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Establishing a Standard Protocol for the Voiding Cystourethrography

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abstract

The voiding cystourethrogram (VCUG) is a frequently performed test to diagnose a variety of urologic conditions, such as vesicoureteral reflux. The test results determine whether continued observation or an interventional procedure is indicated. VCUGs are ordered by many specialists and primary care providers, including pediatricians, family practitioners, nephrologists, hospitalists, emergency department physicians, and urologists. Current protocols for performing and interpreting a VCUG are based on the International Reflux Study in 1985. However, more recent information provided by many national and international institutions suggests a need to refine those recommendations. The lead author of the 1985 study, R.L. Lebowitz, agreed to and participated in the current protocol. In addition, a recent survey directed to the chairpersons of pediatric radiology of 65 children's hospitals throughout the United States and Canada showed that VCUG protocols vary substantially. Recent guidelines from the American Academy of Pediatrics (AAP) recommend a VCUG for children between 2 and 24 months of age with urinary tract infections but did not specify how this test should be performed. To improve patient safety and to standardize the data obtained when a VCUG is performed, the AAP Section on Radiology and the AAP Section on Urology initiated the current VCUG protocol to create a consensus on how to perform this test.

INTRODUCTION

The voiding cystourethrogram (VCUG) and the nuclear cystogram are the accepted tests in national and international institutions to diagnose vesicoureteral reflux (VUR). The VCUG aims to image the urinary tract, including the urethra, bladder, ureters, and kidneys, during bladder filling and emptying. The VCUG has many components that can be individually reviewed on the basis of evidence, but no evidence-based protocol for the VCUG per se is available. The International Reflux Study in 1985[1] is the only published protocol. However, a recent survey directed to the chairpersons of pediatric radiology of 65 children's hospitals in the United States and Canada showed that VCUG protocols vary substantially.[2] The use of different VCUG protocols raises concerns

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about patient safety and does not allow valid comparison of data and outcomes between individuals and institutions. Unlike the VCUG, most imaging studies are performed by using protocols that have national and often international consensus that allow the comparison of results across centers and achieve a uniform level of patient safety. Recent guidelines from the American Academy of Pediatrics (AAP) recommend a VCUG for children between 2 and 24 months of age with a urinary tract infection but did not specify how this test should be performed.[3] Ward et al[4] compared the radiation exposure and effective dose in children undergoing VCUG. They found an 8 times reduced radiation exposure when using grid-controlled, variable-rate pulsed fluoroscopy versus conventional continuous fluoroscopy. To strike the balance between obtaining high-quality images and minimizing radiation exposure, radiology departments should observe the "as low as (is) reasonably achievable" (ALARA) and Image Gently guidelines. Image Gently is an initiative of the Alliance for Radiation Safety in Pediatric Imaging. Both promote radiation protection for the patient and radiologic personnel.[5,6]

Differences in individual test parameters can have a significant effect on the outcome of the test and have the potential to influence management protocols for individual patients. In a study in 183 patients after minimally invasive ureteral injection therapy, 60% of patients with a postoperative positive VCUG result did not show VUR until the bladder was filled over the age-adjusted bladder capacity.[7] If an alternative protocol had been used that filled the bladder just to the age-adjusted capacity, those patients would have had a negative study result, and their surgery would have been considered successful. Therefore, the postoperative success rates would be a function not only of the surgical technique and skill of the surgeon but also of the specific VCUG imaging technique.

Many components of the VCUG are universally accepted and performed equally throughout different institutions. Little discussion exists regarding the necessity to empty the bladder before the test and to use a small nonballoon catheter for filling. The use of more than 1 bladder filling is a common standard, because several groups showed that cyclic filling increases the reliability to detect VUR.[8,9] It is also well established that several voiding cycles may be necessary to detect the presence of an ectopic, refluxing ureter.[10] The documented relationship between bladder volume at the onset of VUR and outcome causes many pediatric urologists to ask their radiology departments to note the bladder volume when VUR first occurs. Bladder volume when VUR first occurs is important, because previous studies have shown that VUR occurring at lower bladder volumes and pressure has a tendency to resolve spontaneously less often, independent of grade.[11] In addition, Alexander et al[8] verified that bladder volume at the onset of VUR is an independent risk factor for breakthrough febrile urinary tract infection.

The VCUG can be a traumatizing test for patients and parents alike. Sedation can be used as long as the effects do not alter the voiding phase and therefore the outcome of the test. However, patient and parent education, along with providing a comfortable environment with well-trained staff and the addition of child life specialists when available, is of great importance to minimize stress.[12,13]

The multitude of data on the effect of the VCUG technique on test outcome has caused many departments to adapt similar parameters of the VCUG in their protocols, such as the practice guidelines of the American College of Radiology.[14] However, other components of the VCUG are controversial, such as the use of sedation or immobilization. These controversies lead to different protocols among institutions, making it problematic to compare outcomes even when the details of the technique are reported.

