Value of Ultrasound in Detecting Urinary Tract Anomalies After First Febrile Urinary Tract Infection in Children

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Abstract

Background. Urinary tract infection (UTI) is an infection that affects part of the urinary tract. Ultrasound is a noninvasive test that can demonstrate the size and shape of kidneys, presence of dilatation of the ureters, and the existence of anatomic abnormalities. The aim of the study is to estimate the value of ultrasound in detecting urinary tract anomalies after first attack of UTI. Methods. This study was conducted at the Nephrology Clinic, New Children’s Hospital, Faculty of Medicine, Cairo University, from August 2012 to March 2013, and included 30 children who presented with first attack of acute febrile UTI. All patients were subjected to urine analysis, urine culture and sensitivity, serum creatinine, complete blood count, and imaging in the form of renal ultrasound, voiding cystourethrography, and renal scan. Results. All the patients had fever with a mean of 38.96°C ± 0.44°C and the mean duration of illness was 6.23 ± 5.64 days. Nineteen patients (63.3%) had an ultrasound abnormality. The commonest abnormalities were kidney stones (15.8%). Only 2 patients who had abnormal ultrasound had also vesicoureteric reflux on cystourethrography. Sensitivity of ultrasound was 66.7%, specificity was 37.5%, positive predictive value was 21.1%, negative predictive value was 81.8%, and total accuracy was 43.33%. Conclusion. We concluded that ultrasound alone was not of much value in diagnosing and putting a plan of first attack of febrile UTI. It is recommended that combined investigations are the best way to confirm diagnosis of urinary tract anomalies.

Keywords
urinary tract infection, ultrasound, urinary tract anomalies

Introduction

Urinary tract infections (UTIs) are common and important clinical problems in childhood.¹ Prompt diagnosis and effective treatment of recurrent febrile UTI and treatment of bowel and bladder dysfunction that predisposes many children to UTI may be more important than identifying anatomic or functional genitourinary abnormalities after the first febrile UTI in preventing renal scarring.²

Congenital anomalies of the kidney and urinary tract occur in 3 to 6 per 1000 live births and are responsible for 34% to 59% of chronic kidney disease and for 31% of all cases of end-stage renal disease in children in the United States.³

The rationale for imaging in young children with UTI is to identify abnormalities of the genitourinary tract that require additional evaluation or management (eg, obstructive uropathies, dilating vesicoureteral reflux [VUR]).⁴ Evidence to support the utility of routine imaging in reducing long-term sequelae (renal scarring, hypertension, renal failure) is limited and there is a lack of consensus about the optimal imaging strategy.⁵

Ultrasonography is a noninvasive test that can demonstrate the size and shape of the kidneys, the presence of duplication and dilatation of the ureters, and the existence of gross anatomic abnormalities. It can also

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identify renal or perirenal abscess or pyonephrosis in children with acute UTI who fail to improve with antimicrobial therapy. It is not reliable in detecting renal scarring or VUR.6

When the ultrasound should be performed depends on the clinical situation; in infants and young children with unusually severe illness or failure to improve as expected after initiation of antimicrobial therapy, it should be performed as soon as possible during the acute phase of illness to identify complications (eg, renal or perirenal abscess, pyonephrosis). However, for infants and young children who respond as expected to appropriate antimicrobial therapy, it should be performed after the acute phase (to reduce the risk of false positive results secondary to renal inflammation during the acute episode).7 Voiding cystourethrography (VCUG) should be performed at the earliest convenient time.7

The aim of this study was to determine the value of ultrasound in detecting urinary tract anomalies in patients with first attack of UTI. We aimed also to evaluate ultrasound in comparison with VCUG and dimercaptosuccinic acid (DMSA) scan.

Patients and Methods

This study was conducted on 30 patients, selected randomly from those who fulfilled inclusion and exclusion criteria, attended the Nephrology Clinic at the New Children Hospital Cairo University, during the period from August 2012 to March 2013.

Patients aged between 1 and 14 years with the diagnosis of UTI based on suggestive clinical symptoms (dysuria, polyuria, frequency, fever, etc) and at least 1 positive urine culture were included in the study. Children who had been diagnosed with any type of renal disorder (immunological, malformative, or inflammatory), children with recurrent UTIs, and patients with negative urine culture were excluded from the study.

Urinary tract infection is the presence of pyuria and/or bacteriuria on urinalysis and of at least 50 000 colony-forming units (CFUs) per milliliter of an uropathogen from the quantitative culture of a properly collected urine specimen.8

All the studied patients were subjected to the following:

A. History taking and clinical examination to detect presence or absence of fever, presence of hypertension (defined as either systolic and/or diastolic blood pressure ≥95th percentile measured on 3 or more occasions),7 and evidence of UTI (urinary symptoms [dysuria, frequency, urgency, or strong smelling urine], secondary nocturnal enuresis, hematuria, suprapubic or loin pain, or suprapubic or renal masses or tenderness).

B. Laboratory investigations: urine analysis (urine was centrifuged and the supernatant was examined by dipsticks and direct microscopy), urine culture and sensitivity with colony count, blood urea nitrogen (BUN) and serum creatinine (using multichannel autoanalyzer, Hitachi, Japan), complete blood count with differential count (using hematology counter [Cell Dyne 3700], C-reactive protein (using latex-enhanced nephelometry), and erythrocyte sedimentation rate by Westergen method.

