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Correlating Degree of Hydronephrosis on Ultrasound with Ureteric Calculus Size on Computed Tomography.

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KEYWORDS

type 1 diabetes mellitus, hyperglycemia, oxidative stress, exfoliative cytology, buccal mucosa

ABSTRACT:

AIM & OBJECTIVE: To correlate the degree of hydroureteronephrosis on ultrasound with ureteric stone size determined by non-contrast CT.

MATERIALS AND METHODS: This is a prospective study which was done in the period between Jan 2024 and December 2024 using 'Samsung HS70A' & 'Toshiba Aquilion prime160 slice' CT scanner. All patients with hydronephrosis secondary to ureteric calculus in ultrasound and CT underwent screening CT and USG respectively with proper consent. Hydronephrosis severity was graded on ultrasound and stone size was categorized as ≤5 mm or >5 mm based on CT.

RESULTS: Among the 112 patients, 86 had stones ≤5 mm and 26 had stones >5 mm. Increasing degree of hydronephrosis on ultrasound was associated with an increasing proportion of ureteral calculi larger than 5 mm ($P < .001$). Patients with none or mild hydronephrosis were less likely to have larger ureteral calculi than those with moderate or severe hydronephrosis (12.4% vs 35.4%; $P < .001$). An increasing degree of hydronephrosis was associated with a higher likelihood of larger stones.

CONCLUSION: There was statistically significant correlation between the degree of ultrasound detected hydronephrosis and the size of the obstructing ureteric calculus. Patients with less severe hydronephrosis are less likely to have stones >5 mm. Thus, ultrasound may help identify low-risk patients and guide imaging decisions, potentially reducing unnecessary CT scans and radiation.

INTRODUCTION

Urolithiasis, the formation of urinary tract stones, is a global health issue with a lifetime prevalence of 5%–12%, influenced by geographic and demographic factors. Ureteric calculi are a major cause of acute flank pain and require prompt diagnosis to prevent complications like infection, obstruction, and renal damage, especially when urine outflow is blocked, causing hydronephrosis [1,2]

Ultrasound (USG) is widely used as the initial imaging tool due to its safety, cost-effectiveness, and accessibility, particularly in children and pregnant women.

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Hydronephrosis, seen as renal pelvis and calyceal dilation on USG, is a key indicator of ureteric obstruction. While routinely graded as mild, moderate, or severe, this grading remains subjective [3,4].

A positive correlation exists between stone size and hydronephrosis. Larger stones typically cause more severe obstruction and greater hydronephrosis. Song et al. (2015) reported hydronephrosis in over 89% of 248 patients with ureteric stones, with stone size significantly predicting its degree [5]. Iwahashi et al. (2024) found that hydronephrosis area measurements were more predictive of stone impaction than traditional grading [6].

Although USG being less sensitive in detecting stones than CT, it effectively evaluates hydronephrosis. Leo et al. (2017) showed that USG-detected hydronephrosis had an 88% positive predictive value for stones >5 mm and an 89% negative predictive value when absent [7]. Hydronephrosis severity has also been linked with pain intensity in renal colic, reinforcing its diagnostic value [8].

Other studies support hydronephrosis as a proxy for stone burden. Özbir et al. (2019) developed a predictive model using hydronephrosis grade, ureteral wall thickness, and Hounsfield units [9]. Ucar and Kurugoglu (2020) highlighted the use of Doppler USG and renal resistive index in distinguishing non-obstructive from obstructive hydronephrosis [10].

However, hydronephrosis is absent in 10%–15% of patients with symptomatic stones, particularly in early or partial obstruction, limiting its diagnostic reliability when used alone [5,11]. Thus, understanding the contexts in which hydronephrosis reflects stone size is essential.

Advancements in ultrasonography, such as renal pelvis diameter and area quantification, offer improved diagnostic precision. Quantitative assessment of hydronephrosis may surpass traditional grading in predicting stone impaction and guiding treatment [6].

This study aims to correlate ultrasound-detected hydronephrosis degree with ureteric stone size to enhance non-invasive diagnostic accuracy, reduce unnecessary CT use and improve clinical decision-making in ureteric stone treatment.

MATERIALS AND METHODS

This **prospective observational study** was conducted in the Department of Radiology at Meenakshi Academy of Higher Education & Research, Kanchipuram, between January 2024 and December 2024.

Study Population

All adult patients (≥18 years) presenting with hydronephrosis secondary to ureteric calculus confirmed on both ultrasound and NCCT were eligible. Patients with known structural renal anomalies, non-obstructive hydronephrosis, or multiple ureteric calculi were excluded to maintain diagnostic clarity. **A total of 112 patients** were included in the study after obtaining Informed consent.

