ORIGINAL ARTICLE

COMPARISON OF URINE JET VELOCITY IN VARIOUS GRADES OF HYDRONEPHROSIS IN THE CASE OF URETERIC OBSTRUCTION BY REAL-TIME

Midrarullah Khan[1], Raham Bacha[1], Muhammad Zubair[1], Muhammad Tayyab [2], Zafar Iqbal[1], Syed Muhammad Yousaf Farooq[1], Mehreen Fatima[1]

ABSTRACT

Introduction: Hydronephrosis is a common complication of the kidney that is caused by obstruction to kidney ureters and bladder. The renal pelvis and pelvicalyceal system of the kidney become dilated. The obstruction may either be in the upper or lower urinary tract. Upper urinary tract obstruction includes ureteropelvic junction obstruction, renal stone, tumours, and vesicoureteric junction obstruction while lower tract includes benign prostatic hyperplasia, prostate tumours posterior urethral valves.

Material & Methods: This cross-sectional study was conducted at the Department of Radiology Lady Reading Hospital Peshawar, Pakistan**.** The study duration was 9 months (September 2020 and May 2021). A total of 120 participants were presented with a history of flank and are suspicious for renal stone causing hydronephrosis. 30 patients were taken as control with no renal disease while 90 were cases having renal disease. Grading of hydronephrosis and Urine jet velocity was recorded by using real-time and spectral doppler ultrasound.

Results: A total of 120 participants were included in this study. The mean jet velocity in the normal individuals was recorded as 50.37 ± 6.4 cm/s, however, in patients with mild, moderate, and severe hydronephrosis the mean jet velocity was recorded as 14.23 ± 10.47 cm/s, 7.32± 8.14 cm/s and, 1.5 ± 3.98 cm/s respectively.

Conclusion: Urine jet velocity is a good indicator of ureteric obstruction in a patient with various grades of hydronephrosis. The velocity of the urine jet reduced significantly with increasing the severity of hydronephrosis.

Key Words: Hydronephrosis grading, real-time sonography, spectral Doppler, ureteric obstruction

Authors' Declaration: The authors declared no conflict of interest and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed substantially to the planning of research, question designing, data collection, data analysis and write-up of the article.

Authors' Affiliation

[1]University Institute of Radiological Sciences and Medical Imaging Technologies, Faculty of Allied Health Sciences, University of Lahore, Lahore, Pakistan

[2]Institute of Biotechnology and Genetics engineering, university of agriculture Peshawar, Pakistan

Corresponding Author

Midrarullah Khan

University Institute of Radiological Sciences and Medical Imaging Technologies, Faculty of Allied Health Sciences, University of Lahore, Lahore, Pakistan

Email: midrar.ipms@kmu.edu.pk

This article may be cited as: Khan M, Bacha R, Zubair M, Tayyab M, Iqbal Z, Farooq SMY, Fatima M. Comparison of urine jet velocity in various grades of hydronephrosis in the case of ureteric obstruction by real-time**.** Rehman J Health Sci. 2022;4(1). 64-68

Submitted: June 29, 2021 Revisions Submitted: July 26, 2021 Accepted: July 30, 2021

INTRODUCTIO

Hydronephrosis is the distension of the major and minor calyces along with the renal pelvis of the kidney with urine in case of obstruction distal to the renal pelvis. An increase in the diameter of the ureter is known as hydroureter. Both hydronephrosis and hydroureter are very common problems for urologists, nephrologists, medical physicians, and emergency physicians.[1]

