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ROLE OF JET FLOW PEAK VELOCITY LN PREDICTING THE SPONTANEOUS EXPULSION OF DISTAL URETERAL STONES MEASURING 4-10MM

Dr. Danish Niaz1, Dr. Murli Lal2, Dr. Harris Hassan Qureshi3, Dr. Ameet Kumar Lalwani4, Dr. Syed Adibul Hasan Rizvi5, Dr. Abdul Ghayas6
1Resident, Department of Urology, Sindh Institute of Urology & Transplantation (SIUT) Karachi
2Professor of Urology, Sindh Institute of Urology & Transplantation (SIUT) Karachi
3Professor of Urology, Sindh Institute of Urology & Transplantation (SIUT) Karachi
4Associate Professor Department of Radiology, Sindh Institute of Urology & Transplantation (SIUT) Karachi
5Professor of Urology, Sindh Institute of Urology & Transplantation (SIUT) Karachi
6Epidemiologist, Health Department, Government of Balochistan
Email: drdanishniaz@gmail.com
chhabriam@yahoo.com
dr_hhq@live.com
dramitsl@gmail.com
arizvi@siut.org
dr.ghayas12@gmail.com
***Corresponding Author:** drdanishniaz@gmail.com

ABSTRACT

Objective: To evaluate the role of jet flow peak velocity ln predicting the spontaneous expulsion of distal ureteral stones measuring 4-10mm.

Study Design: Descriptive cross-sectional study.

Study Duration: 10th of July 2025 till 10th of October 2025.

Material and methods: This study was carried out in Karachi at the Sindh Institute of Urology and Transplantation's Department of Urology, after CPSP and ethical approval. 150 individuals having distal ureteric stones that are unilaterally radiopaque (4–10 mm) between the ages of 18 and 65 were included in the study. Patients with infection, renal impairment, prior urinary surgery, bilateral stones, or gross hydronephrosis were excluded. The peak velocity of jet flow was assessed via Doppler ultrasonography.

Results: In this study of 150 Individuals suffering from distal ureteral stones measuring 4–10 mm, spontaneous stone expulsion occurred in 50.7% of cases after 4 weeks of medical expulsive therapy (MET). Logistic regression analysis revealed that higher jet flow peak velocity (Vmax) on the stone side significantly predicted spontaneous expulsion ($p = 0.015$, OR = 1.303), while larger stone size reduced the likelihood of passage ($p < 0.001$, OR = 0.623). The predictive model demonstrated good discriminative accuracy (AUC = 0.738). Conclusion: Jet flow peak velocity on the stone side is an independent predictor of spontaneous distal ureteral stone expulsion and can enhance decision-making during medical expulsive therapy.

KEYWORDS: Jet Flow Peak Velocity; Distal Ureteral Stones; Spontaneous Stone Expulsion; Doppler Ultrasonography; Medical Expulsive Therapy.

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INTRODUCTION

One of the most prevalent conditions in Pakistan is kidney stone disease (KSD), which accounts for 70% of urologic admissions in rural areas and 50% in urban areas.[1] The precise prevalence is uncertain since there aren't enough population-based epidemiological research. Nonetheless, the disease's scope is enormous, according to statistics released by significant tertiary care facilities.[1] For the management of ureteric stones different modalities are available that include observation for asymptomatic non-obstructing stones, drainage in case of obstruction, depending on the clinical situation, shockwave lithotripsy (SWL) or ureteroscopy. Distal ureteric stones are more likely to form, and the position affects the chance of spontaneous stone transit.[2] With the advancements in minimally invasive surgery, conservative management is still a viable option in small distal ureteric stones.[3] A multicenter study involving seventy one hospitals from four European countries reported success of conservative management as 89% in small stones, located in distal ureter. They found size of the stone, its location in ureter and severity of the symptoms as main factors impacting the decision.[3]

