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Assessment of increase in renal pelvic size on post-void sonography as a predictor of vesicoureteral reflux

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Abstract *Background.* During the course of our routine renal ultrasound examinations, we noticed that some children who developed dilatation of a renal pelvis following voiding had reflux found on voiding cystourethrography (VCUG).
Purpose. To determine if increase in renal pelvic size on post-void ultrasound is an accurate predictor of vesicoureteral reflux.
Materials and methods. Fifty-seven children (113 kidneys) underwent renal ultrasound and VCUG on the same day. Anteroposterior dimensions of the renal pelves were prospectively measured on ultrasound prior to and following patient voiding and correlated with the results of the VCUG.
Results. The diameter of the renal pelvis increased in 12 and decreased in 38 kidneys on post-void ultrasound. Vesicoureteral reflux occurred in 19 kidneys and among these kidneys, renal pelvic diameter increased in 2, decreased in 7, and was unchanged in 10 following voiding. There was no significant correlation between post-void change in renal pelvic diameter and the presence of vesicoureteral reflux.
Conclusion. Increase in renal pelvic size on post-void ultrasound is not a reliable indicator of vesicoureteral reflux.

Introduction

Renal ultrasound and voiding cystourethrogram (VCUG) are usually performed to evaluate neonatal hydronephrosis and urinary tract infections (UTI) in infants and children. In some centers, renal ultrasound alone is performed to evaluate older children and adolescents with UTI, as well as children with hematuria, hypertension and abdominal pain with the need for additional studies based on the ultrasound results.

Our routine renal ultrasound examination includes imaging of the kidneys and bladder prior to and following voiding. A full bladder is helpful in assessing bladder wall thickness and for detection of bladder calculi and distal ureteral dilatation. The post-void imaging of the bladder allows determination of the degree of bladder emptying, which can be useful in evaluating children with dysfunctional voiding. Furthermore, mild or even moderate renal collecting system dilatation seen on ultrasound may decrease or resolve following bladder emptying, indicating the absence of an underlying fixed obstruction. During the course of routine clinical care, however, we noticed that some patients developed renal pelvic dilatation following voiding. Some of these patients also underwent VCUG and were found to have vesicoureteral reflux. We performed the following study to determine if a post-void increase in the size of the renal pelvis was a reliable indicator of vesicoureteral reflux.

Materials and methods

This prospective study was performed between 25 August 1995 and 15 November 1996 at the Children's Hospital of Philadelphia in 48 girls and 9 boys known to be undergoing both renal ultrasound and VCUG on the same day. Only children with full bladder who voided during the course of the ultrasound examination were

