Pediatric Voiding Cystourethrogram: Indications, practice and findings of the technique based on current literature and experience

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Learning objectives

This poster aims:

• To provide an understanding of the imaging method, called Voiding Cystourethrography (VCUG).

• To review the most recent guidelines concerning the indications of VCUG in the pediatric population.

• To provide an insight to the anatomical structures of the normal pediatric urinary tract as observed through the use of the technique, and describe pathological findings detected by VCUG.
Background

Voiding cystourethrogram (VCUG), also micturating cystourethrogram (MCUG), is a technique that utilizes fluoroscopic and radiographic imaging to examine the lower urinary tract. The main advantage of MCUG, is the quality in which it can demonstrate the anatomical features of the lower urinary tract, and its high sensitivity in detecting Vesicoureteral Reflux (VUR) although radiation exposure and patient discomfort pose some considerable limitations for its routine use. VCUG examinations involve a radiation dose of (1 mSv), that is equivalent to 4 months of natural background radiation, although various techniques have been developed and are employed where possible in order to limit this dose.³

**INDICATIONS AND CONTRAINDICATIONS**

VCUG has been extensively used for the detection of VUR, especially in children who had Urinary Tract Infection requiring further investigation. However, its use is not limited to the latter. VCUG is requested by physicians for the investigation of a variety of pathologies, a summary of which is provided in Table 1. While no absolute contraindications exist, any sensitivity of the urethra due to a recent surgery or the patient’s allergy to iodinated contrast should be taken into consideration as relative contraindications before performing the examination.¹

<table>
<thead>
<tr>
<th>Urinary tract infection</th>
<th>Congenital genitourinary anomalies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydronephrosis (Prenatally diagnosed)/Hydroureter</td>
<td>Bladder outlet obstruction</td>
</tr>
<tr>
<td>Dysuria</td>
<td>Postoperative urinary tract evaluation</td>
</tr>
<tr>
<td>Dysfunctional voiding</td>
<td>Trauma</td>
</tr>
<tr>
<td>Neurogenic dysfunction of the bladder</td>
<td>Incontinence</td>
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<tr>
<td>Hematuria</td>
<td></td>
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</table>

**COMMON INDICATIONS FOR THE USE OF VCUG**¹.

**VCUG FOR THE INVESTIGATION OF UTI AND VUR**

Since the main indication for the majority of the VCUG examinations performed in children is the investigation of UTI for the presence of VUR, it has been considered imperative to include current evidence on this subject. The Royal College of
Physicians (RCP) has recommended guidelines for the management of UTI in children in 1991 (2), and their revised form has been published by the National Institute of Clinical Excellence (NICE) UK, in 2007 (3). Moreover, such guidelines have been produced by the American Academy of Pediatrics (AAP) in 1999 (4) and revised in 2011 (5). The guidance illustrated below is in accordance to the NICE guidelines which differ in very little from the AAP guidance. Table 2. summarizes the indications for the use of VCUG in children for the investigation of UTI as described in NICE guidelines.

<table>
<thead>
<tr>
<th>AGE</th>
<th>ABSOLUTE INDICATION</th>
<th>RELATIVE INDICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger than 6 months</td>
<td>Atypical UTI a</td>
<td>Abnormal Ultrasound scan (performed within 6 weeks), in a patient that responds well to treatment within 48 hours.</td>
</tr>
<tr>
<td></td>
<td>Recurrent UTI b</td>
<td></td>
</tr>
<tr>
<td>6 months - 3 years old</td>
<td>In atypical or recurrent UTIs in the case that dilatation on ultrasound, poor urine flow, non E-coli infection and family history of VUR are present.</td>
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</tr>
<tr>
<td>3 years old or older</td>
<td>US and DMSA scans should be preferred</td>
<td>US and DMSA scans should be preferred</td>
</tr>
</tbody>
</table>

RECOMMENDATIONS FOR THE USE OF VCUG FOR THE INVESTIGATION OF UTI IN CHILDREN (3)

a. Atypical UTI includes: Poor urine flow, seriously ill patient, abdominal or bladder mass, raised creatinine, septicaemia, no response to treatment in 48 hours, non E-coli infection (3).

b. Recurrent UTI is defined as: two or more UTI episodes with upper UTI infection or acute pyelonephritis OR, one episode of upper UTI/acute pyelonephritis and an episode of cystitis or lower UTI OR, three or more episodes of cystitis or lower UTI (3).

The rationale behind the use of VCUG in the investigation of UTI in children has mainly been the need for early detection of VUR, a condition that was thought to predispose children to the development of renal scarring in a manner reversible.
with the surgical correction of VUR. Studies have shown however, that the surgical correction of VUR is no more beneficial in preventing renal scarring than the use of prophylactic antibiotics, while some suggest that even the latter might not be beneficial as well, depending on the grade of reflux \(^5, (8)\).

Thus, recent UK and US recommendations having taken under consideration the burden of the use of VCUG in children, do not recommend the routine use of VCUG after a first time febrile UTI in children, with minor differences concerning other indications \(^5\). The use of VCUG in infants younger than 6 months is still recommended, since it can be valuable in delineating correctable congenital abnormalities or the presence of bladder outlet obstruction as in the case of posterior urethral valves.
Imaging findings OR Procedure details

**TECHNIQUE OVERVIEW**

VCUG is performed with the use of fluoroscopic and radiographic imaging and involves the aseptic catheterization of the bladder and the use of iodinated contrast media.

