

Vesicoureteral Reflux Grading using Different Imaging Techniques (MCUG, NM, and US): A Comparative Study

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Abstract

The aim of this study was to compare the different imaging procedures (micturating cystourethrogram [MCUG], nuclear medicine [NM], and ultrasound [US]) in the evaluation of vesicoureteral reflux (VUR).

Methods and Results: A retrospective study was conducted to compare different radiological investigations in the characterization and grading of VUR. In total, 93 patients (53 boys and 40 girls) with a mean age of 2.2 years were referred to the radiology department for exclusion or diagnosis of VUR. Age, sex, the pathway of obstruction, presence of VUR, degree of obstruction with VUR, presence of hydronephrosis, calcification, and grading according to MCUG were the main variables collected for US, NM, and MCUG.

Our results show that according to the frequency distribution, MCUG showed a higher sensitivity for detecting VUR and the degree of obstruction than the other imaging tools. US showed a higher sensitivity for the presence of hydronephrosis. The grading of VUR was more effectively detected by MCUG than by US and NM grading. We revealed a statistical association between VUR grades and the gender of a study's population, with a higher frequency of grade 5 in boys than in girls ($P=0.037$). Grades 3-5 showed higher frequencies in MCUG, in which the younger patients (0–50 weeks old) were more affected by obstruction and VUR than the other age groups. Moderate hydronephrosis was higher in boys than in girls ($P=0.006$).

Conclusion: The grading of VUR is more effectively detected by MCUG than by US and NM grading. (International Journal of Biomedicine. 2023;13(1):106-110.)

Keywords: vesicoureteral reflux • grading • micturating cystourethrogram

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Abbreviations

CL, the confidence level; ce-VUS, contrast-enhanced voiding urosonography; DMSA, dimercapto succinic acid; NM, nuclear medicine; NASHA/Dx, non-animal stabilized hyaluronic acid/dextranomer gel; MCUG, micturating cystourethrogram; RNC, radionuclide cystography; US, ultrasound; UTI, urinary tract infection; VUR, vesicoureteral reflux.

Introduction

The normal process and pathway of urination are affected by various pathological conditions involving interference with the normal passage of urine from the kidneys to the urinary bladder, which can result in infection of various

sites with various microorganisms, stones, strictures, or soft tissue masses. The normal process requires normal sphincters to judge the micturition, which is physiologically controlled by the normal innervation process.⁽¹⁾

Vesicoureteral reflux (VUR), the flow of urine back to the kidneys from the bladder, is a well-recognized, frequently

diagnosed, and understandable phenomenon.⁽²⁾ The big bang theory of reflux nephropathy postulates that renal parenchymal infection and scarring can result from the reflux of infected urine through the ureters to the upper renal tract.⁽³⁾ Pyelonephritis-induced renal scarring in childhood is a major risk factor for protein in the urine,⁽⁴⁾ renal hypertension, and renal failure.^(5,6) About 39%-40% of children with UTI presented with VUR.⁽⁷⁾

Untreated VUR can lead to various urinary tract manifestations, renal infections,^(8,9) pyelonephritis,⁽⁵⁾ and chronic renal failure (CRF) as a consequence of congenital renal hypoplasia.⁽¹⁰⁾ Gbadegehin et al.⁽⁶⁾ reported that VUR is a hereditary disease associated with a mutation in the gene encoding tenascin XB (TNXB in 6p21.3). One study on VUR after kidney transplantation found that 4.5% of patients had this disorder.⁽¹¹⁾

Imaging is an important step in the diagnosis and management of VUR, as it helps identify a congenital or acquired process due to anatomical or functional congenital abnormalities.⁽¹²⁾ VUR can be investigated using different methods to identify the grade of disease (VUR is graded 1–5, with 5 being the most severe);⁽¹³⁾ MCUG, also known as voiding cyst urography, is frequently used as a standard method of diagnosis, but because there are issues of increasing the radiation dose, some authors have introduced the use of ce-VUS,^(14,15) direct and indirect RNC,⁽¹⁵⁾ Tc-99m DMSA renal scintigraphy, and renal ultrasonography.⁽⁵⁾