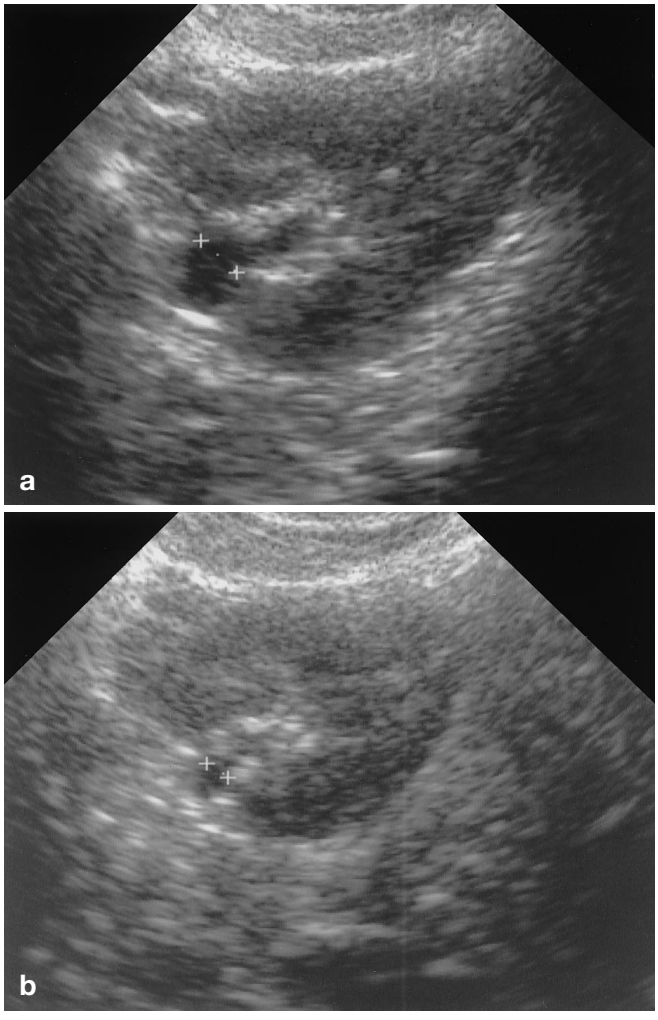

Fig. 1 a, b Diameter of the renal pelvis was measured on transverse ultrasound images through the mid-kidney. Transverse ultrasound images through the mid-kidney performed before (**a**) and after (**b**) voiding. There is a 3 mm decrease in pelvic size following voiding. The VCUG demonstrated grade III reflux

included in the study. Ages ranged from 1 month to 16.5 years (mean 5 years). One hundred thirteen kidneys were examined. Indications for referral were urinary tract infection (51), antenatal hydronephrosis (3), incontinence (1), and unknown (2).

Ultrasound exams were performed on Advanced Technology Laboratory (Ultramark 5, Ultramark 9 and HDI 3000) equipment. Measurements were made on the widest section of each renal pelvis on transverse, mid-kidney images (Fig. 1). Patients were imaged in either the supine or prone position before voiding. After voiding, the ultrasound exam was performed in the same position and plane to control for the effect that position can have on renal pelvic distension. The time interval between voiding and the repeat ultrasound examination was not noted, but was generally no more than a few minutes. A difference of 1 mm or more on pre- and post-void images was considered a change in pelvic diameter.

A fluoroscopic voiding cystourethrogram was performed on the same day of the preceding ultrasound. The international system was used to grade the severity of the vesicoureteral reflux [1]. Statistical analysis (correlation coefficient using x-y pairs) was performed using StatView SE + (v 1.03, Abacus Concepts, Inc. Berkeley, Calif.).

Table 1 Pre-void renal pelvic diameter

Diameter (mm)	Number of kidneys (kidneys w/VUR)
0	47 (6)
1	2 (0)
2	14 (4)
3	13 (3)
4	8 (3)
5	10 (1)
6	10 (2)
7	4 (0)
8	2 (0)
9	2 (0)
10	1 (0)

Table 2 Post-void renal pelvic diameter

Diameter (mm)	Number of kidneys (kidneys w/VUR)
0	53 (7)
1	2 (1)
2	17 (3)
3	21 (7)
4	9 (0)
5	2 (0)
6	1 (1)
7	5 (0)
8	1 (0)
9	2 (0)

Results

Renal pelvic diameter ranged from 0 to 10 mm (mean 2.5 mm ± 2.7) on pre-void images (Table 1). Renal pelvic diameter ranged from 0 to 9 mm (mean 1.9 mm ± 2.2) on post-void images (Table 2). VCUG showed vesicoureteral reflux in 19 kidneys. Correlation with reflux was 0.005 for pre-void pelvic diameter, 0.017 for post-void pelvic diameter, and 0.014 for post-void change in pelvic diameter. Twelve kidneys (11 %) demonstrated an increase in renal pelvic size on post-void sonography and 38 kidneys (34 %) demonstrated a

Table 3 Change in renal pelvic diameter after voiding

Change (mm)	Number of kidneys (kidneys w/VUR)
− 6	3 (1)
− 5	1 (0)
− 4	4 (1)
− 3	6 (1)
− 2	15 (3)
− 1	9 (1)
0	63 (10)
+ 1	6 (1)
+ 2	2 (0)
+ 3	3 (0)
+ 4	0
+ 5	0
+ 6	1 (1)

Table 4 Results: presence of reflux with post-void increase in renal pelvic dilatation (*VUR* vesicoureteral reflux)

	Post-void increase?		
		Yes	No
VUR	Yes	2	10
	No	17	84

decrease in renal pelvic size (Table 3). The sensitivity for detecting reflux based on increased pelvis size on post-void ultrasound was 11 % and specificity was 89 % (Table 4). The positive and negative predictive values were 17 % and 83 %, respectively (Table 4).

