ORIGINAL ARTICLE

Renal ultrasound findings and vesicoureteral reflux in children hospitalised with urinary tract infection

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Aims: To determine the sensitivity, specificity, and predictive values of renal ultrasound findings for vesicoureteral reflux (VUR).

Methods: Retrospective review of the ultrasound and voiding cystourethrogram (VCUG) results of 162 children under 5 years of age admitted with their first episode of urinary tract infection (UTI) over a two year period. Ultrasound findings were considered suggestive of VUR if "dilatation of the pelvi-calyces", "dilatation of the ureters", or "dilatation of the collecting system" of one or both kidneys was reported.

Results: A total of 162 patients were eligible for inclusion (median age 85 days; 71 (44%) were female). The prevalence of VUR was 22%. Ultrasound findings were positive for VUR in 14 of 35 patients with confirmed VUR on VCUG, and positive in 30 of 127 patients without VUR on VCUG. Of 21 patients who had a normal ultrasound but showed VUR on VCUG, 14 had grade II reflux, five grade III reflux, and two grade IV reflux. The sensitivity and specificity of ultrasound in suggesting VUR were 40% and 76%, respectively. The positive predictive value of ultrasound in suggesting VUR was 32%; the negative predictive value was 82%.

Conclusion: Renal ultrasound findings are neither sensitive nor specific for VUR in children with a first UTI.

Urinary tract infection (UTI) is a common paediatric problem. It has been estimated that 8% of girls and 2% of boys will have a UTI during childhood.¹ Vesicoureteral reflux (VUR), the retrograde flow of urine from the bladder to the ureter and renal pelvis, has been identified as a risk factor for the development of UTI; one study found that it was present in 18–40% of children investigated for their first UTI.² Current American Academy of Pediatrics³ practice guidelines recommend routine imaging (ultrasound and either voiding cystourethrogram or radionuclide cystography) after the initial UTI in febrile infants and young children (ages 2 months to 2 years). The purpose of the imaging studies is to detect anatomical abnormalities of the urinary tract system as well as VUR. Furthermore, radiologists often report various degrees of dilatation of the collecting system of the kidney and urinary tract on renal ultrasound, suggesting that further investigation for VUR should be done. In a study investigating the optimal timing of voiding cystourethrogram (VCUG) after UTI, only 48% of patients had their scheduled VCUG performed.⁴ This may be related to the invasive nature of the VCUG, which requires urethral catheterisation. Furthermore, parents and physicians may be reassured by a normal ultrasound, and forgo performing the VCUG. The objective of this study was to determine whether the presence of a dilated collecting system of the kidney and urinary tract, as reported by radiologists, predicted the presence of VUR on VCUG.

METHODS

All patients admitted to The Hospital for Sick Children (HSC) from 1 January 1996 to 31 March 1998, with a discharge diagnosis of UTI were identified by searching the computerised health records for urinary tract infection, pyelonephritis, and acute pyelonephritis. HSC is a tertiary care children's hospital in Toronto, Canada.

We reviewed the charts of all children under 5 years of age admitted with UTI, defined as a catheter proven culture of a bacterial growth greater than or equal to 10^5 colony forming units/ml. Children with known underlying genitourinary abnormalities or a history of UTI were excluded.

At HSC, the current standard of care requires that all children under 5 years of age admitted with a culture proven UTI be investigated with ultrasound and VCUG. The timing of these tests is left to the discretion of the attending paediatrician. In this study, a renal ultrasound was considered suggestive of VUR if "dilatation of the pelvi-calyces", "dilatation of the ureters", or "dilatation of the collecting system" of one or both kidneys was reported. All ultrasound scans and VCUGs were performed at HSC and the results reported by staff paediatric radiologists. Reflux was graded using the international system of radiographic grading of VUR.⁵

At HSC, voiding cystourethrograms are performed in a standardised manner. The urinary bladder is catheterised with a flexible #8 French silastic catheter without a balloon and taped into position. Hypaque 18% contrast material is then instilled by gravity from a height no more than 1 m above the fluoroscopy tabletop with the patient in a supine position. Intermittent fluoroscopy is performed during the filling stage to detect VUR or other abnormality. A spot image of the filled bladder is normally obtained. Once the bladder is sufficiently filled, infants and young toddlers will spontaneously void. Older children are instructed to void when they feel full, girls lying supine on a bedpan and boys in a left anterior oblique position over a urinal. Spot images are obtained of bladder and urethra during voiding, the catheter having either been pulled out or fallen out. A post-void image of the bladder and renal fossae is obtained to assess post-void volume and reflux. Ultrasound scans were performed with Acuson Sequoia and ATL 5000 equipment. All studies were performed with sector, curved array, and linear high resolution transducers.