Imaging Protocol

Ultrasound examinations were performed using the *Samsung HS70A* ultrasound system, while NCCT imaging was conducted with the *Toshiba Aquilion Prime 160-slice* CT scanner. Renal ultrasound was used to assess and grade hydronephrosis as **mild, moderate, or severe** based on the standard sonographic definitions:

- **Mild**: Pelvicalyceal system dilation without loss of papillary impressions.
- **Moderate**: Rounded calyces with partial obliteration of papillae.
- **Severe**: Ballooning of calyces with cortical thinning.

NCCT was considered the gold standard for stone measurement. Stone size was recorded as the maximum axial dimension and categorized into two groups: ≤5 mm and >5 mm. This cutoff was selected based on the established threshold for spontaneous passage likelihood, as supported in prior literature.

Data Collection and Analysis

All imaging assessments were independently reviewed by two experienced radiologists to reduce interobserver variability. Discrepancies in grading were resolved by consensus. Demographic data, degree of hydronephrosis, and stone dimensions were recorded.

Data were surveyed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY). Categorical variables, including hydronephrosis grade

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and stone size (≤5 mm or >5 mm), were summarized using frequencies and percentages. The correlation between the degree of hydronephrosis and stone size was assessed using the **Chi-square test**, and **$p < 0.05$** was considered statistically significant. The strength of correlation between hydronephrosis grade and stone size was further evaluated using **Kendall's Tau B** correlation coefficient.

RESULTS

A total of 112 patients diagnosed with ureteric calculi were included in this prospective observational study. Men dominated in presentation, accounting for 74 (66%) of the cases. Considering age, males (Mean = 47.2, SD = 2.8) and females (Mean = 49.6, SD = 4.2) were comparable. Based on non-contrast computed tomography (NCCT), the majority of the stones measured ≤5 mm (n = 86, 76.8%), while the remaining 26 patients (23.2%) had calculi >5 mm (**Figure 1**).

Distribution of Hydronephrosis

Ultrasound examination was used to assess the degree of hydronephrosis. Of the 112 patients, 17 (15.2%) showed no hydronephrosis, 62 (55.4%) had mild hydronephrosis, 26 (23.2%) exhibited moderate hydronephrosis, and 7 (6.3%) had severe hydronephrosis (**Figure 2**). The findings suggest that mild hydronephrosis was the most common presentation in this cohort.

Association Between Hydronephrosis and Stone Size

The relationship between the grade of hydronephrosis and ureteric calculus size was examined using a contingency table (**Table 1**). Among the 17 patients without hydronephrosis, all had stones measuring ≤5 mm (100%). In the mild hydronephrosis group, 61 patients (98.4%) had stones ≤5 mm, and only 1 patient (1.6%) had a stone >5 mm.

In contrast, among the 26 patients with moderate hydronephrosis, 19 (73.1%) had stones >5 mm, while only 7 (26.9%) had stones ≤5 mm. Severe hydronephrosis showed the highest association with large stones; 6 out of 7 patients (85.7%) had calculi >5 mm, and only 1 patient (14.3%) had a stone ≤5 mm.

A Chi-square test was performed to assess the statistical association between hydronephrosis severity and stone size. The result was highly significant ($\chi^2 = 72.97$, degrees of freedom = 3, $p < 0.001$), indicating a strong correlation between the degree of hydronephrosis and the likelihood of having a larger ureteric stone.

Correlation Analysis

To further explore the relationship between hydronephrosis and stone size, Kendall's Tau B correlation coefficient was calculated (**Table 2**). A statistically significant and strong positive correlation was observed (**Kendall's Tau B = 0.676, $p < 0.001$**), suggesting that an increase in hydronephrosis grade is positively correlated with an increase in stone size. This implies that more severe hydronephrosis on ultrasound is a reliable indicator of larger ureteric calculi.

Figure 1: Distribution of Ureteric Calculi Size (n = 112)

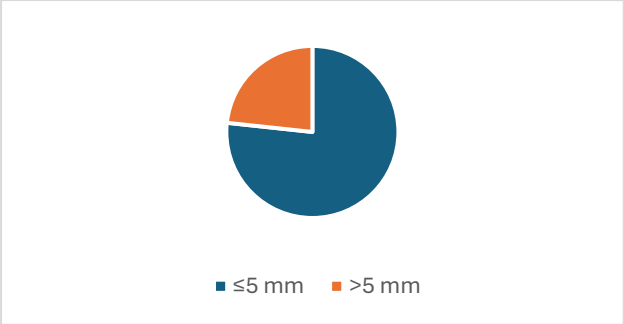

Figure 2: Distribution of degree of hydronephrosis (n = 112)