Treatment of VUR is antibiotic prophylaxis or ureteral re-implantation to prevent complications.⁽¹⁶⁾ Serial imaging is required to identify the degree of resolution after antibiotic prophylaxis.⁽¹⁷⁾ Another method involving the endoscopic injection of NASHA/Dx (Deflux) was also introduced.⁽¹⁸⁾

The aim of this study was to compare the different imaging procedures (micturating cystourethrogram [MCUG], nuclear medicine [NM], and ultrasound [US]) in the evaluation of VUR.

Materials and Methods

A retrospective study was conducted to compare different radiological investigations in the characterization and grading of VUR. All examinations were carried out at King Salman bin Abdulaziz Medical City in Almadinah Almunawwarah from 2021 to 2022.

In total, 93 patients (53 boys and 40 girls) with a mean age of 2.2 years were referred to the radiology department for exclusion or diagnosis of VUR.

Age, sex, the pathway of obstruction, presence of VUR, degree of obstruction with VUR, presence of hydronephrosis, calcification, and grading according to MCUG were the main variables collected for US, NM, and MCUG.

MCUG was performed using the Luminos dRF Max Fluoroscopy machine produced by Siemens. The bladder was filled with 350 mg of Omnipaque (a contrast medium), diluted with normal saline, to visualize the urine pathway and identify any reflux. An ultrasound scan was performed with the patient in a supine position to identify the bladder, ureters, and kidneys, in order to determine the degree of hydronephrosis. Thirty-seven patients underwent successive

MCUG, ultrasound (Voluson E10), and renal scintigraphy scans (SPECT/CT, GE Healthcare).

Five grades of VUR were analyzed (Figure 1)⁽¹³⁾

Grade I: reflux into a nondilated ureter.

Grade II: reflux into the upper collecting system without dilatation.

Grade III: reflux into the dilated ureter and/or blunting of calyceal fornices.

Grade IV: reflux into a grossly dilated ureter.

Grade V: massive reflux, with significant ureteral dilatation and tortuosity and loss of the papillary impression.

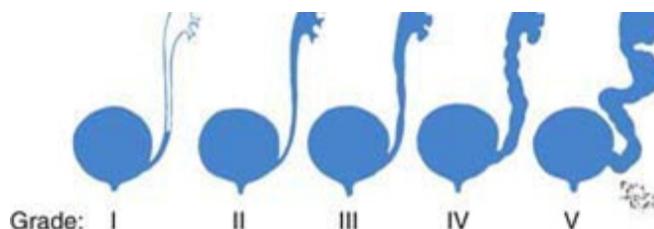


Fig. 1. The International Reflux Study Classification of I to V based on the appearance of the urinary tract on a contrast voiding cystourethrogram (VCUG).⁽¹³⁾

Statistical analysis was performed using statistical software package SPSS version 20.0 (SPSS Inc, Armonk, NY: IBM Corp). For descriptive analysis, results are presented as mean \pm standard deviation (SD). The independent t-test was applied to compare two groups for data with normal distribution. Group comparisons with respect to categorical variables are performed using chi-square test. A probability value of $P < 0.05$ was considered statistically significant.

Ethical approval for this study was obtained from the Ethical Committee at King Salman bin Abdulaziz Medical City (Almadinah Almunawwarah). Written informed consent was obtained from each patient's parent/guardian/ relative.

Results

An obstructed vesicoureteral junction was identified in 14 and 13 out of 37 patients in NM and US, respectively, while the same patients, in addition to the 65 patients, revealed obstructed pathways in the MCUG study (Table 1). Cross-tabulations revealed a statistical association between grades and the gender of a study's population, with a higher frequency of grade 5 in boys than in girls ($P = 0.037$) (Table 2). Moderate hydronephrosis was higher in boys than in girls. ($P = 0.006$) (Table 3). In our study, the more frequent grades were grades 3-5, with a higher percentage for grade 5 (Figure 2).

