Correlation of ureteric jet characteristics with the degree of hydro-nephrosisand serum creatinine

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Abstract- Acute ureteric colic caused by ureteric calculus disease is a commonly encountered clinical problem. Ultrasonography is one of the treatment modality available in the evaluation of patients with acute urologic disorders. Color Doppler Ultrasonography is an advancement of the conventional ultrasonography in which the Doppler Effect is employed. It can be used to visualize "ureteric jets". The purpose of this study is to describe the usefulness of color Doppler ultrasound and serum creatinine in evaluation of patients with ureteric calculi.This descriptive study was conducted using 83 patients with calculus disease, aged 20-60 years. All the patients underwent X-ray KUB and color Doppler sonography with ureteral jet assessments and their serum creatinine levels were obtained. The frequency of jets, peak ureteric jet velocity and the duration of the ureteric jet in seconds was measured.According to the results, there were no significant differences in mean serum creatinine values among various degrees of hydronephrosis (p=0.510). There was a significant association between the ureteric jet status with the degree of hydronephrosis (p=0.001). Hence the assessment of ureteric jet on ultrasound, along with serum creatinine, is useful in the assessment of the degree of hydronephrosis in evaluation of patients with ureteric calculi.

Index Terms- hydronephrosis,X-ray KUB, Color Doppler Ultrasonography,ureteric jets,serum creatinine levels,

I. INTRODUCTION

Acute ureteric colic caused by ureteric calculus disease is a commonly encountered clinical problem; its prevalence is estimated to be 12% in USA [1], about 2%-5% of life time risk is present for the Asian population [2].

A ureteric calculus can have various outcomes. Most ureteric stones can be managed under adequate analgesia for uneventful stone passage [3]. Some stones may obstruct the ureter leading to acute obstructive hydro nephrosis. If not correctly treated and persisted for long enough it can result in shutdown of the affected kidney. The management of the urolithiasis depends on the stone location, size, and degree of obstruction of the ureter, patient factors, anatomical considerations and surgeon preference. There are multiple treatment modalities that the surgeon can choose from including, watchful waiting and medical expulsion therapy, ureteroscopy, shock wave lithotripsy (SWL), open surgical interventions like ureterolithotomy and/or combinations of these methods depending on the above factors [4].

Ultrasonography is one of the several imaging modalities (Intravenous urogram, CT KUB, CT urogram, MR urogram) available to the physician in the evaluation of patients with acute urologic disorders. Color Doppler Ultrasonography is an advancement of the conventional ultrasonography in which the Doppler Effect is employed. It can be used to visualize "ureteric jets". The ureteric jet creates when the bolus of urine being transmitted through the ureter reaches the terminal portion; it is ejected forcefully in to the bladder through the vesicoureteric junction (VUJ). Many studies have shown that there is an association between ureteric obstruction and the ureteric jets [5, 6, 7, 8, and 9].

Color Doppler Ultrasonography is an advancement of the conventional ultrasonography in which the Doppler Effect is employed. In Doppler Ultrasonography measurements and visual records are made of the shift in frequency of a continuous ultrasonic wave proportional to the blood flow velocity in underlying vessels. The energy of the returning echo is displayed as an assigned color; by convention echoes representing flow towards the transducer is seen as shades of red, and those representing flow away from the transducer is seen as shades of blue.

The color display is usually superimposed on the B-mode image, thus allowing simultaneous visualization of anatomy and flow dynamics. It can be used to visualize "ureteric jets". The ureteric jet creates when the bolus of urine being transmitted through the ureter reaches the terminal portion; it is ejected forcefully in to the bladder through the vesicoureteric junction (VUJ).

Usually lasts for a few seconds but is sufficient enough to produce a frequency shift which can be demonstrated by color Doppler Ultrasound. Color Doppler Ultrasound is in fact the easiest method for demonstrating the jet and it is also amenable for further characterization using a pulse-wave Doppler wave-form. Many studies have shown that there is an association between ureteric obstruction and the ureteric jets.[10]

The purpose of this study is to describe the usefulness of colour Doppler ultrasound and serum creatinine in evaluation of patients with ureteric calculi.