Worldwide it is estimated that 6% of new births have serious birth anomalies and 1% of them faced the inherited disease of the urinary tract.[2] Pelvic ureteric junction obstruction is the major cause of hydronephrosis in neonates and infants. In many cases, hydronephrosis spontaneously resolves by the age of 2 years. Vesical ureteric junction and stricture posterior ureteral valve are the other common anatomical anomalies that cause obstruction.[3] In young adults hydroureteronephrosis is most commonly caused by nephrolithiasis. Most of the stones contain calcium and oxalate. Calcium and oxalate stone (71.6%) were present in the majority of cases, in 22.4% constitutes bicarbonate and calcium oxalate. Less common calculi that are ammonium and cysteine were found in less than 10% of the total stones.[4,5] Approximately 0.6 million US adults are suffering from kidney stones. According to the National Health and Nutrition Examination Survey (NHANES), there is 8.8% prevalence of renal stones in the US. Men suffer more than women by the ratio of 10.6% and 7.1 %.[6 7] The ratio of kidney stones in Pakistan is also high[5], however, there is no epidemiological data present for the prevalence of nephrolithiasis.[8] In elder patients, the most common causes of hydronephrosis are an enlarged prostate, prostate tumour, pelvis, and retroperitoneal tumour. In 80 % of pregnant women, hydronephrosis is commonly identified due to compression of ureters and uterus enlargement.[9]

Doppler ultrasound along with real-time sonography is utilized in assessing hemodynamic and blood flow kidneys and bladder for urine jet in case of ureteric obstruction which shows additional information in the diagnosis. If the intravesical urine jet is identified, then spectral Doppler is used to measure urine jet frequency,

mean jet velocity, jet duration, with the calculation of ureteric jet index (UJI) unilateral renal function are also assessed. Thus giving more information regarding ureterodynamics.[10] Ultrasound can detect distension of the collecting system but cannot differentiate obstructive and non-obstructive causes and provide no physiological or functional information about obstruction. The dilatation of the collecting system is not always due to obstruction but may be due to pregnancy and many other unobstructed conditions like external pelvis, prominent renal veins, diverticulum, reflux disease, diuretics, renal papilla necrosis, over the distended urinary bladder, pyelonephritis, diabetes insipidus, prostatic hypertrophy or carcinoma, renal artery aneurysm, peri pelvic cysts, and retroperitoneal or pelvic neoplasms.[11-14] Grades of hydronephrosis in a patient with urinary tract dilatation are examined by ureterovesical jet flow using a Doppler ultrasound window with manual compression. Diagnosis and treatment of ureteric obstruction are very important as permanent damage to the kidneys occurs if not treated immediately and left for a long time.

This study aims to compare urine jet velocity in the various grades of hydronephrosis as it is easy, cost-effective, does not use ionizing radiation or any contrast medium which is used in other imaging modalities.

MATERIAL AND METHODS

This cross-sectional study was conducted at the Department of Radiology Government Lady Reading Hospital Medical Teaching Institute Peshawar, Pakistan. The duration of the study was 9 months (September 2020 to May 2021). The institutional review board of the University of Lahore permitted this study. A total of 120 participants were referred for ultrasonography and were suspicious for hydronephrosis in which 30 participants had no hydronephrosis or any other disease in the urinary system and were kept as control group. A total of 90 participants had hydronephrosis and were kept as diseased patients (n=30 mild, n=30 moderate, and n=30 severe hydronephrosis). The participants with ureteric obstruction, history of hydronephrosis the patient's age range from 10 years to 60 years were included. While patients presenting with urinary tract infection, benign prostatic hyperplasia, reflux disease, bladder outlet obstruction associated with pelvic organ prolapse and neurogenic bladder, ureteric stents, pregnancy, recent surgery, the duplex ureter were excluded from the study. After taking an informed written consent form, data was collected according to the variables of the questionnaire that was age, gender, stone location, presence or absence, degree of hydronephrosis, urine jet velocity in obstructed ureters. Toshiba Nemio 20 (Xairo), Mindray DC 70, with frequency range 2.5-3.5 MHz convex probe was used. The patients were advised to drink water (750-1000ml) before the examination, ultrasound of the kidney ureter and bladder was done 15-30 minutes after drinking water. Stone size, location, and degree of Hydronephrosis were assessed by gray-scale ultrasound. All the patients were observed for at least 10 minutes for ureterovesical orifices in the axial plane. All the machine settings were optimized for better results. Red colour was assigned for flow toward the transducer and blue for away from the probe. The frequency of the urine jet was then calculated. Data were evaluated and analysed with SPSS version 22.0 using descriptive, cross-tabulation, and one-way ANOVA tests.

