moderate	74.23	4.21
6.	Severe	87.19	5.81
7.	severe	112.32	6.24
Mean ± SE		70.22 ± 9.27	4.05 ±0.56

Table 2: Mean ± SE of BUN and creatinine across different grades of hydronephrosis

S.N.	Grade of hydronephrosis	Mean BUN (mg/dL) ± SE	Mean Creatinine (mg/dL) ± SE
1.	Mild (n=2)	43.14 ± 3.65	2.49± 0.10
2.	Moderate (n=3)	68.58 ± 2.99	3.78 ± 0.31
3.	Severe (n=2)	99.75 ± 12.56	6.02 ± 0.21

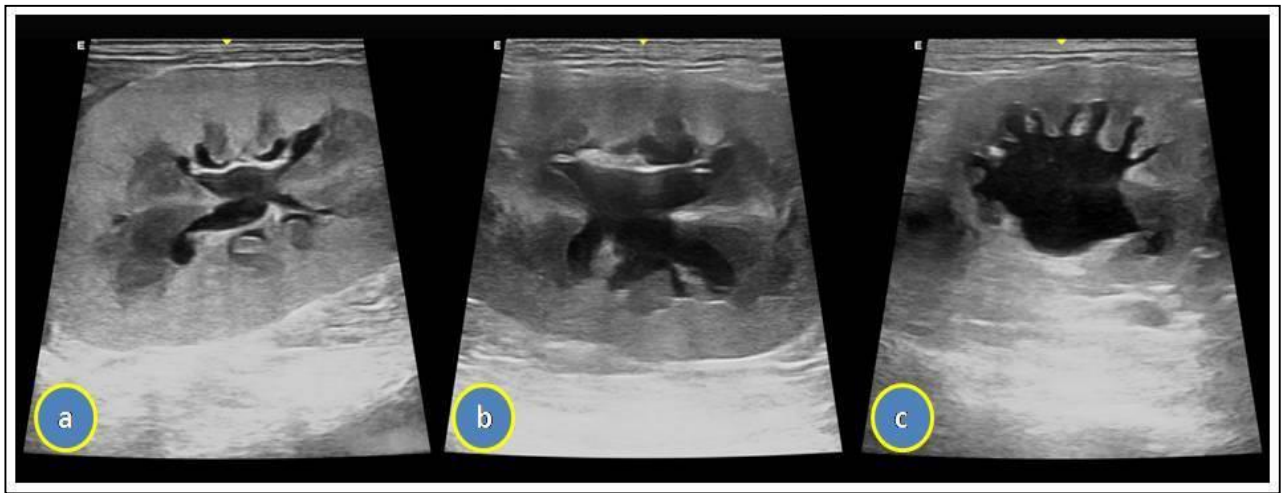

Fig 1: Ultrasonographic images showing different grades of hydronephrosis in cats: (a) mild, (b) moderate and (c) severe hydronephrosis

Conclusion

This study successfully establishes a clear and statistically significant association between the severity of serum biochemical alterations, specifically elevated BUN and creatinine concentrations and the ultrasonographically assessed grade of hydronephrosis in cats with urethral obstruction. The combined use of serum BUN and creatinine levels with ultrasonographic evaluation offers a highly reliable and comprehensive diagnostic protocol for accurately grading hydronephrosis and assessing the extent of renal damage. The findings emphasize that even mild hydronephrosis is associated with detectable biochemical changes, highlighting the critical importance of early diagnosis and prompt clinical response. This integrated diagnostic strategy is essential for guiding timely management, potentially reversing renal damage and ultimately improving the clinical outcomes and long-term prognosis for cats suffering from hydronephrosis induced by urethral obstruction.

Conflict of interest: None.

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Authors Contribution

Ajit Kumar Singh, V.K. Varun, and M.V. Jithin were involved in the conceptualization and writing of the manuscript. Sagar Chaudhary and Harshita contributed to sample and data collection. Data analysis and final editing were carried out by Ajit Kumar Singh, V.K. Varun, M.V. Jithin and T.K. Sarkar.

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