II. MATERIALS AND METHODS

This descriptive study was conducted using 83 patients with calculus disease, aged 20-60 years, who presented to Teaching Hospital, Peradeniya, from July 2015 to July 2016. All the patients underwent-ray KUB and color Doppler sonography with ureteral jet assessments and their serum creatinine levels

were obtained. Patients who had more than one ureteric calculus, ureteric calculus size more than10mm, bilateral calculi of the ureters, abnormal serum creatinine level (more than 1.2mg/dl in men and 1.0mg/dl in women,)hydronephrosis due to causes other than calculus disease, history of renal or urological surgical interventions and pregnancy were excluded from the study.

All the subjects underwent an ultrasound- KUB examination on the same day. Kidneys, ureters and bladder were scanned. Data on the length and the degree of hydronephrosis were recorded by grey-scale ultrasound. The degree of hydronephrosis was graded as none, mild, moderate, or severe according to standard definitions. Ten minutes of continuous real-time observation and simultaneous recording of both obstructed and non-obstructed ureterovesical orifices in axial plane at the trigone level was evaluated by means of Colour Doppler ultrasonography to visualize ureteric jets as an additional procedure. The frequency of jets was recorded for each ureteric meatus in every patient. The peak ureteric jet velocity and the duration of the ureteric jet in seconds was measured by using a standard software in the scan machine.

III. RESULTS

The mean creatinine level was 89.51± 30.43 mmol/L. The percentage of patients with mild, moderate, severe and no hydronephrosis was 72.7%, 4.0%, 3.9% and 19.5% respectively.

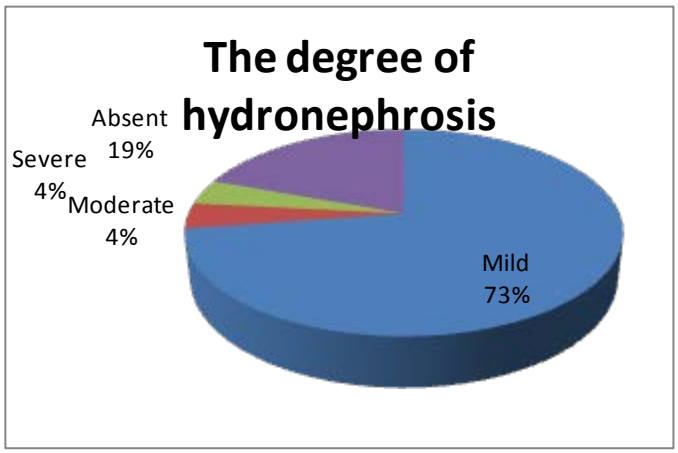

Figure 01; The percentage of patients with mild, moderate, severe and no hydronephrosis

Ipsilateral jet was absent in 44.6% of patientswhile jet was present in 55.4%. Serum creatinine was elevated in 22.6% of patients with absent ureteric jet, and in 3.6% of patients with normal jets. Patients with absent ipsilateral ureteric jet had significantly higher mean serum creatinine levels (mean=103.2 mmol/L) compared to the patients with observable jet (mean=75.9 mmol/L) (p=0.001). There were no significant differences in mean serum creatinine values among various degrees ofhydronephrosis (p=0.510). There was a significant association between the ureteric jet status with the degree of hydronephrosis (p=0.001)

IV. DISCUSSION

Out of the medical imaging methods available color Doppler ultrasonography of the ureteric jet is a valuable tool in detecting obstructive uropathy because it yields real time functional information than plain radiography and B-mode ultrasonogrphy. It demonstrates the degree of ureteric obstruction, without exposing the patient to ionizing radiation as in other imaging modalities such as IVU or CT [11].This is undoubtedly beneficial in the management of obstructive uropathy caused by a ureteric stone. By determining an association between the degree of hydronephrosis and the ureteric jet characteristics, it is possible to ascertain the degree of obstruction.

A study done using 25 healthy men in Japan, showed that the detection of the jet phenomenon by Doppler color flow mapping is a promising new way of examining renal or ureteric function non-invasively [9]. Then a study done in 1997 concluded that the analysis of ureteric jets with color Doppler enable detection and qualitative determination of the degree of ureteric obstruction in many patients with unilateral calculi [13].