Prior to the examination, prophylactic antibiosis is orally administrated for 3 days and the VCUG examination should be performed on the second day. Unless already available, a preliminary abdominal radiograph of the investigated area should be acquired prior to the administration of contrast agent, in order to observe for calcifications and skeletal anomalies. Following, during the bladder catheterization, the child is not sedated but local anesthetic is used for the insertion of 5 (<3 months of age), 8 or 10 (adolescents) French catheters according to the age and anatomy of the child, always by experienced personnel. The contrast agent (iodinated contrast media 12%-18% weight/volume solution) is administrated through the catheter into the bladder by gravity drip (1, 3, 6).

An early filling last-image capture of the bladder should be acquired in order to evaluate the bladder anatomy, and fluoroscopic observation follows until the filling of the bladder. Expected bladder capacity volume can be calculated according to the following formula: For Ages < 1 y.o.: \( V = \text{Weight (kg)} \times 7 \), For Ages>1 y.o.: \( V = [\text{Age (y)} + 2] \times 30 \). The resulting volumes can be used for the prediction of the administrated contrast media and the bladder filling time. Left and right oblique images focused on the ureterovesicular junction should be obtained with a full bladder. The patient should be given time and motivation to initiate urination and upon the urinating phase, pulsed fluoroscopy should be utilized to detect any signs of reflux. Upon the initiation of voiding, the renal fossae should be demonstrated by anteroposterior images to document the presence or absence of reflux. When reflux is detected, the operator should record it in the frontal projection especially in the case of intra-renal reflux (1, 6).

The demonstration of the urethra is also considered necessary, and while in females this can be obtained in the frontal view, in males the urethra should be demonstrated in the oblique view during voiding. Spot images after voiding are useful in documenting any residue urine, the presence or absence of reflux in the cases that the patient has been allowed to use the restroom due to inability to initiate voiding on the exam table, and in cases of suspected obstruction in which
delayed images are useful in estimating contrast drainage from the pyelocalyceal system \(^{(1)}\).

It is important that the operator monitors fluoroscopy time and ensures minimal radiation exposure through the use of pulsed fluoroscopy, last image capture and limited image acquisition and where available, video recording \(^{(1, 6, 7)}\).

VCUG ASSESSMENT AND FINDINGS

The VCUG examination should be assessed for the following features \(^{(1, 6)}\):

- The anatomy of the urinary bladder including its volume before and after voiding to document any bladder dysfunction, its contour and lumen to indicate any masses or the presence of ureterocele, bladder tumors or bladder diverticula.
- The anatomy of the urethra.
- The anatomy of the pelvic area to indicate any congenital anomalies e.g anomalies of the sacrum or genitourinary fistulas.
- The presence of vesicoureteral reflux, its grade and whether or not it involves intra-renal reflux.
- The presence of any calcifications, foreign bodies and opaque calculi

ASSESSMENT AND DOCUMENTATION OF VESICOURETERAL REFLUX (VUR)

Suspicion of VUR consists the indication of the majority of VCUG requests. The presence of VUR should be documented along with the characterization of the degree of reflux, according to the International Reflux system \(^{(6)}\) as presented in Fig. 1 on page :  

- GRADE I: Reflux into the ureter
- GRADE II: Reflux into the ureter and into the pyelocaliceal system with no signs of dilatation
- GRADE III: Reflux into the ureter and into the pyelocaliceal system which appear mildly dilated.
- GRADE IV: Reflux into the ureter with tortuous ureter appearance and into the pyelocaliceal system which is dilated and has blunted fornical angles.
• GRADE V: Reflux into ureter which appears markedly dilated and tortuous, and into the pyelocalyceal system with obliteration of the forniceal angles and the pappillary impressions.

ANATOMICAL ANOMALIES OF THE BLADDER AND THE URETHRA

As previously described, VCUG can be valuable in describing the anatomy of the urinary bladder and the urethra. Abnormal findings of the bladder wall and the urethra can be delineated by the contour described through the use of contrast media while defects in bladder volume or in the ability to void can be identified through the filling of the bladder. VCUG can also reveal pre and post-surgical or congenital anomalies, such as fistulas involving the lower urinary tract (e.g. urethrovesical fistulas, urethrovaginal fistulas).

A case of urinary bladder diverticula revealed through the use of VCUG in a patient with U/S diagnosis of congenital dilation of the pyelocalyceal system is attached to illustrate the value of the technique in the identification of anomalies in the contour of the urinary bladder Fig. 2 on page 9.

Furthermore, in the presence of VUR, VCUG can aid the detection of anatomical anomalies of the ureters, the pyelocalyceal system and the kidney, as illustrated in a case of an ectopic kidney with VUR that was falsely perceived as kidney aplasia on ultrasound examination and was detected on a re-examination by ultrasound following VCUG (Fig. 3 on page 10).
Fig. 1: Figure displaying images and an illustration of the grades of VUR according to the International Grading System.

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Fig. 2: Figure displaying diverticula of the urinary bladder in an patient with congenital hydronephrosis.

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Fig. 3: Figure displaying an ectopic left kidney with the presence of VUR as revealed by VCUG.

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Conclusion

VCUG is a method used for a long time now and a wealth of experience has been accumulated on its indications, applications and interpretation. The limitations of the technique correspond to its risk for complications such as infections or trauma of the urethra, the exposure to ionising radiation (approximately 1 mSV), and the nature of the technique that is usually stressful to patients and parents / carers.

However, VCUG is still considered as the gold standard for the investigation of VUR and can be invaluable in investigating anatomical abnormalities of the lower urinary tract. The emergence of modern techniques such as MR cystography, cystosonography and radionuclide cystography and the changes in the management of VUR have rendered the indications of VCUG under reconsideration but have certainly not substituted its use \(^3\).

The careful use of VCUG with respect to the recommendations of international bodies, the utilization of radiation-limiting techniques and the combination with other imaging methods are means of taking advantage of the technique’s value in investigating pediatric disease in the modern clinical setting.
References