RESULTS

The study population comprised of case and control groups (90 diseased, 30 control) (Fig. 01). The proportion of male and female were 61 % (n=73) and 39 % (n=47) respectively. The mean age of the patients was recorded as 35± 8.2 years. Out of 120 participants, 90 (75%) patients had urinary obstruction while the rest of patients 30 (25%) were normal individuals having no sonographic evidence of hydronephrosis. 81 (67.5%) had ureteric stone on the right site while 39 (32.5%) had stones on left side. Stones were present throughout the ureter either right or left side at a different location in which 24 (20%) patients had pelvic ureteric junction obstruction, 1 (0.8%) have a stone in proximal ureter 13 (10.8%) had stones in the middle ureter, 3 (2.5), 49(40.8%) had distal ureteric stone and Vesico ureteric stone, respectively (figure 1). Hydronephrosis was present in 90 (75%) of patients while 30 (25%) of the participants had no obstructions in the kidney and ureters or no sonographic evidence of hydronephrosis (figure 2). Urine jet velocity was detected in 69 (57.5%) of the patients while in 51 (42.5%) jet velocity was not detected. In normal or healthy individuals' urine jet velocity was detected in all patients. In mild hydronephrosis patient's urine jet velocity was detected in 20 patients while in 10 patients it was not detected or observed, in moderate hydronephrosis, it was observed in 14 patients while in 16 patients' urine jet velocity was observed. In a severe case, the frequency of urine jet velocity was recorded in 5 cases and was absent in 25 patients (table 1). The mean jet velocity in the normal individual who has no renal disease was recorded as 50.37 ± 6.4 cm/s (figure 4) in mild hydronephrosis the mean jet velocity was recorded as 14.23 ± 10.47 cm/s. Similarly, in moderate and severe hydronephrosis it was recorded as 7.32± 8.14 cm/s and 1.5 ± 3.98 cm/s, respectively. The mean plot figure shows that the urine jet velocity decreases significantly with increasing the severity of hydronephrosis (table 2, figure 5).

DISCUSSION

The current study was designed to identify the severity of hydronephrosis and analysis of urine jet velocities in confirmed patients of hydronephrosis. Advancement in ultrasound technology can provide a wide-ranging way to evaluate anatomical, functional and morphological information about the urinary system.[15] Urinary tracts can be evaluated by conventional ultrasound as the first line of imaging modality however due to compromised scan in obese patients and abdominal gases restrict optimal visualization for diagnosis by beam attenuation, multislice computed tomography can effectively detect, localize and assess calculi composition and stone burden in the urinary tract. However, there is an increased radiation dose, contrast-induced reaction.[16] Magnetic Resonance Imaging is the alternate modality in which patients are not exposed to radiation, but it is more expensive and more time consumable than other imaging modalities. MRI is contraindicated for the patient with neurotransmitters, pacemakers, certain

types of stents, claustrophobic patients and is less sensitive for detecting and localizing urinary stones. In contrast, ultrasound is non-invasive, real-time, inexpensive, and does not need any contrast medium. Greyscale and Doppler ultrasound is used for localization of ureteral orifice and examining the urine jet flow into the bladder. Many studies were conducted to examine the ureterovesical jet flow using Doppler ultrasound. A maximum of 10 minutes of continuous examination of the urinary bladder in the transverse was used in our study. However, there is no fixed time for the urinary jet to detect because previous studies evaluated urine jet for 5 minutes.[17,18] Cox et al reported that for bilaterally symmetrical urinary jet the bladder must be examined for at least 30 minutes.[19] The mean age of patients that were recorded in this study was 35± 8 years similar mean age was also recorded in a study conducted by Hayan et al showing the mean age of 32.8 years. [20] The ureteric stone that was recorded in our study on the right side of the patients were 81(67.5%) and patients that had ureteric stones on the left side were 39(32.5%). Mahmoud et al reported 723 (88.72%) patients who had ureteral stones, the patients that had ureteric stones on the right side were 340 (47.0%) and on the left side were 383(53.0%).[21] In our study, 24 (20%) patients had pelvic ureteric junction obstruction, 1(0.8%) patients had proximal ureter stone, 13(10.8%) had stones in the middle ureter, 3(2.5) had distal ureteric stone, and 49(40.8%) had Vesico ureteric stone respectively. Abdel-Gawad et al reported the presence of stone in which 190 (20.3%) patients had proximal ureter stone, 77(8.2%) had middle ureteric stone, and 671 (71.5%) patients had lower ureteric stone. [22] Nery et al also reported 12(7.8%) patients had stones in the upper pelvic junction, 17(11.0%) patients had proximal ureteric stone, 14(9.1%) had middle ureteric, 63(40.9%) patients had distal ureteric, and 48(31.2%) patients had a stone in the vesicoureteric junction. [23] Jandaghi et al also reported the stone located throughout the urinary tract. [24] Pelvic ureteric junction stone was n=6 (13%) that located at the proximal ureter was 12(26.1%), mid ureter 13(28.3), and 15(32.6%) in the distal third of the ureter.