Grade I reflux was seen in 11, grade II in 4 and grade III in 4 kidneys. Reflux was bilateral in 6 and unilateral in 7. Only 2 of the 19 renal units with vesicoureteral reflux had an increase in the renal pelvic dilatation after voiding. Both of these kidneys had grade I reflux. Ten kidneys without vesicoureteral reflux had a post-void increase in renal pelvic size.

Discussion

Acute urinary tract infections are an important source of morbidity in children. Renal damage from recurrent or chronic infections is a cause of hypertension and renal failure. Reflux of urine from the bladder into the upper collecting system provides a pathway for bacteria in the bladder to reach the kidney and compromises the child's natural defenses. Most often, vesicoureteral reflux is a primary process due to immaturity or maldevelopment of the ureterovesical junction (UVJ). Secondary reflux occurs with an underlying urinary tract abnormality such as voiding dysfunction or a bladder diverticulum at the UVJ [2].

Radiologic evaluation of children with urinary tract infections is performed to exclude vesicoureteral reflux, calculus, outflow obstruction, congenital anomaly and renal scarring. Currently, no single method of imaging is satisfactory to answer all of these questions. Ultrasound is performed to evaluate urinary tract obstruction, renal scarring and congenital anomalies. VCUG and radionuclide cystogram (RNC), both of which require catheterization and radiation exposure, are used to detect reflux.

Many investigators [3–8] have evaluated the ability of ultrasound to diagnose or exclude vesicoureteral reflux. Blane et al. [3], DiPietro et al. [4], and Davey et al. [5] performed retrospective reviews in children who underwent VCUG and renal ultrasound on the same day. Blane et al. studied children ranging from 1 week to 19 years of age. DiPietro et al. limited their review to children older than 5 years of age. Both authors found that ultrasound was neither sufficiently sensitive nor specific to avoid a VCUG or RNC when accurate diagnosis of reflux was needed.

Davey et al. [5] retrospectively measured the AP diameters of the renal pelves in 455 children who were 10 years or younger with renal pelvic dilatation $\leq$ 10 mm. These authors found that the frequency of reflux in children with mild renal pelvic dilatation was not significantly different from those without distension and concluded that mild distension of the renal pelvis should not be an indication for VCUG.

Haberlik [6], Marshall et al. [7] and Hiraoka et al. [8] prospectively studied a variety of ultrasound techniques for the diagnosis of vesicoureteral reflux. Habelik [6] used color Doppler ultrasound to determine the direction of urine flow in the distal ureters in 77 children who were catheterized and had their bladders filled with normal saline. Flow of urine from the UVJ towards the ureter was considered diagnostic of reflux. These results were correlated with VCUG performed immediately afterward and showed a 70 % sensitivity and 92 % specificity for color Doppler in the diagnosis of vesicoureteral reflux.

Marshall et al. [7] used color Doppler ultrasound to study the velocity, longitudinal angle, transverse angle and distance from the midline in the bladder of ureteral jets in 31 children. VCUG was performed within 24 h of the ultrasound and vesicoureteral reflux was found in 16 kidneys. These authors found that the ureteral jets were significantly further from the midline for ureters that refluxed than those that did not. These authors concluded that this finding could be useful in determining which children with a first UTI should undergo VCUG, but that further study was needed.

In another study, Hiraoka et al. [8] peformed ultrasound examinations of the urinary tract prior to, during and following voiding in 17 children who were suspected of having a UTI. The renal pelves were found to increase in size during or following voiding in six kidneys of four children. In two of these children, this pelvic di-

latation occurred only during voiding. VCUG showed reflux in all six of these kidneys.