Another study done with 46 patients in Iran compared the ureteric jet characteristics in obstructed ureter with the non-obstructed side and showed that the ureteric jet characteristics in obstructed ureter showed low frequency, shorter duration and lower peak velocity. Hence, they concluded that Doppler ultrasound examination is a useful adjunct to the normal grey-scale ultrasound in diagnosis of ureteric obstruction considering the safety of this study and the significance difference in ureteric jet characteristics between the obstructed and the unobstructed ureters. [14].

A study done on 100 patients presenting with renal colic in Catania, Italy where they underwent colour-Doppler ultrasonographical evaluation of their urinary tracts showed that colour-Doppler ultrasonography (CDU) improves the diagnostic accuracy of ultrasound in differentiating the obstructive and non-obstructive dilatation. They went on to say that when combined with CT, CDU has 100% sensitivity and specificity [15]. Doppler visualization of ureteric jets in unilateral hydronephrosis in children and adolescents was done in one study where they could show that the absence of jets in patients with acute obstruction due to ureteric calculus strongly correlates with high-grade obstruction [16].

Considering the management of ureteric stones, they can be managed with multiple methods including observation and medical expulsion therapy, ureteroscopy, shock wave lithotripsy (SWL), open surgical interventions like ureterolithotomy and/or combinations of these methods. The choice of the method depends on stone location, size, patient factors, anatomical considerations and surgeon preference [17]. Commonly applied method for evaluating patients with acute flank pain is a radiography film of kidneys, ureter and bladder (X ray-KUB) which is mostly combined with ultrasonography [12].Most ureteric stones can be observed under adequate analgesia for uneventful stone passage. This is a less costly and less invasive method compared to other interventions [18].

Spontaneous passage of ureteric stones is mainly dependent on stone size and location amongst other factors. One study done in United States using unenhanced computed tomography showed that ureteric stones < 5 mm had a greater than 75%

chance of spontaneous passage regardless of location. Larger stones were less likely to pass (for stones 5-7 mm, 60%; for stones 7-9 mm, 48%; and for stones larger than 9 mm, 25%). Stone location regardless of size was also a significant factor; spontaneous passage rates were 48% for stones in the proximal ureter, 60% for mid ureteric stones, 75% for distal stones, and 79% for ureterovesical junction stones [19]. Another study revealed that the time to stone passage can take greater than a month but can be as high as 95% in stones < 5 mm in size [18]. It has been recommended that the time allowed for spontaneous stone passage should not exceed four to six weeks due to the risk of renal damage [20].

In those patients with no evidence of an infection, adequately controlled symptoms, and smaller ureteric stones, observation for spontaneous passage is an excellent option. It has been shown that attempts at spontaneous passage of stones can save a patient from invasive surgical interventions as well as significant cost [21].

Conservative expectant management is not appropriate in patients with persisting or recurrent pain, persistent ureteric obstruction, urinary tract infection, solitary kidney or renal insufficiency.

Several studies have been conducted to assess the predicting factors of success rates in medical expulsion therapy. In 2012, a study was done to investigate stone passage with tamsulosin-based medical expulsion therapy and they noted that transverse stone diameter, longitudinal stone diameter, ureteric diameter (proximal to stone), and ureter-to-stone diameter ratio which are parameters on CT imaging were inversely associated with successful stone passage, of stone position within the ureter ($P < 0.001$). Only longitudinal stone diameter (maximal stone diameter on coronal reconstruction) was significantly associated with stone passage on logistic regression analysis. Rates of stone expulsion appeared to drastically decrease at the 5 mm mark measured longitudinally with 70% and 84.3% passage of 4-5 mm upper and lower ureteric stones, respectively and 42.9% and 44.8% passage of 5-6 mm upper and lower ureteric stones, respectively [22].

Active stone removal should be the option for stones with a diameter $\geq$ 7 mm and when adequate pain relief cannot be achieved, ureteric obstruction is associated with infection; there is a risk of urosepsis in solitary kidneys with obstruction or in cases of bilateral obstruction, without going for medical expulsion therapy. [26]. When active removal of the ureteric stone treatment is needed, the choice of intervention is dependent on several factors apart from stone size and location, including surgeon's preference, patient's preference, cost and availability of equipment [23].