In 90 (75.0%) patients of hydronephrosis, urine jet flow velocity was detected in 69 (57.5%) patients and not detected in 51 (42.5%) patients. Pethiyagoda et al reported that an increase in serum creatinine in 22.6% of patients, urine jet was not detected while in 3.6% of patients with urine jet seen. [25] Similar, urine jet velocity was not observed in 44.6% while present in 55.4% of the total patients. Serum creatinine was reported high (mean 103.3mmol/L) in a patient with ureteric jet not detected. In ureteric jet presence, creatinine level was (mean 75.9 mmol/L). In normal or grade 0 urine jet velocity was detected in 30 (25.0%) patients, in mild or grade I hydronephrosis the urine jet velocity was found in 20 patients, in moderate or grade II hydronephrosis the urine jet velocity was found in 14 patients, and in severe or grade III hydronephrosis the urine jet velocity found in 05 patients (p=0.000). Park et al reported grade 0 hydronephroses in 113 patients, grade I hydronephrosis in 46 patients, grade II hydronephrosis in 119 patients, and grade II hydronephrosis in 40 patients. [26] The mean urine jet velocity in normal groups was reported 50.37± 6.4cm cm/s, in mild hydronephrosis, it was recorded as 14.23±10.47cm/sec, moderate hydronephrosis shows a velocity of 7.32±8.14cm/sec, severe hydronephrosis shows 1.5±3.98cm/sec. Hayan et al also reported the urine jet flow velocity varied from 23.16±86.83cm/sec with a mean of 50.89cm/sec. [20] Ciftci et al also reported the mean jet velocity of the normal or grade 0 patients 56.0±32cm/sec, while on the obstructive side the mean jet velocity was 0-50cm/sec (average was 17.10±20cm/sec). [14]

CONCLUSION

Urine jet velocity is a good indicator of ureteric obstruction in patients with various grades of hydronephrosis. The velocity of the urine jet reduced significantly with increasing the severity of hydronephrosis.

