

Assessment of the usefulness of classic Voiding Cystourethrography in monitoring vesicoureteral reflux treatment

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Abstract

Vesicoureteral reflux (VUR) is a retrograde urine flow from the urinary bladder into upper units of urinary tract. It is often associated with posterior urethral valve anomaly in about half of patients with VUR. Voiding Cystourethrography (VCUG) is a gold standard in prediction and monitoring VUR outcomes. In our study we prove the significance of the conventional

method of prediction of vesicoureteral reflux which is voiding cystourethrography and its value in evaluating the treatment progression. Although this diagnostic method is conventional, but still useful and crucial in modern pediatric urology.

Keywords: vesicoureteral reflux, voiding Cystourethrography, posterior urethral valve

Introduction

Vesicoureteral reflux (VUR) is a condition which is caused by retrograde urine flow from the urinary bladder into one, both ureters or even renal calyces [1]. The prevalence of the disorder is estimated at 0,4 to 1,8% in the pediatric population [2]. The reflux is mostly diagnosed antenatally in children without any symptoms [3]. VUR's causes might be divided into two components depending on previous disorders - primary and secondary [1]. The first one is due to abnormal antireflux action as a result of disfunction of ureterovesical junction(UVJ) [1]. The second one is caused by antireflux action, which function is correct, nevertheless its mechanism is overwhelmed [1]. Bladder-out-let obstruction, neurogenic bladder or infection can be ascribed to the main reason of secondary VUR [1]. Even 68% of patients with the disorder will recover spontaneously, mostly in patients with grade 1-3 VUR [4]. From 20% even to 30% of the patients will develop urinary infection (UTI) and only few will suffer from long-term renal sequelae [5]. In accordance with international

guidelines in VUR diagnosis is a voiding cystourethrography (VCUG) [6, 7]. The imaging method has a unique ability in detection anatomical abnormalities of lower urinary tract [7, 8]. Besides of VUR, one can reveal bladder shape, size and capacity [9]. VCUG reveals reflux of urine retrogressing through non-dilated ureters (grade I) to dilated and tortuous ureters with calyceal clubbing (V) [6]. The severity of the pathology conditioning reflux grading (Tab 1).

Mild VUR is referred as grade I and II, moderate VUR is grade III and severe are grades IV and V [10, 11]. The examination consists of urethral catheterization and filling the bladder with iodine contrast medium. Subsequently, the patient is undergoing a x-ray irradiation in fluoroscopy [12, 13, 14]. While distending the bladder with contrast, filling it with its capacity and micturition, the spot images should be taken. The procedure ends when the patient voids under fluoroscopy [11]. Regrettably, VCUG is not considered to be a «benign procedure». The main drawback of this procedure is radiation, but also a fact that it leads to traumatic and painful children's experience and can

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Table 1 The severity of the pathology conditioning reflux grading

VUR grading		Description of radiological image
I	MILD	retrograde urine flow does not reach the urine pelvis
II		retrograde urine flow reaches the renal pelvis and does not dilate fornices
III	MODERATE	retrograde urine flow might minimally deform fornices
IV	SEVERE	retrograde urine flow causes moderate ureter dilatation and/or tortuosity and moderate dilatation of renal pelvis and calyces; blunt fornices, but the impression of papillae is not visible in majority of papillae
V		retrograde urine flow causes gross ureter dilatation and tortuosity; loss of papillary impression

Source: Own.

cause urinary tract infection in 1-3% of patients [6, 14, 15]. Management depends on the grade determined in VCUG and should be assort individually to each patient. It is worth mentioning that benefits, balance risk and effects of treatment vs. risks of not treating the condition are crucial in making treatment decisions [3, 16]. The management is consisted into two options - preservative which involves observation as well as antibiotic prophylaxis and invasive one that includes endoscopic injection and ureteral reimplantation [4, 3]. The association of the vesicoureteral reflux and other abnormalities, such as: posterior urethral valves (PUV) and anatomical or functional bladder disturbances are confirmed in many cases [13, 14, 15, 17]. One of the most common concomitant disease is posterior urethral valves, which prevalence ranges from 26 to 72% cases patients with VUR [18]. PUV is the main cause of bladder trabeculation [17, 18]. Valve ablation is a recommended method of treatment, which leads to spontaneous resolution of reflux in half of patients [18]. Another disorders connected with VUR are bladder anatomical or functional irregularities, including bladder trabeculation. Bladder trabeculation is a condition in which increased intravesical pressure leads to hypertrophy of its wall [17]. The aim of this study is to prove the significance of the conventional method of prediction of vesicoureteral reflux which is voiding cystourethrography and its value in evaluating the treatment progression.