Descriptive statistics for the entire group included age, sex, and prevalence of VUR. The statistical indices used to evaluate the properties of the diagnostic test were sensitivity, specificity, and predictive values (positive and negative). When a gold

Abbreviations: HSC, The Hospital for Sick Children; UTI, urinary tract infection; VCUG, voiding cystourethrogram; VUR, vesicoureteral reflux

Table 1 Ultrasound results by grade of VUR on VCUG

Grade of VUR on VCUG	Ultrasound +	Ultrasound –	Total
I	2	0	2
II	6	14	20
III	1	5	6
IV	5	2	7
V	0	0	0
Total	14	21	35

standard test exists (in this case, VCUG), sensitivity is defined as the proportion of those with the disorder (VUR) in whom the test (renal ultrasound) is affirmative; specificity is the proportion of those without the disorder in whom the test is negative. From a clinical perspective, however, these two indices are not as helpful as predictive values. The positive predictive value in this context is the probability of VUR in children with dilatation noted on the ultrasound scan; the negative predictive value is the probability of no reflux in children with no dilatation noted on ultrasound. Unlike sensitivity and specificity, predictive values are influenced by the prevalence of disease. For all indices, 95% confidence intervals were calculated around the point estimates.

RESULTS

A total of 202 charts of patients less than 5 years of age with a discharge diagnosis of UTI were identified. Thirty two were excluded because of a previous episode of UTI or a negative catheter urine culture, leaving 170 who fulfilled the inclusion criteria of a first episode, catheter proven UTI. Eight patients who were booked for a VCUG as outpatients did not return for their appointment, leaving 162 patients with a first episode UTI who had a VCUG performed.

The median age of the 162 subjects was 85 days; 71 (44%) were female. The median age for males was significantly lower than for females (74 v 157 days, respectively, $p < 0.05$). The age range for males was 6–712 days, and for females 3–1606 days. The median number of days between start of treatment for UTI and ultrasonography was 2 days (interquartile range: 1 day, 3 days). Thirty five patients were found to have VUR on VCUG, giving a prevalence of 22%. Of these 35 patients, two had grade I reflux, 20 had grade II reflux, six had grade III reflux, seven had grade IV reflux, and none had grade V reflux. Ultrasound results suggested the presence of VUR in 14 of these 35 patients, and in 30 of 127 patients without VUR on VCUG. Table 1 shows the distribution of the 35 patients with VUR on VCUG by grade and ultrasound result.

The sensitivity of ultrasound for detection of VUR was 40% (95% CI: 24% to 56%); specificity was 76% (95% CI: 69% to 83%). The positive predictive value of ultrasound for VUR was 32% (95% CI: 18% to 46%) and the negative predictive value was 82% (95% CI: 75% to 89%).

Predictive values were calculated for subjects less than 18 months (151 of the 162 subjects were less than 18 months). The positive predictive value of ultrasound for VUR was 30% (95% CI: 18% to 46%) and the negative predictive value was 82% (95% CI: 73% to 88%). Because only 11 subjects were older than 18 months of age, predictive values were not calculated for this age group.

DISCUSSION

This study shows that ultrasound findings are not predictive of VUR on VCUG. Furthermore, some children with higher grade VUR by VCUG were not detected by renal ultrasound, including five children with grade III and two with grade IV reflux.

Thus, in our opinion, a VCUG is necessary to rule out VUR, regardless of renal ultrasound findings.

For a first episode UTI in infants, renal ultrasound is performed to rule out anatomic abnormalities of the urinary tract. It is a non-invasive form of imaging performed before the VCUG and after the initial infection. Various degrees of dilatation of the collecting system of the kidney seen on renal ultrasound are often reported. A Medline search, however, found only three studies that examined the significance of these findings in children. Davey and colleagues⁶ looked at older children (mean age 4.2 years) who were referred for renal ultrasound and VCUG for a variety of indications, including UTI. They found that the frequency of VUR in children with mild renal pelvic distension did not differ significantly from that in children with no distension on renal ultrasound (39% v 32%, $p = 0.365$). Blane and colleagues⁷ retrospectively analysed VCUG and ultrasound results of 493 children. All children who had a VCUG within eight hours of a renal ultrasound scan were included, except for children with myelomeningocele or renal surgery. The mean age of their study population was 4.9 years. They found that ultrasound was not sensitive for VUR. Of the kidneys with VUR, 74% had normal ultrasound scans. DiPietro and colleagues⁸ found that ultrasound was unreliable in excluding VUR in children aged 5 years or older who were being evaluated for a UTI. Only two of 21 children with VUR on VCUG had abnormal renal ultrasound scans.