The AUA and EAU guidelines support medical expulsion therapy with alpha blockers for distal ureteric stones less than 1cm. If conservative management fails after 4-6 weeks, intervention can be planned based on shared decision- making.[4] The likelihood of stone transit has been shown to be influenced not only by stone size and position but also by the thickness of the ureter's wall.[5,6] According to a recent research by Ongun et al., jet flow velocity is a reliable indicator of ureteral stone transit. Patients

with jet flow velocities greater than 22.3 +/-9 cm/s had a stone ejection rate of 74.3%, while those with jet flow velocities less than 13.3 cm/s +/-9 had a rate of 25.6%.[5,6] The rate of flow of urine from the ureteric aperture through the bladder as determined by Doppler ultrasonography is known as the ureteral jet.[7] Jet waveforms may be classified into six patterns: square, continuous, polyphasic, triphasic, biphasic, and monophasic. Waveforms that are square and continuous, which are often seen during forced diuresis, are usually not included in the study. Jets that are monophasic are classified as immature, whilst the others are classified as mature. Adults with monophasic jets had mean velocities of 57.65 cm/s and complicated jets of 78.89 cm/s.[8]

Since delayed intervention in unsuitable candidates for conservative care might result in consequences such as infection, hydronephrosis, and renal impairment, this study is crucial to find a reliable, non-invasive predictor for the spontaneous transit o1 distal ureteral stones. The ureteric jet flow peak velocity measured by Doppler ultrasonography has shown potential in predicting stone ejection. Clinicians may be able to better stratify patients and make better treatment options if a substantial link is found. This study will highlight the necessity of alternate or combination of predictors within the management of distal ureteral stones, though, if no association is discovered.

METHODOLOGY

The Sindh Institute of Urology and Transplantation's Department of Urology in Karachi was the site of this cross-sectional study, over a period of Three months from 10th of July 2025 till 10th of October 2025 after approval of the study from institutional ethical review committee ERC (SIUT-ERC-2025/A-600).

Using non-probability sequential sampling, 150 patients of either gender who presented with unilateral radio-opaque distal ureteric stones measuring 4–10 mm and were between the ages of 18 and 65 were included in the study. The following conditions were excluded: history of non-remitting colic, bilateral distal ureteric stones, significant hydronephrosis, acute or chronic kidney illness (serum creatinine > 2.0 mg/dL), a single kidney or congenital renal defect, or a current UTI (confirmed by urine tests).

After obtaining written informed consent, all eligible patients underwent assessment for jet flow peak velocity using standardized ultrasonographic Doppler criteria as defined in the operational definitions. Baseline demographic and clinical information, including age, gender, BMI, duration of ureteral stone disease, stone size, side of the stone, and urinary calcium excretion, were documented on a standardized data collection form. All participants were administered oral diclofenac sodium (50 mg twice daily) for pain management and received medical expulsive therapy for a period of 28 days using tamsulosin (0.4 mg once day). During the four-week follow-up, spontaneous stone expulsion was confirmed via ultrasonography of kidneys, ureters, and bladder (KUB). SPSS version 26.0 was used to input and evaluate the data. Quantitative data, such as body mass index (BMI), age, and jet flow velocity, were shown as means with standard deviations (SD). Conversely, categorical variables, including gender and spontaneous stone ejection, were reported as frequencies and percentages.

Binary logistic regression was used for inferential analysis to find spontaneous stone passage predictors, with stone size, Vmax (jet flow peak velocity) on the stone side, Vmax on the stone-free side, and age serving as independent variables. The accuracy of the anticipated jet flow peak velocity was further assessed utilizing the Receiver Operating Characteristic (ROC) curve, and the calculation of the Area Under the Curve (AUC) were done. A p-value of less than or equal to 0.05 was considered statistically significant.

RESULTS

This research included 150 individuals with distal ureteral stones ranging from 4 to 10 mm in size. The mean age of participants was 41.27 ± 14.00 years, with 46.7% aged between 18–40 years and 53.3% between 41–65 years. The mean BMI was 26.49 ± 3.46 kg/m², the mean BUN level was 14.74 ± 4.43 mg/dl, The average amount of serum creatinine was 1.00 ± 0.19 mg/dl. Average size of the stones was 7.01 ± 1.78 mm. On the stone side, the average jet flow peak velocity (Vmax) was 10.91 ± 4.28 cm/sec, whereas on the stone-free side it was higher, 14.11 ± 4.95 cm/sec. Among the study participants, 65.3% were male and 34.7% were female. Smokers constituted 29.3% of the study population, and 70.7% were non-smokers. The right ureter was impacted in 54.0% and the left ureter in 46.0% of patients.