REFERENCES

1. Thotakura R, Anjum F. Hydronephrosis And Hydroureter. In: StatPearls. Treasure Island (FL): StatPearls Publishing Copyright © 2021, StatPearls Publishing LLC.; 2021.
2. Rasouly HM, Lu W. Lower urinary tract development and disease. Wiley Interdiscip Rev Syst Biol Med 2013;5(3):307-42.
3. Choi YH, Cheon J-E, Kim WS, Kim I-O. Ultrasonography of hydronephrosis in the newborn: a practical review. Ultrasonography (Seoul, Korea) 2016;35(3):198-211.
4. Wathigo FK, Hayombe A, Maina D. Urolithiasis analysis in a multiethnic population at a tertiary hospital in Nairobi, Kenya. BMC Res Notes 2017;10(1):158.
5. Mithani S, Zaidi S. Comparison of 24 hours urinary citrate levels in urolithiasis patients and healthy controls. JPMA. The Journal of the Pakistan Medical Association 2005;55:371-3.
6. Scales CD, Jr., Smith AC, Hanley JM, Saigal CS. Prevalence of kidney stones in the United States. Eur Urol 2012;62(1):160-5.
7. Sorokin I, Mamoulakis C, Miyazawa K, Rodgers A, Talati J, Lotan Y. Epidemiology of stone disease across the world. World J Urol 2017;35(9):1301-20.
8. Ahmad S, Ansari TM, Shad MA. Prevalence of Renal Calculi; Type, Age and Gender Specific in Southern Punjab, Pakistan. The Professional Medical Journal 2016;23(04):389-95.
9. Rasmussen PE, Nielsen FR. Hydronephrosis during pregnancy: a literature survey. Eur J Obstet Gynecol Reprod Biol 1988;27(3):249-59.
10. Wu C-C. Ureteric Jet. Journal of Medical Ultrasound 2010;18(4):141-6.
11. Jandaghi AB, Falahatkar S, Alizadeh A, Kanafi AR, Pourghorban R, Shekarchi B, et al. Assessment of ureterovesical jet dynamics in obstructed ureter by urinary stone with color Doppler and duplex Doppler examinations. Urolithiasis 2013;41(2):159-63.
12. Nuraj P, Hyseni N. The Diagnosis of Obstructive Hydronephrosis with Color Doppler Ultrasound. Acta Informatica Medica 2017;25(3):178.
13. Webb J. Ultrasonography and Doppler studies in the diagnosis of renal obstruction. BJU international 2000;86:25-32.
14. Ciftci H, Cece H, Dusak A, Savas M, Verit A, Yeni

E. Study of the ureterovesical jet flow by means of dupplex Doppler ultrasonography in patients with residual ureteral stone after extracorporeal shock wave lithotripsy. Urological research 2010;38(1):47-50.
15. Hacker HW, Szavay P, Dittmann H, Haber HP, Fuchs J. Pyeloplasty in children: is there a difference in patients with or without crossing lower pole vessel? Pediatr Surg Int 2009;25(7):607-11.
16. Juan YS, Huang CH, Wang CJ, Chou YH, Chuang SM, Li CC, et al. Predictive role of renal resistance indices in the extracorporeal shock-wave lithotripsy outcome of ureteral stones. Scand J Urol Nephrol 2008;42(4):364-8.
17. Asrat T, Roossin MC, Miller EI. Ultrasonographic detection of ureteral jets in normal pregnancy. Am J Obstet Gynecol 1998;178(6):1194-8.
18. Burke BJ, Washowich TL. Ureteral jets in normal second- and third-trimester pregnancy. J Clin Ultrasound 1998;26(9):423-6.
19. Cox IH, Erickson SJ, Foley WD, Dewire DM. Ureteric jets: evaluation of normal flow dynamics with color Doppler sonography. AJR Am J Roentgenol 1992;158(5):1051-5.
20. Hayan F, Bacha R, Farooq SMY, Hassan Z-u, Yousaf M, Gilani SA, et al. Doppler Comparison between Ureteric Obstruction and Ureteric Jet Velocity. 2019.
21. Abdel-Gawad M, Kadasne RD, Elsobky E, Ali-El-Dein B, Monga M. A prospective comparative study of color Doppler ultrasound with twinkling and noncontrast computerized tomography for the evaluation of acute renal colic. The Journal of urology 2016;196(3):757-62.
22. Abdel-Gawad M, Kadasne R, Anjikar C, Elsobky E. Value of color doppler ultrasound, kub and urinalysis in diagnosis of renal colic due to ureteral stones. International braz j urol 2014;40(4):513-9.
23. Nery DR, Costa YB, Mussi TC, Baroni RH. Epidemiological and imaging features that can affect the detection of ureterolithiasis on ultrasound. Radiologia brasileira 2018;51(5):287-92.
24. Jandaghi AB, Falahatkar S, Alizadeh A, Kanafi AR, Pourghorban R, Shekarchi B, et al. Assessment of ureterovesical jet dynamics in obstructed ureter by urinary stone with color Doppler and duplex Doppler examinations. Urolithiasis 2013;41(2):159-63.
25. AUB Pethiyagoda KP. Correlation of ureteric jet characteristics with the degree of hydro-nephrosisand serum creatinine. International Journal of Scientific and Research Publications 2016;Volume 6(Issue 12):15-8.
26. Park SJ, Yi BH, Lee HK, Kim YH, Kim GJ, Kim HC. Evaluation of patients with suspected ureteral calculi using sonography as an initial diagnostic tool: how can we improve diagnostic accuracy? Journal of Ultrasound in Medicine 2008;27(10):1441-50.