Our results show that according to the frequency distribution, MCUG showed a higher sensitivity for detecting VUR and the degree of obstruction than the other imaging tools. US showed a higher sensitivity for the presence of hydronephrosis. The grading of VUR was more effectively detected by MCUG than by US and NM grading.

Higher frequency ultrasounds were able to identify mild hydronephrosis, followed by moderate to severe conditions

with the possibility of no hydronephrosis (Figure 3). Grades 3-5 showed higher frequencies in MCUG, in which the younger patients (0–50 weeks old) were more affected by obstruction and VUR than the other age groups (Figure 4). Notably, there was a significant correlation between the degree of hydronephrosis and gender.

Table 1.

Different imaging procedures (MCUG, NM, and ultrasound) in the evaluation of VUR according to the degree of the vesicoureteral junction obstruction.

Vesicoureteral junction	NM	US	MCUG
Obstruction	14	13	92
No obstruction	8	5	1
Not clear obstruction	15	19	0
Total	37	37	93

Table 2.

Cross-tabulation of VUR grade and sex.

		VUR grading (MCUG)					Total	Statistics
		Grade 1	Grade 2	Grade 3	Grade 4	Grade 5		
Sex	Boys	2	2	8	13	26	51	Yates' $\chi^2 = 6.581$ $P\text{-value} = 0.160$
	Girls	1	7	11	8	11		
Total		3	9	19	21	37	89	
P-value		0.794*	0.059*	0.131	0.625	0.037		

*-P-value in chi-square test with Yates' correction

Table 3.

Cross-tabulation of the hydronephrosis by US grade and sex.

		Hydronephrosis by US				Total	Statistics
		Mild	Moderate	Severe	No hydronephrosis		
Sex	Boys	19	16	10	5	50	$\chi^2=12.059$ $P=0.008$
	Girls	18	3	5	12		
Total		37	19	15	17	88	
P-value		0.378	0.006	0.398	0.011		

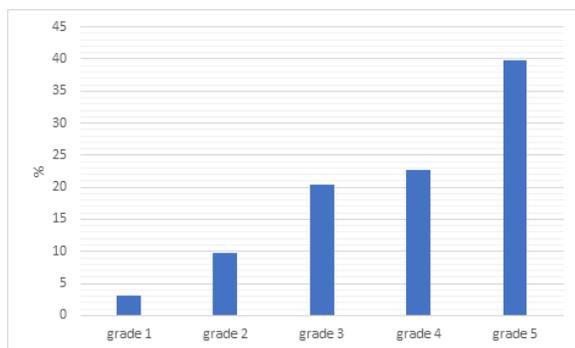


Fig. 2. Reflux grading according to MCUG.

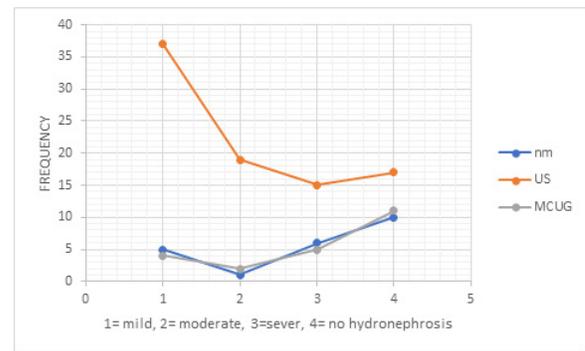


Fig. 3. Hydronephrosis grading.