Table I. Baseline Demographic, Clinical, Laboratory, and Doppler Characteristics of Patients (N = 150)

Variable	Category / Measure	n (%) / Mean ± SD
Age	18–40 years	70 (46.7%)
	41–65 years	80 (53.3%)
	Mean age	41.27 ± 14.00
Gender	Female	52 (34.7%)

	Male	98 (65.3%)
Smoking status	No	106 (70.7%)
	Yes	44 (29.3%)
Side of stone	Left	69 (46.0%)
	Right	81 (54.0%)
BMI	Mean ± SD	26.49 ± 3.46
BUN (mg/dL)	Mean ± SD	14.74 ± 4.427
Creatinine (mg/dL)	Mean ± SD	1.00 ± 0.195
Stone size (mm)	Mean ± SD	7.01 ± 1.78
Jet flow peak velocity on stone side (cm/sec)	Mean ± SD	10.91 ± 4.28
Jet flow peak velocity on stone-free side (cm/sec)	Mean ± SD	14.110 ± 4.95

After 4 weeks of medical expulsive therapy (MET), spontaneous stone expulsion occurred in 76 (50.7%) patients, while 74 (49.3%) did not show stone passage. Binary logistic regression was applied to identify predictors of spontaneous stone expulsion. The results demonstrated that jet flow peak velocity on the stone side (Vmax) was a significant independent positive predictor of spontaneous expulsion ($p = 0.015$; OR = 1.303; 95% CI: 1.053–1.614), indicating that each unit increase in Vmax increased the likelihood of stone passage by approximately 30%. Stone size showed a strong inverse association with spontaneous expulsion ($p < 0.001$; OR = 0.623; 95% CI: 0.504–0.770), suggesting that larger stones had significantly lower odds of spontaneous passage.

Table II. Spontaneous Expulsion After 4 Weeks of MET (N = 150)

Variable	Category	n (%)
Spontaneous expulsion after 4 weeks of MET	No	74 (49.3%)
	Yes	76 (50.7%)

Conversely, jet flow peak velocity on the stone-free side was negatively associated with stone expulsion ($p = 0.031$; OR = 0.817; 95% CI: 0.680–0.982). Age did not show a statistically significant association with stone passage ($p = 0.330$). Overall, Vmax on the affected side and stone size emerged as the most important predictors of spontaneous stone expulsion.