Studies have reported on the reliability of colour flow Doppler sonography in the diagnosis of VUR in children.^{9–10} The relation between various degrees of renal collecting system dilatation on fetal ultrasound and postnatal VUR has also been reported; however, this does not apply to our study population.^{11–12}

The median age of the children in our study was 85 days, reflecting the group that often requires hospitalisation for treatment of UTI. They were considerably younger than the children studied previously.^{6–8} The prevalence of VUR in our study population was 22%, an estimate similar to that found in previous studies in the same age group.² The compliance rate for completing the VCUG after the renal ultrasound was excellent (162/170, 95%).

Our study, being retrospective in design, had some limitations. Only children admitted to the hospital were included. All ultrasound and VCUG studies were reviewed by a group of six staff paediatric radiologists. However, inter-rater reliability was not assessed.

Radiologists reading the VCUG results were not blinded to the ultrasound results. Any bias, however, would have been expected to be towards reporting more VUR in patients with “suggestive” ultrasound findings, a bias not evident in the study results.

Conclusion

Renal ultrasound findings are neither sensitive nor specific for VUR in children with a first UTI. Therefore, clinicians should not use renal ultrasound results to influence the decision on whether or not to proceed with a VCUG in the investigation of a first episode UTI in young children.

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REFERENCES

- 1 **Hellstrom A**, Hanson E, Hansson S, *et al*. Association between urinary symptoms at 7 years old and previous urinary tract infection. *Arch Dis Child* 1991;**66**:232–4.
- 2 **Dick PT**, Feldman W. Routine diagnostic imaging for childhood urinary tract infection: a systematic overview. *J Pediatr* 1996;**128**:15–22.
- 3 **American Academy of Pediatrics**. Practice parameter: the diagnosis, treatment, and evaluation of initial urinary tract infection in febrile infants and young children. *Pediatrics* 1999;**103**:843–52.
- 4 **McDonald A**, Scranton M, Gillespie R, *et al*. Voiding cystourethrograms and urinary tract infections: how long to wait? *Pediatrics* 2000;**105**. <http://www.pediatrics.org/cgi/content/full/105/4/e50>.
- 5 **Lebowitz RL**, Olbing H, Parkkulainen KV, *et al*. International system of radiographic grading of vesicoureteric reflux. International reflux study in children. *Pediatr Radiol* 1985;**15**:105–9.
- 6 **Davey MS**, Zerlin JM, Reilly C, *et al*. Mild renal pelvic dilatation is not predictive of vesicoureteral reflux in children. *Pediatr Radiol* 1997;**27**:908–11.
- 7 **Blane CE**, DiPietro MA, Zerlin MJ, *et al*. Renal sonography is not a reliable screening examination for vesicoureteral reflux. *J Urol* 1993;**150**:752–5.
- 8 **DiPietro MA**, Blane CE, Zerlin MJ. Vesicoureteral reflux in older children: concordance of US and voiding cystourethrographic findings. *Radiology* 1997;**205**:821–2.
- 9 **Oak SN**, Kulkarni B, Chaubal N. Color flow Doppler sonography: a reliable alternative to voiding cystourethrogram in the diagnosis of vesicoureteral reflux in children. *Urology* 1999;**52**:1211–14.
- 10 **Haberlik A**. Detection of low-grade vesicoureteral reflux in children by color Doppler imaging mode. *Pediatr Surg Inter* 1991;**12**:38–43.
- 11 **Anderson NG**, Abbott GD, Magridge N, *et al*. Vesicoureteral reflux in the newborn: relationship to fetal renal pelvic diameter. *Pediatr Nephrol* 1997;**11**:610–16.
- 12 **Persutte WH**, Koyle M, Lenke RR, *et al*. Mild pyelectasis ascertained with prenatal ultrasonography is pediatrically significant. *Ultrasound Obstet Gynecol* 1997;**10**:12–18.

ARCHIVIST

Father's work and birth defect risk

It has been suggested that perhaps 60% of birth defects of unknown cause could be due to occupational and environmental teratogens. Maternal exposure in pregnancy has been well studied but paternal exposure less so. The relationship between paternal occupation and risk of birth defect has been reviewed (S-E Chia and L-M Shi. *Occupational and Environmental Medicine* 2001;**59**:149–55).

Ten studies reported between 1989 and 1999 were reviewed. Men found to be at increased risk of having a child with a birth defect included janitors, painters, printers, those exposed to solvents, fire fighters, and agricultural workers. Suggested teratogens include pesticides, solvents, and wood preservative but the writers of this review point to methodological weaknesses in most of the studies and question the strength of the evidence. Paternal occupational exposure could act either directly by an effect on spermatozoa or indirectly by contamination of the mother. Maternal contamination could be a result of contamination of the home or of teratogens secreted into the father's semen.

Certain paternal occupations seem to be associated with an increased risk of birth defect. Future studies need to be concentrated on men in these occupations.