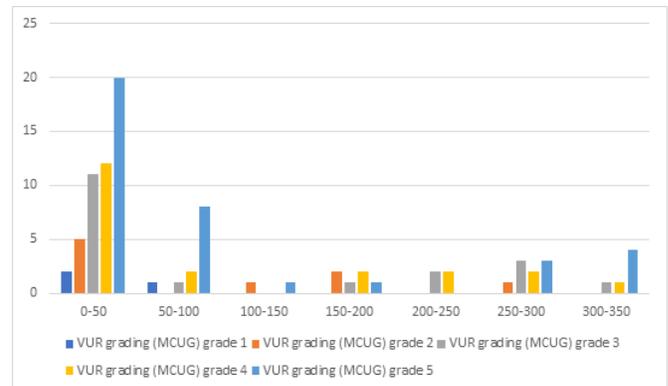


Fig. 4. Cross-tabulation of the VUR grade and age groups (in weeks)

Discussion

Identification of the reflux process in childhood genitourinary disease is considered an important step in identifying the treatment lines. The MCUG image shows (Figure 5) marked retention of contrast reaching both kidneys, an ultrasound of the same patient shows a dilated calyceal system, and a DMSA scan shows prominent hyperactive kidneys. We compared pathway obstructions seen in 37 NM scans with 93 MCUG scans. The results showed X-ray scans to be more sensitive in grading VUR than the other imaging procedures, which indicated that complete urinary tract obstructions are not frequently seen. An obstructed vesicoureteral junction was identified in 14 and 13 out of 37 patients in NM and US, respectively, while the same patients, in addition to the 55 patients, revealed obstructed pathways in the MCUG study (Table 1).



Fig. 5. VUR grading with MGUC (A), a dilated calyceal system showing the degree of hydronephrosis (B), and an NM scan of dilated kidneys (C)

We observed that obstruction could be confirmed after a few minutes of voiding in NM scans, as was seen in Papadopoulou et al.⁽¹⁹⁾ MCUG is indicated for patients with recurrent UTI, UTI with fever, bladder outlet obstruction, and abnormal US scans to exclude dysfunctional voiding as a result of a neurogenic bladder. International guidelines identify 5 grades of VUR. In our study, the more frequent grades were grades 3-5, with a higher percentage for grade 5 (Figure 2).

All advanced grades of VUR showed a variable degree of dilatation, which indicates the presence of hydronephrosis. All compression revealed that US imaging is the best method of quantifying such a condition, with MCUG and DMSA scans being the least effective. Higher frequency ultrasounds were able to identify mild hydronephrosis, followed by moderate to severe conditions with the possibility of no hydronephrosis. Braga et al.⁽²⁰⁾ identified hydronephrosis as a major risk factor for VUR.

Correlation analysis was done to investigate the gender effect on the presence and grading of VUR using various imaging modalities. The male gender was predominant in this study, and other authors reported similar results.^(20,21) Cross-tabulations revealed a statistical association between grades and the gender of a study's population, with a higher frequency of grade 4 and grade 5 in boys than in girls (Table 2). A statistical association was noted between the degree of hydronephrosis and gender; however, mild hydronephrosis occurs at the same frequency in females and males. Moderate to severe hydronephrosis was higher in boys than in girls (Table 3).

The study also indicated a statistical association between VUR grades and age group, with children aged 0–50 weeks having a predominantly higher frequency of grade 5. Chang et al.⁽²²⁾ obtained a similar result, noting that children aged 0.3–1.3 years have a higher frequency of VUR than other age groups.

Conclusion

VUR can be congenital or acquired.⁽²³⁾ Our results reveal the importance of the choice of imaging procedure in grading VUR (MCUG), ascertaining the presence of hydronephrosis (US), and identifying related factors that lead to VUR. The grading of VUR is more effectively detected by MCUG than by US and NM grading. Such knowledge is necessary to determine the best treatment for the patient, to ensure early management, and to avoid possible complications, such as renal scarring and agenesis, in follow-up care.

Competing Interests

The authors declare that they have no competing interests.

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