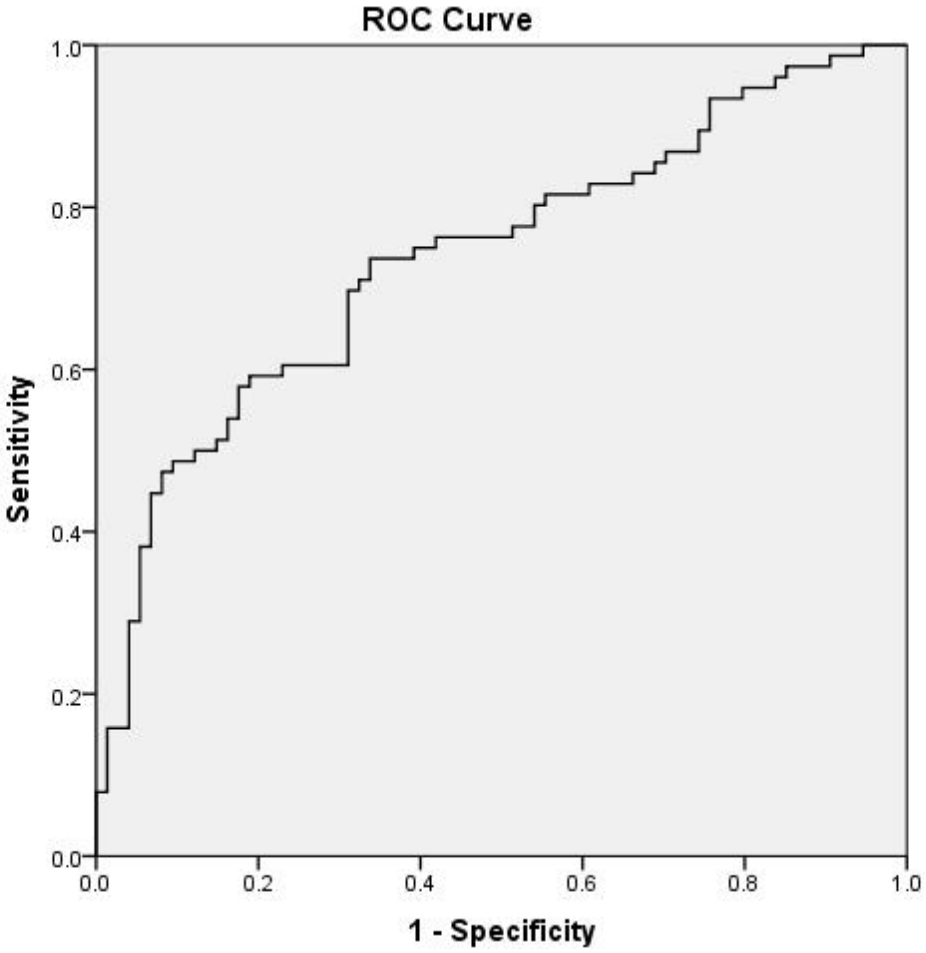
Table III. Logistic Regression Analysis for Predicting Spontaneous Expulsion

Variable	B	S.E.	Wald	df	p-value	OR (95% CI)
Vmax stone side (cm/sec)	0.265	0.109	5.904	1	0.015	1.303 (1.053–1.614)
Stone size (mm)	-0.473	0.108	19.142	1	<0.001	0.623 (0.504–0.770)
Age (years)	-0.013	0.013	0.948	1	0.330	0.987 (0.963–1.013)
Vmax stone-free side (cm/sec)	-0.202	0.094	4.631	1	0.031	0.817 (0.680–0.982)
Constant	3.824	1.102	12.039	1	0.001	45.785

The ROC curve analysis for the predicted probability derived from the regression model showed an Area Under the Curve (AUC) of 0.738. This indicates a good discriminative ability of the model in predicting spontaneous stone expulsion. The result suggests that the combination of jet flow peak velocity and stone size provides a reasonably accurate predictive performance for clinical outcomes. Stratification was performed to assess potential confounding effects of age, BMI, gender, smoking status, and side of stone on spontaneous stone expulsion. The analysis revealed no statistically significant association between spontaneous expulsion and any of the stratified variables (all $p > 0.05$).

Specifically, neither age groups (18–40 vs 41–65 years), BMI categories, gender, smoking status, nor stone side demonstrated a significant impact on stone passage rates. These findings suggest that these variables did not confound the relationship between jet flow peak velocity and spontaneous stone expulsion.

Table VI: evaluation of the role of jet flow peak velocity ln predicting the spontaneous expulsion of distal ureteral stones measuring 4-1Omm.



Area Under the Curve
Test Result Variable(s): Predicted probability
Area
.738

Table V. Stratification of Spontaneous Expulsion After 4 Weeks of MET

Variable	Category	No n (%)	Yes n (%)	p-value
Age	18–40 years	35 (50.0%)	35 (50.0%)	0.879
	41–65 years	39 (48.8%)	41 (51.2%)	
BMI	Normal	28 (51.9%)	26 (48.1%)	0.644
	Overweight/Obese	46 (47.9%)	50 (52.1%)	
Gender	Female	22 (42.3%)	30 (57.7%)	0.210
	Male	52 (53.1%)	46 (46.9%)	

Smoker	No	56 (52.8%)	50 (47.2%)	0.184
	Yes	18 (40.9%)	26 (59.1%)	
Side of stone	Left	36 (52.2%)	33 (47.8%)	0.521
	Right	38 (46.9%)	43 (53.1%)	