Table 1: Urine jet velocity detected or not detected in normal, mild-moderate, and severe

		UJV detected	UJV not detected
Hydronephrosis Grade (Normal, Mild, Moderate, Severe)	Normal	30	0
	Mild	20	10
	Moderate	14	16
	Severe	5	25

Table 2: showing mean urine jet velocity in normal, mild, moderate, and severe hydronephrosis

Participant status	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
Normal	50.0	6.4	1.1	47.6	52.4
Mild	14.2	10.4	1.9	10.3	18.1
Moderate	7.3	8.1	1.4	4.2	10.3
Severe	1.5	3.9	0.7	0.1	3.0

Table 3: mean difference and statistical significant between dependent variables and urine jet velocity

(I) Hydronephrosis Grade	(J) Hydronephrosis Grade	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Normal	Mild	35.8000*	1.9744	.000	30.654	40.946
	Moderate	42.7100*	1.9744	.000	37.564	47.856
	Severe	48.4400*	1.9744	.000	43.294	53.586
Mild	Normal	-35.8000*	1.9744	.000	-40.946	-30.654
	Moderate	6.9100*	1.9744	.004	1.764	12.056
	Severe	12.6400*	1.9744	.000	7.494	17.786
Moderate	Normal	-42.7100*	1.9744	.000	-47.856	-37.564
	Mild	-6.9100*	1.9744	.004	-12.056	-1.764
	Severe	5.7300*	1.9744	.023	.584	10.876
Severe	Normal	-48.4400*	1.9744	.000	-53.586	-43.294
	Mild	-12.6400*	1.9744	.000	-17.786	-7.494
	Moderate	-5.7300*	1.9744	.023	-10.876	-.584