Materials and methods

Study design and patient population

There were 100 patients with the diagnosis of vesicoureteral reflux who were followed at Pediatric Surgery and Urology Clinic in the Clinical Voivodeship Hospital No. 2 in Rzeszow from 2017 to 2023. We retrospectively reviewed the records of patients with vesicoureteral reflux from 2014 to 2023, who were examined minimum 2 VCUGs. We evaluated clinical parameters of gender, VCUG findings, PUV presence or absence, unilateral or bilateral character of the disease, other coexistence urinary

tract anomalies, methods of treatment and absence or presence of improvement after treatment. We compared VCUG findings before and after management. We also analyzed the most common abnormalities conjuncted with VUR.

Clinical strategy for VUR and criteria

The diagnosis of VUR was made according to VCUG confirmed by radiologists. The diagnosis was based on standarized evaluation of critical areas and conditions. They include anteroposterior (AP) projection of bladder and urinary tract during early filling, fulfilling phase and voiding, which ends the procedure. It is essential to grade the renal collecting system with or without the presence of reflux. Reveal of posterior urethral valves in boys is also crucial in the examination. The grading for severity of VUR is based on the International Reflux Study in Children. Analysis of the x-ray images enables to grade VUR from 1 to 5. Similarly, like in other x-ray procedures, radiologists followed the principle of As Low As Reasonably Achievable (ALARA), which means using appropriate radiation dose to acquire the desired image.

Statistical analysis

VUR management was analyzed with the Statistica Program. Clinical characteristics were compared between children with PUV and without this abnormality in the whole population of children with VUR using the Chi-square and McNemar tests. Statistical significance was established at $P < 0.05$.

Results

The analysis involved 100 children with VUR, 65 of them were diagnosed with PUV by VCUG examination. Among the study group 10 were female and 90 were male. Laterality was unilateral in 52 patients (52%) and bilateral in 48 cases (48%). Unilateral VUR was right in 29 patients and left in 23. The most common abnormal findings by VCUG were posterior urethral valves, bladder trabeculation, bladder neck obstruction and other disorders, at a low frequency, such as : duplication of pelvicalyceal system, megaureter, horseshoe kidney, urethral stricture, polyp of the verumontanum, multicystic dysplastic kidney, diverticulum of bladder (Fig. 1).

Simultaneously, the population were examined with kidney function and observed its normal function, hypofunction (22%) and afunction (8%). The therapeutic management includes invasive (85%) and solely conservative treatment (15%). All patients (65%) with PUV underwent urethrotomy (invasive procedure). We identify a statistical significant association between the presence of PUV and bladder trabeculation ($p=0,0001$). Bladder trabeculation was examined in 71 patients (71%), 55 (55%) in patients with PUV, 16 (16%) without PUV (Fig. 2).

ANATOMICAL ABNORMALITIES CO-EXISTENCE WITH VUR

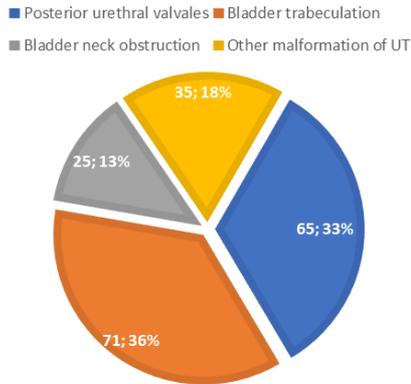


Fig. 1 Other malformations of urinary tract includes: duplication of pelvicalyceal system, megaureter, horseshoe kidney, urethral stricture, polyp of the verumontanum, multicystic dysplastic kidney, diverticulum of bladder
Source: Own.

The VUR grading was divided into 3 groups of its severity including mild (I and II grade), moderate (III grade) and severe (IV and V grade). The analysis of treatment improvement was based on decrease of VUR grade in VCUG. The regression of reflux after management was stated in 73 patients (73%). The analysis showed statistical significant correlation between presence of bilateral VUR and treatment improvement in a group with diagnosis of PUV ($p=0.003$). The output normal renal function increases the chance of improvement after treatment in both populations - with PUV ($p=0,017$) and without PUV ($p=0,015$).

There is also a correlation between renal function and a grade of VUR in a group without PUV ($p=0.04$) (Fig. 5). The majority of patients without PUV had normal renal function and severe grade of VUR (13%).