DISCUSSION

In this prospective cohort of 150 patients with stones in the distal ureter (4–10 mm) treated with medical expulsive therapy (MET), On the stone side, we found that the jet flow peak velocity (Vmax_stone_side) was an independent predictor of spontaneous stone expulsion at four weeks (OR = 1.303 per 1 cm/s increase, p = 0.015). Stone size was a strong inverse predictor (OR = 0.623 per 1 mm increase, p < 0.001), while age was not significant. The model demonstrated acceptable discriminative performance (AUC = 0.738), suggesting that the combination of jet velocity and stone size provides clinically useful predictive information. Our results align with the research conducted by Ongün et al. (2018), who demonstrated that ureteral jet peak velocity measured by Doppler ultrasonography was independently linked to the distal ureteral stones' spontaneous passage. They suggested a Vmax threshold of approximately 15.25 cm/s, which demonstrated 63% specificity and 85% sensitivity in predicting stone passage. This supports our conclusion that higher jet velocity on the affected side increases the likelihood of spontaneous expulsion. Similarly, according to Ahmed et al. (2015), the most crucial factor influencing spontaneous transit is stone size, with passage rates significantly decreasing as stone diameter increases. Our results corroborate this inverse association, showing a 38% decrease in odds of spontaneous passage with each millimeter increase in stone size. Recent research has expanded ultrasound-based prediction to include additional sonographic parameters such as Urineal wall thickness (UWT), jet frequency, degree of hydronephrosis, and CT-derived features such as Hounsfield units. Wang et al. (2024) demonstrated that combining ureteral jet parameters with stone length and location significantly improved predictive accuracy compared to single parameters. Likewise, nomograms developed by Yang T et al. (2025) integrated Vmax, stone size, and UWT, resulting in better diagnostic performance for predicting stone passage. These studies align with our results and further suggest that multi-parameter models outperform size-based prediction alone. We also found that higher Vmax on the contralateral (stone-free) side was inversely associated with spontaneous passage (OR = 0.817, p = 0.031). This observation is physiologically plausible since increased contralateral flow may reflect compensatory enhancement secondary to ipsilateral obstruction. Leung VY et al. (2007) and Jandaghi AB et al. (2016) similarly noted asymmetric ureteral jet flow patterns in patients with obstructive uropathy, indicating that bilateral comparison provides diagnostic insights that surpass those obtained from unilateral assessment. Hence, when diagnosing, a binocular Doppler scan can help doctors be more accurate in predicting how a stone will behave.

Our study supports incorporating Doppler-based ureteral jet assessment into the clinical evaluation of distal ureteral stones. A higher jet velocity on the stone side can be a good sign for spontaneous transit. In contrast, a lower jet velocity, together with bigger stones, might indicate that early treatment is needed. Since Doppler ultrasonography is non-invasive, radiation-free, and widely available, including this factor in the MET decision-making process could cut down on needless images and improve management strategies. Previous studies exploring ureteral jet velocity were limited by small sample sizes, retrospective design, and inconsistent measurement protocols (15–17). Few studies have included assessments of both sides of the body, or integrated jet characteristics with other factors like stone size and patient age, in a model that considers several variables. By prospectively including both sides' Vmax, controlling for confounders, and reporting predictive accuracy (AUC = 0.738), our study provides more robust evidence for the clinical utility of Doppler jet analysis and helps bridge the gap toward standardization of this emerging parameter.

Limitations

Our research has several limitations. It may be less generalizable because it was carried out at a single center. Doppler velocity measurements rely on the operator, and differences in how they are done may impact how consistently the results can be reproduced, unless standard procedures are utilized. Additionally, we did not evaluate stone density or ureteral wall thickness, which are known to improve prediction accuracy (12,18). Future multicentric studies are required to validate and generalize these findings.

CONCLUSION

Doppler ultrasonography measurements of jet flow peak velocity are an important, independent predictor of spontaneous evacuation of distal ureteral stones ranging in size from 4 to 10 mm. When the size of the stones is considered, the ability to predict treatment results is improved. By filling the evidence gap regarding bilateral jet assessment and providing a standardized analysis of its predictive value, this study contributes to a more personalized, non-invasive approach to stone management.

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