The standard first-line approach in the management of symptomatic ureteric stone is relief of obstruction by insertion of a nephrostomy tube or a double-J stent and fragmentation of the stone later. If there is evidence of sepsis at the time of presentation, Insertion of a nephrostomy tube under local anesthesiais is considered to be better as it is also relatively less invasive. However, it's likely disadvantages are leakage, dislodgement of the tube and the need to manage the stoma [18]. Insertion of a double-J stent, can give rise to complications such as perforation of the ureter and failure to pass the stent in some cases, and increased the risk of urosepsis[24].

Shock-wave lithotripsy (SWL) was introduced to clinical practice as a treatment for ureteric stones in the early 1980s. The lithotriptor attempts to break up the stone with minimal collateral damage by using an externally applied, high-energy shock waves or high-intensity acoustic pulse. Today, even with presence of newer methods for stone removal such as ureteroscopy, SWL remains the primary treatment for most uncomplicated upper urinary tract calculi. The meta-analysis published by the American urological association nephrolithiasis Guideline Panel in 1997 documented that the stone-free rate for SWL for proximal ureteral stones overall was 83% (78 studies, 17,742 patients) [25]. The current meta-analysis analyzed stone-free rates following SWL for three locations in the ureter (proximal, mid, distal). They are 82% in the proximal ureter (41 studies, 6,428 patients), 73% in the mid ureter (31 studies, 1,607 patients), and 74% in the distal ureter (50 studies, 6,981 patients) [25].

Ureteroscopy(URS) is another treatment option for ureteric stones, it is as upper urinary tract endoscopy performed most commonly with an endoscope passed through the urethra, bladder, and then directly into the upper urinary tract. Overall stone-free rates are remarkably high at 81% to 94% depending on stone location, with the vast majority of patients rendered stone free in a single procedure [25]

Shock-wave lithotripsy and URScan achieve success for most cases of ureteric calculi [25]. In extreme situations or in cases of simultaneous open surgery for another purpose, open surgical ureterolithotomy might rarely be considered. For most cases with very large, impacted, and/or multiple ureteric stones in which SWL and URS have either failed or are unlikely to succeed, laparoscopic ureterolithotomy is a better alternative than open surgery if expertise in laparoscopic techniques is available. Although highly effective, laparoscopic ureterolithotomy is not a first-line therapy in most cases because of its invasiveness, longer recovery time, and the greater risk of associated complications compared to SWL and URS [25].

The use of ureteric jet characteristics by colour ultrasonography may provide an immediate radiologically less costly solution to this acute agonizing condition to decide on the patient management.

V. CONCLUSION

Assessment of ureteric jet on ultrasound, along with serum creatinine, is useful in the assessment of the degree of obstruction in evaluation of patients with ureteric calculi.

REFERENCES

[1] Clark JY, Thompson IM, Optenberg SA. Economic impact of urolithiasis in the United States. *J Urol* 154(6):2020-2024

[2] Ramello A, Vitale C, Marangella M. Epidemiology of nephrolithiasis. Journal of Nephrology 2000; 13 (Suppl. 3): 545–50.

[3] Miller OF, Kane CJ. Time to stone passage for observed ureteral calculi: A guide for patient education. *J Urol*. 1999;162:688–91

[4] Wood KD, Gorbachinsky I, Gutierrez J. Medical expulsive therapy.*Indian J Urol*. 2014; 30(1): 60–64

[5] Matsuda T[1], Saitoh M. Detection of the urine jet phenomenon using Doppler color flow mapping. *International journal of Urology* 1995; 2(4):232-4.

[6] Burge HJ[1], Middleton WD, McClennan BL, Hildebolt CF. Ureteral jets in healthy subjects and in patients with unilateral ureteral calculi: comparison with color Doppler US.*Radiology* 1991; 180(2):437- 42.

[7] Jandaghi AB, Falahatkar S, Alizadeh A, Kanafi AR, Pourghorban R, Shekarchi B, Zirak AK, Esmaeili S. Assessment of ureterovesical jet dynamics in obstructed ureter by urinary stone with color Doppler and duplex Doppler examinations. *Urolithiasis* 2013; 41(2):159-163.