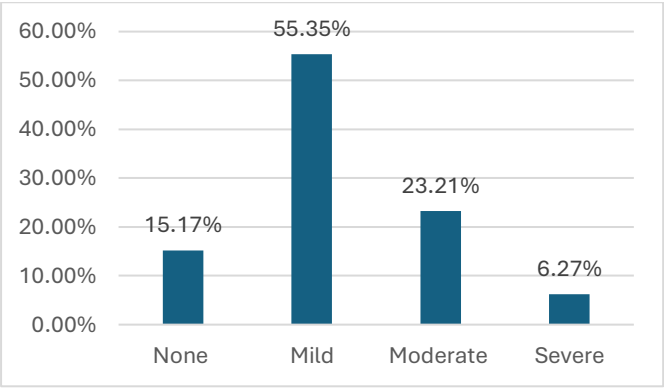

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Table 1: Association between degree of hydronephrosis & Ureteric Calculi Size (n = 112)

Degree of hydronephrosis	Ureteric Calculi Size		n
	≤5 mm	>5 mm	
None	17 (100%)	0	17 (100%)
Mild	61 (98%)	1 (2%)	62 (100%)
Moderate	7 (26%)	19 (73%)	26 (100%)
Severe	1 (15%)	6 (85%)	7 (100%)
Total	86 (77%)	26 (33%)	112 (100%)

Chi-square value (χ^2): 72.97, **Degrees of freedom (df):** 3, **p value** = < 0.001 (highly statistically significant)

Table 2: Correlation between degree of hydronephrosis & Ureteric Calculi Size (n = 112)

Correlation matrix – Kendall's Tau B	Ureteric Calculi Size	Hydronephrosis
Ureteric Calculi Size	-	**Kendall's Tau B** = 0.676 **p** = < 0.001
Hydronephrosis	**Kendall's Tau B** = 0.676 **p** = < 0.001	-

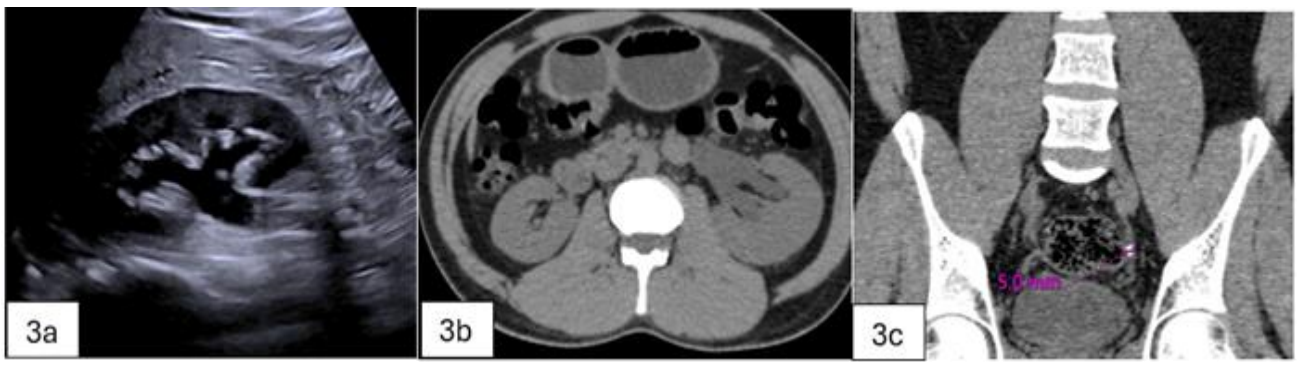

Figure 3: a) Ultrasound B mode image of left kidney shows mild dilatation of pelvicalyceal system and proximal ureter, suggesting mild hydroureteronephrosis. Axial non-contrast CT image at renal level and Coronal CT image of lower abdomen showing mild hydroureteronephrosis consistent with USG findings(b) and a small, hyperdense calculus measuring 5.0 mm in the left distal ureter near the vesicoureteral junction (VUJ) (c) respectively. The stone size suggests a reasonable chance of spontaneous passage with conservative management.