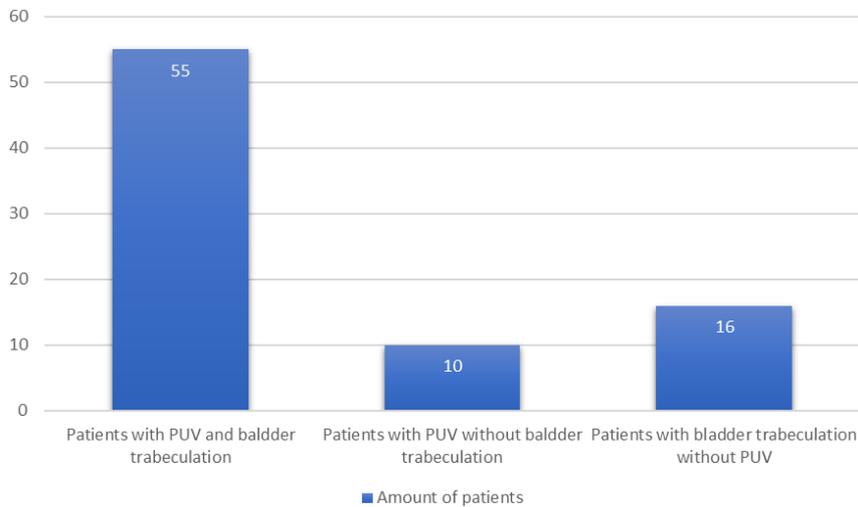


Fig. 2 Comparison of PUV and bladder trabeculation co-existence
Source: Own.

Correlation of kidney function at diagnosis in patients with PUV and improvement after treatment.

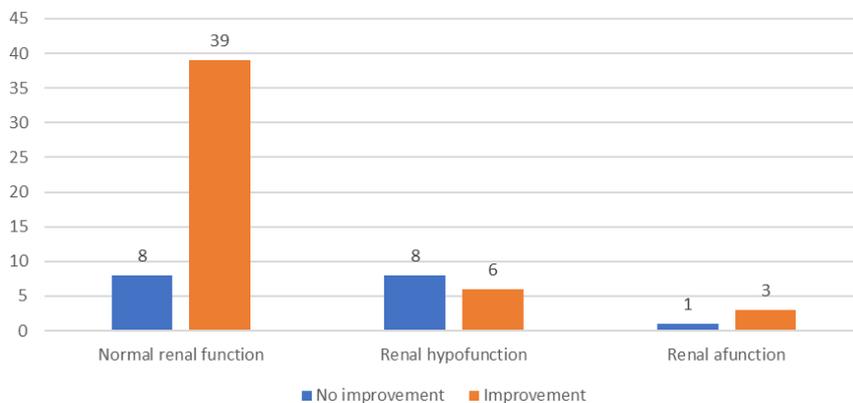


Fig. 3 Correlation of kidney function at diagnosis in patients with PUV and improvement after treatment
Source: Own.

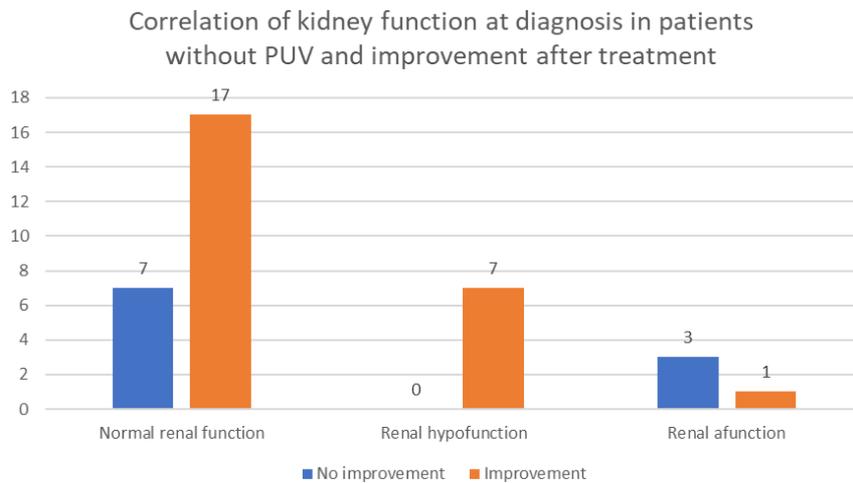


Fig. 4 Correlation of kidney function at diagnosis in patients without PUV and improvement after treatment
Source: Own.

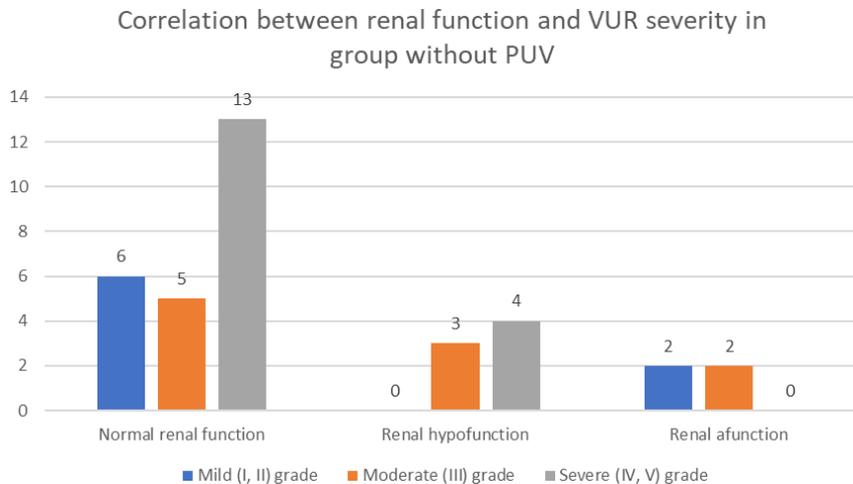


Fig. 5 Correlation between renal function and VUR severity in group without PUV
Source: Own.