[8] Kuzmii AC, Brkljačić B, Radoš M , Galešić K. Doppler visualization of ureteric jets in unilateralhydronephrosis in children and adolescents. *European Journal of Radiology* 2001; 39(3):209-214.

[9] Pepe P[1], Motta L, Pennisi M, Aragona F.Functional evaluation of the urinary tract by color-Doppler ultrasonography (CDU) in 100 patients with renal colic.*Eur J Radiol.* 2005 Jan;53(1):131-5.

[10] Matsuda T[1], Saitoh M. Detection of the urine jet phenomenon using Doppler color flow mapping..*International journal of Urology* 1995; 2(4):232-4.

[11] Erwin BC, Carroll BA, Sommer FG. Renal colic: the role of ultrasound in initial evaluation. *Radiology* 1984; 152(1) :L47 -50

[12] Dalla Palma L, Pozzi-Mucelli R, Stacul F. Present-day imaging of patients with renal colic. *Eur Radiol*.2001;11:4–17.

[13] Burge HJ[1], Middleton WD, McClennan BL, Hildebolt CF. Ureteral jets in healthy subjects and in patients with unilateral ureteral calculi: comparison with color Doppler US. *Radiology* 1991; 180(2):437- 42.

[14] Jandaghi AB, Falahatkar S, Alizadeh A, Kanafi AR, Pourghorban R, Shekarchi B, Zirak AK, Esmaeili S. Assessment of ureterovesical jet dynamics in obstructed ureter by urinary stone with color Doppler and duplex Doppler examinations. *Urolithiasis* 2013; 41(2):159-163.

[15] Pepe P[1], Motta L, Pennisi M, Aragona F.Functional evaluation of the urinary tract by color-Doppler ultrasonography (CDU) in 100 patients with renal colic.*Eur J Radiol.* 2005 Jan;53(1):131-5.

[16] Kuzmii AC, Brkljačić B, Radoš M , Galešić K. Doppler visualization of ureteric jets in unilateralhydronephrosis in children and adolescents. *European Journal of Radiology* 2001; 39(3):209-214.

[17] Wood KD, Gorbachinsky I, Gutierrez J. Medical expulsive therapy.*Indian J Urol*. 2014; 30(1): 60–64.

[18] Wood KD, Gorbachinsky I, Gutierrez J. Medical expulsive therapy.*Indian J Urol*. 2014; 30(1): 60–64.

[19] Coll DM, Varanelli MJ, Smith RC. Relationship of spontaneous passage of ureteral calculi to stone size and location as revealed by unenhanced helical CT. *AJR AMJ Roentgenol. 2002;178:101-3*

[20] Cooper JT, Stack GM, Cooper TP. Intensive medical management of ureteral calculi. *Urology*.2000;56:575–8

[21] Lotan Y, Gettman MT, Roehrborn CG, Cadeddu JA, Pearle MS. Management of ureteral calculi: A cost comparison and decision making analysis. *J Urol*. 2002; 167:1621–9.

[22] Lee SR, Jeon HG, Park DS, Choi YD. Longitudinal stone diameter on coronal reconstruction of computed tomography as a predictor of ureteral stone expulsion in medical expulsive therapy. *Urology*.2012; 80:784–9.

[23] Autorino R, Osorio L, Lima EA. Rapid extracorporeal shock wave lithotripsy for proximal ureteral calculi in colic versus noncolic patients. *Eur Urol*. 2007;52:1264–5

[24] Joshi HB, Obadeyi OO, Rao PN. A comparative analysis of nephrostomy, JJ stent and urgent *in situ*extracorporeal shock wave lithotripsy for obstructing ureteric stones. *BJU Int.* 1999; 84:264–9.

[25] Preminger GM, Tiselius HG, Assimos DG, Alken P, Buck C, Gallucci M, et al. Guideline for the management of ureteral calculi. *J Urol* 2007;178:2418–34.

[26] Pepe P[1], Motta L, Pennisi M, Aragona F.Functional evaluation of the urinary tract by color-Doppler ultrasonography (CDU) in 100 patients with renal colic.*Eur J Radiol.* 2005 Jan;53(1):131-5.

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