Standard evidence-based protocols in medicine are important to minimize patient risk and to improve the validity of comparing data and outcomes between individuals and institutions. Great efforts were made to ensure that the renal scan protocol used in the Randomized Intervention for Children with VesicoUreteral Reflux (RIVUR) Study was uniform across the participating centers.[15] However, the very test that evaluated the presence and grade of VUR was not standardized. To improve our understanding of VUR, a standardized protocol of how to perform the diagnostic VCUG study is necessary.

Because the VCUG is ordered by many different pediatric specialties and the test results are used to determine treatment of the individual patient, this statement disseminates the current protocol to reach the broad community of pediatric health care providers. Medical circumstances can make it necessary to alter the protocol to accommodate a patient's specific needs; in those cases, the reasons should be documented and the changes noted in the report.

VCUG TEMPLATE

Patient Name; Date of Birth; Medications; Medical Record Number

Date of Study

Reason for Examination: Information Provided by Ordering Physician

Comparison: Previous Studies

Technique

Informed consent is obtained and documented in the patient's record.

1. Observe ALARA and Image Gently principles (see ALARA/Image Gently Principles).[5,6]

2. Observe recommendations for possible sedation (see Sedation).
3. Observe recommendations for possible immobilization (see Immobilization).
4. Toilet trained: allow patient to void in private bathroom immediately before the study.
5. After voiding and for non–toilet-trained individuals: insert a small age-appropriate (3.5–8 French) nonballoon catheter with the use of sterile technique (see Sterile Catheterization).
6. Measure postvoid residual (PVR) urine in milliliters.
7. Obtain a single anterior-posterior (AP) scout image covering the kidneys, ureters, and bladder (KUB).
8. Retrograde fill the bladder (see Bladder Filling) with radiographic contrast (see Contrast) at body temperature.
9. During filling, obtain multiple spot images in AP, right and left oblique, and lateral positions (see Spot Images).
10. Fill bladder until voiding occurs and stop contrast flow (see Bladder Filling).
11. Obtain voiding images of the urethra (see Spot Images).
12. Refill bladder until voiding occurs (see Cyclic Voiding, Bladder Filling).
13. Obtain voiding and postvoid images of the kidneys and bladder (see Spot Images).
14. Record maximum amount of contrast instilled.

Findings

Scout Image

1. Osseous structures, especially symphysis and spine and surrounding soft tissues
2. Any other abnormalities
3. Bowel gas pattern and amount of stool in various portions of the colon to assess for constipation

Bladder

1. Shape and contour
2. Filling defects, trabeculations, or other abnormalities
3. Maximum bladder capacity (at time of first void if cyclic study)
4. Estimate of PVR volume (mild, moderate, or large)
5. Note position and appearance of the bladder neck

VUR

1. Record onset of VUR for each side: (a) approximate bladder volume at which reflux occurred and (b) onset of reflux during filling or voiding.
2. Grade VUR according to the International Reflux Study (see VUR Grading).
3. Comment on the insertion site and anatomy of the ureter(s): (a) normal versus ectopic, (b) single versus duplicated or bifid system, and (c) insertion near or in a diverticulum.
4. Assess drainage of VUR after void. In some patients with VUR, recatheterization may be necessary to assess drainage of the refluxed material, especially in non–toilet-trained children.

Voiding

1. Record bladder volume at onset of voiding.
2. Note appearance of bladder neck as child voids.
3. Estimate bladder volume residual (mild, moderate, or large).

Urethra

1. Record urethral abnormalities including dilatation, valves, strictures, and the appearance in the region of the external sphincter.
2. Record reflux into ejaculatory ducts.

Impression

Summarize findings.

DEFINITION OF PARAMETERS

ALARA and Image Gently Principles

As defined in Title 10, Section 20.1003, of the Code of Federal Regulations (10 CFR 20.1003), ALARA is an acronym for "as low as (is) reasonably achievable," which means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as is practical, consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of nuclear energy and licensed materials in the public interest (US Nuclear Regulatory Commission; last updated December 10, 2012).

The Image Gently Campaign is an initiative of the Alliance for Radiation Safety in Pediatric Imaging. The campaign goal is to change practice by increasing awareness of the opportunities to promote radiation protection in the imaging of children (www.pedrad.org/associations/5364/ig and http://www.imagegently.org/Portals/6/Radiologists/Background4radiologists.pdf).

Sedation

1. Child and family education, preparation, and support during the examination are important for the success of the study (use a certified child life specialist if available).[13]

2. Encourage supportive family members to be present in the fluoroscopic suite.
3. The use of sedation is acceptable in certain situations when all less intrusive methods fail to achieve a relaxed atmosphere for the child and/or family.
4. Because voiding is an integral part of the VCUG, if sedation is used, it should not interfere with voiding.
5. The specific sedation used (oral, intravenous, or inhalation) is at the discretion of the physician and the institution's guidelines. When sedation is used, it should follow the guidelines for preparation, monitoring, and recovery as set forth by the AAP.[16]
6. Because sedation may alter results, its use should be noted in reports, presentations, and manuscripts.