The analysis found no statistical significance in regression after invasive treatment in a group without PUV ($p=0,359$) in McNemar test. We are also unable to identify any correlation between bilateral reflux and renal function in the whole stated population ($p=0,816$).

Discussion

The aim of voiding cystourethrography (VCUG) is to show the anatomy and function of the bladder and urethra. This dynamic procedure presents function and coordination of the lower urinary system. The most important indication for VCUG is to assess the presence or absence of vesicoureteral reflux (VUR). Diseases associated with VUR include congenital urinary tract defects, trauma and postoperative urinary tract evaluation.

In our study, we assessed the usefulness of the classic CUM examination for diagnosis and treatment monitoring in pediatric patients. We focused mainly on showing the usage of CUM as

a test for monitoring the treatment of vesicoureteral reflux. In the study group (100 patients: 90 male and 10 female), we show that CUM is not only a good test for diagnosing urinary tract anomalies but is also effective monitoring of surgical treatment and evaluation after conservative treatment.

Vesicoureteral reflux is often associated with posterior urethral valve anomaly, as approximately half of patients with this anomaly have it at the time of diagnosis [19]. Reflux is likely secondary to increased intravesical bladder valve pressure. Other related factors that may intensify reflux include loss of integrity of the ureterovesical junction from an enlarged bladder or periureteral diverticulum. In our study, this is confirmed: 65% of the examined patients had PUV. Vesicoureteral reflux (VUR) is associated with an increased risk of urinary tract infections and renal scarring or reflux nephropathy. In the pediatric group, reflux nephropathy with VUR can be attributed to scarring from an upper urinary tract infection (UTI) as well as congenital renal dysplasia [3, 20].

Our statistical analysis proved that normal renal function at baseline increases the chance of improvement after treatment in both populations - with PUV ($p=0.017$) and without PUV ($p=0.015$). There is also a correlation between renal function and the degree of VUR in the group without PUV ($p=0.04$). This means that vesicoureteral reflux is unlikely to resolve if it is severe and associated with a poorly functioning kidney. Therefore, early diagnosis and treatment are important, followed by assessment and treatment of the underlying cause, usually vesicoureteral reflux (VUR). This result confirms the importance of appropriate diagnostics are to maintain proper kidney function and achieve therapeutic success. In most cases, VUR does not directly cause any symptoms; it is diagnosed prenatally in children with hydronephrosis or later, after the occurrence of symptomatic UTIs. A UTI can cause permanent kidney damage, which can lead to kidney failure afterwards [3].

A statistically significant relationship was also identified between the presence of PUV and bladder trabeculation ($p=0.0001$). Bladder trabeculation in children and adolescents is mainly caused by (PUV) and excessive detrusor activity [21].

Our study has several limitations. Firstly, our analysis is a retrospective cohort study. Secondly, the age of the study patients was not determined because the protocol and follow-up periods were different. Moreover, patients were subjected to a different number of tests (from 2 to 7). The reliability of the test may also depend on the skills of the person performing the test and the patient's cooperation. Therefore, it is so important that the examination is performed by a trained technician with experience in imaging pediatric patients and assessment and interpretation is done by an experienced radiologist.

Voiding cystourethrography has the unique ability to provide detailed information about both the anatomical and functional status of the urinary tract. However, the literature indicates significant differences between institutions in the VCUG protocol used, as well as inconsistent reporting of VCUG results [8]. Although the grade of VUR is routinely reported, other important anatomical and functional findings are consistently underreported. Given the invasive and relatively unpleasant nature of VCUG, it is important to obtain and report as much information as possible when performing these tests.

VCUG still has many applications in the diagnosis of urinary tract abnormalities. In our study, we show numerous applications of the above study. This is why it is so important to provide good patient care to understand and perform VCUG appropriately.

Conclusions

CUM is a gold standard in prediction and monitoring VUR outcomes. VUR is often associated with PUV, which appearance is estimated about 65% in our study population. Our statistical analysis was entrenched by performing minimum 2 VCUGs - before, after and in some cases during treatment to conduct

further patients' condition monitoring. Although this diagnostic method is conventional, but still useful and crucial in modern pediatric urology.

Author's contribution

The authors agree on equal distribution of partial participation.

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Statements

All authors have read and agreed with the published version of the manuscript

Conflicts of Interest

The authors declare no conflict of interest

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