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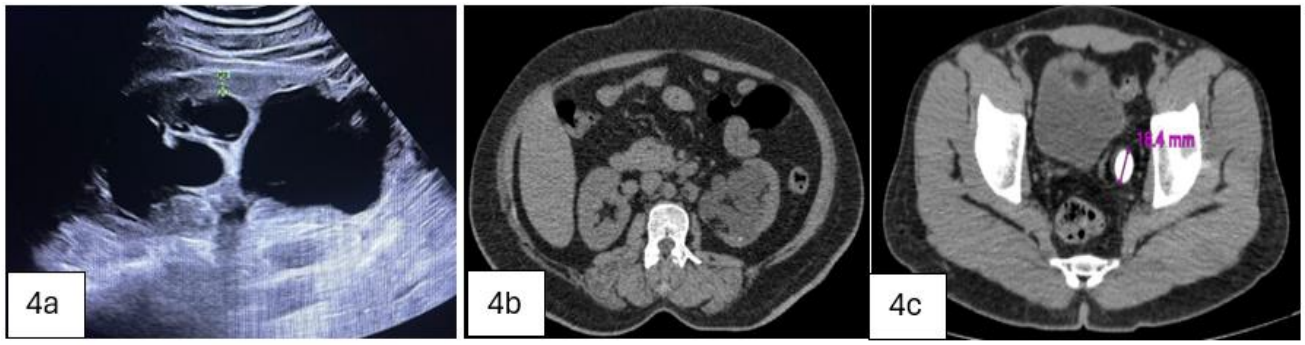

Figure 4: a) Ultrasound B mode image of left kidney shows severe dilatation of pelvicalyceal system and proximal ureter with cortical thinning, suggesting severe hydroureteronephrosis. Axial non-contrast CT image at renal level and urinary bladder level showing severe hydroureteronephrosis consistent with USG findings(b) and a large, hyperdense calculus measuring 18.4 mm in the left distal ureter near the vesicoureteral junction (VUJ) (c) respectively. Given its size spontaneous passage is unlikely and urological intervention is warranted.

DISCUSSION

This prospective observational study aimed to investigate the relationship between hydronephrosis severity and ureteric stone size in a cohort of 112 patients using ultrasound and non-contrast CT. Our study showed a strong positive correlation between increasing stone size and the severity of hydronephrosis, with a statistically notable Chi-square association ($\chi^2 = 72.97$, $p < 0.001$) and Kendall's Tau B correlation (0.676, $p < 0.001$). Specifically, the majority of patients with no or mild hydronephrosis had stones ≤5 mm, while moderate to severe hydronephrosis was predominantly associated with stones >5 mm.

These findings align well with several previously published studies. For instance, Leo et al. (2017) demonstrated that the absence of hydronephrosis on emergency physician-performed ultrasound had a high negative predictive value (89%) for excluding stones >5 mm, reinforcing the reliability of hydronephrosis as a proxy for stone size (Leo et al., 2017) [7]. Similarly, Song et al. (2015) found that stone diameter was a significant predictor of hydronephrosis grade, while factors like age, gender, and stone location were not associated, supporting our observation that stone size plays a central role in hydronephrosis severity (Song et al., 2015) [5].

Further supporting evidence was provided by Jendeberg et al. (2017), who reported that stone size and location are the most reliable prognosticator of spontaneous passage and are strongly associated with hydronephrosis, while hydronephrosis grade also showed relevance in some subgroups (Jendeberg et al., 2017) [12].

Ultra-low-dose CT (ULD-CT) studies have also emphasized the limitations of traditional ultrasound in detecting smaller or distal stones. Cheng et al. (2020) highlighted that 38% of small stones with no associated hydronephrosis were missed by KUB or ultrasound, further emphasizing the correlation between stone size and hydronephrosis visibility (Cheng et al., 2020) [13]. Selvi et al. (2020) explored predictors of spontaneous stone passage and concluded that the absence of hydronephrosis was associated with higher success rates, again pointing to the influence of stone size on urinary tract obstruction [14].

From a technical imaging perspective, Brisbane et al. (2016) and Ziemba & Matlaga (2015) noted that although non-contrast CT is the gold standard, ultrasound remains a preferred initial modality due to safety, despite limitations in detecting small stones or early hydronephrosis (Brisbane et al., 2016); (Ziemba & Matlaga, 2015) [15, 16]. Lastly, Park et al. (2016) incorporated hydronephrosis into their predictive model for shockwave lithotripsy success, finding that hydronephrosis and larger stone size were significant independent predictors of treatment outcomes (Park et al., 2016) [17].

Taken together, our results are consistent with the broader literature, confirming that increasing hydronephrosis severity is a reliable, ultrasound-detectable indicator of larger ureteric stones. The

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strength of our findings is further enhanced by the robust statistical association and the agreement across multiple studies. Limitations of the study are Single-center design and limited sample size and Lack of follow-up on clinical outcomes.

CONCLUSION

This study demonstrates a significant correlation between the severity of hydronephrosis and the size of ureteric calculi, with more severe hydronephrosis strongly correlated with stones larger than 5 mm. Ultrasound, as a non-invasive and accessible imaging modality, proves effective in estimating stone burden through assessment of hydronephrosis. These findings support the use of hydronephrosis grade as a valuable clinical indicator in the prime evaluation and risk stratification of patients with ureteric stones. Thus, ultrasound may help identify low-risk patients and guide imaging decisions, potentially reducing unnecessary CT scans and radiation.

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