We performed our study to clarify an ultrasound finding that we had seen clinically. Like Davey et al. [5], we wondered about the significance of renal pelvic dilatation. Our study, however, was performed prospectively and we were particularly concerned with increase in pelvic dilatation after voiding, when reflux may occur, possibly due to the increased intravesical pressure related to bladder contraction. We found that this finding was a relatively unusual occurrence; it was seen in only 12 of 113 kidneys, and of minimal to mild degree in our patient population. Additionally, vesicoureteral reflux occurred in only 2 of the 12 kidneys with post-void dilatation and there was no post-void increase in pelvic dilatation in the other 17 kidneys with reflux in our study. We conclude that a mild post-void increase in renal pelvic size is not a reliable indicator of vesicoureteral reflux and should not be considered an indication for VCUG. Furthermore, we believe that a VCUG or RNC should be performed when there is clinical concern for vesicoureteral reflux.

References

1. Lebowitz R, Olbing H, Parkkulainen K, et al (1985) International system of radiographic grading of vesicoureteric reflux. Pediatr Radiol 15: 105–109
2. Lebowitz R, Mandell J (1987) Urinary tract infection in children: putting radiology in its place. Radiology 165: 1–9
3. Blane C, DiPietro M, Zerin J, et al (1993) Renal sonography is not a reliable screening examination for vesicoureteral reflux. J Urol 150: 752–755
4. DiPietro MA, Blane CE, Zerin JM (1997) Vesicoureteral reflux in older children: concordance of US and voiding cystourethrographic findings. Radiology 205: 821–822
5. Davey MS, Zerin JM, Reilly C, et al (1997) Mild renal pelvic dilatation is not predictive of vesicoureteral reflux in children. Pediatr Radiol 27: 908–911
6. Haberlik A (1997) Detection of low-grade vesicoureteral reflux in children by color Doppler imaging mode. Pediatr Surg Int 12: 38–43
7. Marshall J, Johnson N, DeCampo M (1990) Vesicoureteric reflux in children: prediction with color Doppler imaging. Pediatr Radiol 175: 355–358
8. Hiraoka M, Hashimoto G, Hori C, et al (1997) Use of ultrasonography in the detection of ureteric reflux in children suspected of having urinary infection. J Clin Ultrasound 25: 195–199

BOOK REVIEW

Staheli, L. T.: Fundamentals of Pediatric Orthopedics, 2nd edition. 160 pp. Philadelphia: Lippincott-Raven 1998. US $ 67.50.

Type of book: This is a single-author, basic text/atlas of clinical pediatric orthopedics.
Scope: The author attempts to cover the principles of diagnosis and management of orthopedic conditions affecting the spine and limbs of children.
Content: The book is clinically oriented and contains 14 chapters and an index. The first three chapters are on normal and abnormal growth, evaluation (including imaging) and management. This is followed by separate chapters on the different anatomic sites of the lower limb (e. g., hip, knee, foot), upper extremity, and spine.

There are separate chapters on trauma, sports medicine, infections, and tumors.
Strengths: The book contains a large number of beautiful and clear color illustrations and diagrams. There are examples of MRI, e. g., in premature growth plate fusion, discoid meniscus, meniscus cyst, and bone tumors; CT, e. g., in tarsal coalition and spine infection; ultrasound, e. g., in joint effusion and neonatal hip problems; arthrograms; tomograms; and bone scans.

I found the basics of foot deformities, scoliosis and kyphosis, and musculoskeletal infections to be particularly well covered in the book.
Deficiencies: Radiographs are somewhat less clearly reproduced and are generally small, e. g., Figs. 4.31 and 9.20. Fig. 8.18 shows vertebral body compression labeled as "disc collapse" from eosinophilic granuloma.
Recommended readership: This book is aimed at family physicians, medical students and residents in family medicine, sports medicine, orthopedics and, to a lesser extent, residents in radiology and rheumatology.
Overall grading: ***

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Grading key

***** = outstanding; **** = excellent; *** = good; ** = fair; * = poor