*. The mean difference is significant with P value < 0.05

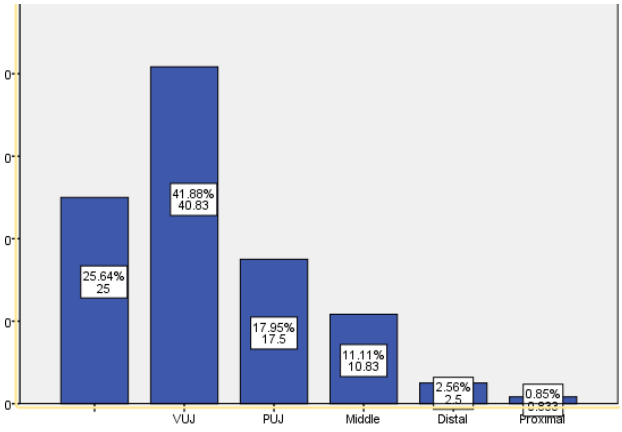

Figure. 1 showing the location of the stone in different areas of the ureters

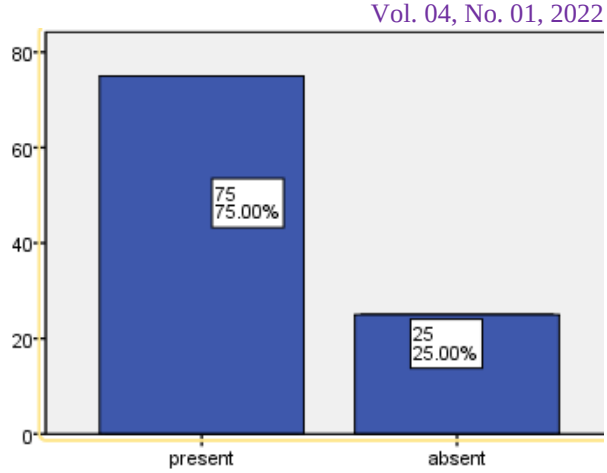

Figure 2: Presence or absence of hydronephrosis in patients

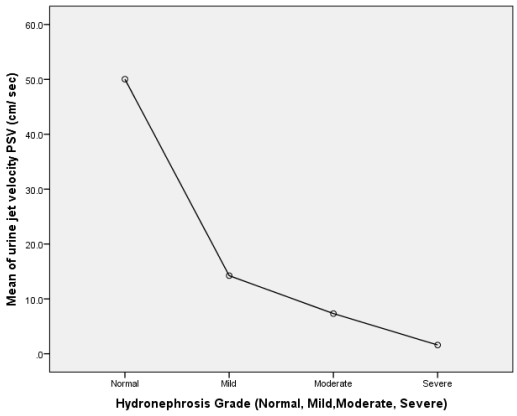

Figure 3 reduction in urine jet velocity with increasing the severity of hydronephrosis

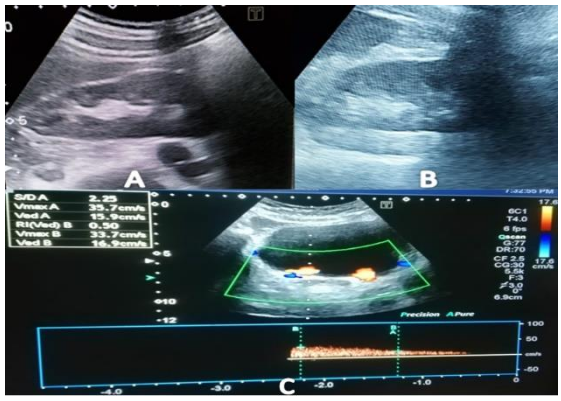

Figure 4: Normal, Right kidney is normal in size, shape, and normal parenchymal echotexture (A). The left kidney is also normal in size, shape, and normal parenchymal echotexture (B). Spectral Doppler was performed during the examination; both ureteric jets are visualized for 2.9 seconds.

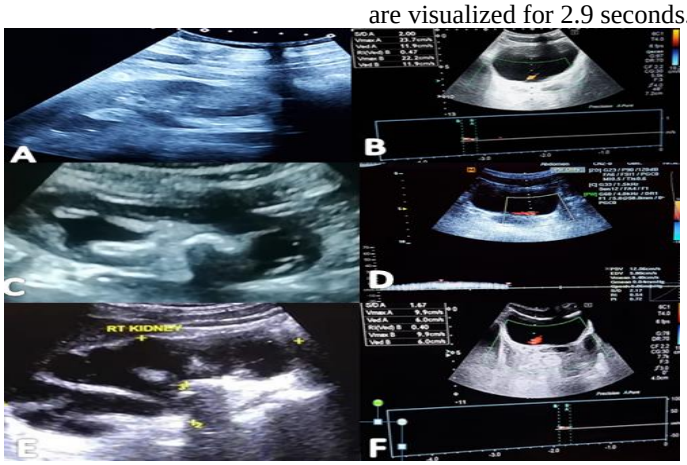

Figure 5: Grades of hydronephrosis, (A) 28-year male presenting with right flank pain, right kidney shows mild hydronephrosis due to distal ureteric stone. (B) Colour and spectral Doppler were performed, during the examination, the right jet is visualized and the duration of the jet was 2.5 seconds. (C) A 31-year male presenting with left flank pain, left kidney shows moderate hydronephrosis due to pelvic ureteric junction stone. (D) Colour and spectral Doppler were performed, during the examination, the left jet is visualized and the duration of the jet was 2.0 seconds. (E) A 40-year male presenting with severe flank pain, right kidney shows severe hydronephrosis due to stone in the pelvic ureteric junction. (F) Colour and spectral Doppler were performed, during the examination, the right jet is visualized and the duration of the jet was 1.0 seconds