Immobilization

High-quality images with observation of the ALARA and Image Gently principles are required. Restraining devices usually are not necessary but can be used in certain situations.

Contrast Material

Commonly used contrast materials include the following: iothalamate meglumine (Cysto-Conray 17%; Mallinckrodt Pharmaceuticals, manufactured by Liebel-Flarsheim Company LLC, Raleigh, NC) and full-strength diatrizoate meglumine (Cystografin; Bracco Diagnostics, Monroe Township, NJ). The type of contrast should be identified in the report.

Sterile Catheterization

Strict adherence to the principles of medical and surgical asepsis should be followed:

1. Wash hands, clean perimeatal region with antiseptic solution and provide a sterile field.
2. Wash hands, reapply sterile gloves, then insert catheter.
3. Appropriate use of lidocaine or other anesthetic gel has been shown to reduce discomfort but requires adequate contact time to be effective. In boys, lidocaine gel is instilled into the urethra. Lidocaine gel on a gauze pad can be applied to the interlabial area in girls, followed by instillation of gel into the urethra.[17]
4. Placement of the catheter is facilitated by clear identification of the urethral meatus, and exposure is often facilitated by an assistant for girls.
5. Collect urine in a sterile container and record PVR.
6. Send urine for analysis and culture as indicated.

Radiology departments can make specific arrangements to send a urine specimen for analysis and culture if requested by the ordering physician.

Spot Images

Images must be of high quality and should be taken in accordance with the ALARA and Image Gently principles. The usual number of images is KUB + 12 images. Images should be saved from the fluoroscopic imaging rather than obtained by separate reexposures to reduce radiation. If there is pathology, additional images can be obtained to show the abnormality.

Recommended images for the different VCUG phases are as follows:

First fill:

1. AP early first fill
2. AP late first fill
3. At late first fill: AP right anterior oblique, AP left anterior oblique, lateral spine included

Second fill:

AP right anterior oblique and AP left anterior oblique

Voiding Phase

1. AP bladder when voiding occurs:
   d. Females: AP urethra (2–4 images)
   e. Males: lateral to oblique, entire urethra during voiding from the bladder neck to the tip of the penis (2–4 images)

Postvoid

Single KUB, including bladder, ureters, and kidneys.

Bladder Filling

1. Fill bladder with gravity at 100 cm above the examination table.
2. If filling pump is used, infuse at 10% of expected bladder capacity per minute.
3. Estimated bladder capacity as follows[18,19]:
   a. For patients <2 years of age: weight (kg) × 7
   b. For patients >2 to 14 years of age:
      i. In ounces: age in years + 1
      ii. In milliliters: (age in years × 30) + 30
   c. For patients >14 years of age: 500 mL
4. Record infused volume[20]:
   a. Standard: record volume:
      i. At onset of VUR
      ii. Maximum volume infused at time of void
      iii. PVR estimate (mild, moderate, or large)
   b. Additional recommendation for complex cases:
      i. Volume when child is uncomfortable
      ii. Volume when voiding with strong stream
5. Fill bladder until voiding occurs. If bladder filling reaches >2 times bladder capacity and no voiding takes place, consider subsequent

evaluation of patient with videourodynamic study.

Cyclic VCUG

At least 2 voiding cycles are recommended to identify a potential ectopic ureter or intermittent VUR.[21]

1. Child can void around the catheter for the first void.
2. Refill bladder and remove catheter for second void.
3. If an ectopic ureter and VUR is identified on first void and good urethral images are obtained, there may be no need for a second cycle.

VUR Grading

Grade I: ureter only

Grade II: ureter, pelvis, and calyces; no dilatation; normal calyceal fornices

Grade III: mild or moderate dilatation and/or tortuosity of the ureter and mild or moderate dilatation of the renal pelvis; no or only slight blunting of the fornices

Grade IV: moderate dilatation and/or tortuosity of the ureter and moderate dilatation of the renal pelvis and calyces; blunting of the sharp angle of the fornices but maintenance of the papillary impressions in the majority of calyces

Grade V: gross dilatation and tortuosity of the ureter; severe dilatation of the renal pelvis and calyces; the papillary impressions are no longer visible in the majority of calyces

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ABBREVIATIONS

AAP: American Academy of Pediatrics
ALARA: as low as (is) reasonably achievable
AP: anterior-posterior
KUB: kidneys, ureters, and bladder
PVR: postvoid residual
VCUG: voiding cystourethrogram
VUR: vesicoureteral reflux

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