C. Imaging studies

1. Renal ultrasonography to detect the gross anatomic abnormalities as dilation of the renal pelvis or ureteric dilatation, renal swelling, local parenchyma changes, stones, or increased bladder wall or pelvic mucosa thickness.

2. Voiding cystourethrography using fluoroscopy and a contrast agent introduced through a catheter in the bladder. It was done to all studied patients whether with normal or abnormal ultrasound. It detects presence and degree of VUR.

3. Renal scintigraphy using DMSA: It works by injecting an isotope intravenously. It was done to all studied patients whether with normal or abnormal ultrasound. It detects acute pyelonephritis and renal scarring.

An informed consent was taken from all parents of the patients.

Statistical Methods

The data were coded and entered using the statistical package SPSS version 15. Data were summarized using mean and standard deviation for quantitative variables and number and percentage for qualitative variables. Comparisons between groups were done using χ2 test for qualitative variables. P ≤ .05 was considered as statistically significant.

Results

The study included 30 patients, 16 girls (53.3%) and 14 boys (46.7%) as shown in Figure 1. The age of the studied patients ranged from 1 to 14 years with a mean age of 3.83 ± 2.48 years.

All patients had fever with a mean of 38.96°C ± 0.44°C. The mean duration of illness was 6.23 ± 5.64 days. The studied patients had different urinary symptoms; the most common was dysuria, followed by frequency, then pain, and last, polyuria (Table 1).
All the studied patients had positive urine culture and sensitivity. Samples were obtained from first morning mid-stream urine for all patients and the results were as follows: *Escherichia coli* in 43.3% of children and it was the commonest organism. The second common agent was Klebsiella, which was found in 30% of culture and sensitivity results. *Pseudomonas aeruginosa* was found in 13.3% and coagulase-negative staphylococcus in 13.3% of culture and sensitivity results (Figure 2).

The most sensitive antibiotics for agents isolated from urine culture were third-generation cephalosporins found in 36.7% from the results. Amikacin was the second most common antibiotic (33.3%). The other antibiotics ordered according to frequency were meropenem (6.7%), vancomycin (6.7%), amoxicillin-clavulanate (6.7%), trimethoprim-sulfamethoxazole (3.3%), imipenem (3.3%), and cefipime (3.3%).

The mean erythrocyte sedimentation rate of all patients was 20.80 ± 13.66 mm/h.

The mean BUN was 14.63 ± 14.85 mg/dL and the mean serum creatinine was 0.68 ± 0.75 mg/dL. Only 2 patients (6.7%) had elevated kidney function (BUN was 42 and 83 mg/dL and creatinine was 1.6 and 4.4 mg/dL).

Ultrasound was done for all patients. Most of patients (19 patients [63.4%]) had abnormal ultrasound results, while 11 patients (36.6%) had normal ultrasound results (Table 2).

Voiding cystourethrography was done for all studied patients. Twenty-four patients (80%) had normal results, while 6 patients (20%) had VUR. Dimercaptosuccinic acid scan was also done for all patients. Nine patients (30%) had abnormal scan (evidence of pyelonephritis). Among the 19 patients who had abnormalities detected by ultrasound only 4 patients (21.1%) had VUR, while the other 15 patients (78.9%) had free VCUG.

Nine patients had abnormalities detected by DMSA (evidence of pyelonephritis), of whom, only 2 patients (22.2%) had VUR detected by VCUG, while among the 21 patients who had free DMSA scan 4 patients (19%) had VUR detected by VCUG.

Eleven patients had no abnormalities detected by ultrasound of which only 1 patient (11.1%) had abnormalities detected by DMSA.

**Discussion**

The ultimate value of detecting anatomic or functional abnormalities of the urinary tract depends on the effectiveness of the interventions designed to prevent recurrent UTI and renal scarring.¹

The purpose of the study was to detect the value of ultrasound to detect urinary tract abnormalities after first febrile UTI. It aimed also to discuss the need for further

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**Table 1. Urinary Symptoms of Urinary Tract Infection.**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dysuria</td>
<td>13</td>
<td>43.3</td>
</tr>
<tr>
<td>Frequency</td>
<td>9</td>
<td>30.0</td>
</tr>
<tr>
<td>Pain</td>
<td>6</td>
<td>20.0</td>
</tr>
<tr>
<td>Polyuria</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

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**Table 2. Abnormal Findings in Ultrasound.**

<table>
<thead>
<tr>
<th>Abnormality</th>
<th>Frequency (n = 19)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidney stone</td>
<td>3</td>
<td>15.8</td>
</tr>
<tr>
<td>Atrophic kidney</td>
<td>2</td>
<td>10.5</td>
</tr>
<tr>
<td>Hydronephrosis</td>
<td>5</td>
<td>26.2</td>
</tr>
<tr>
<td>Nephrocalcinosis</td>
<td>2</td>
<td>10.5</td>
</tr>
<tr>
<td>Cystic dysplastic kidney</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Double ureter</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Ectopic kidney</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Hydroureter</td>
<td>2</td>
<td>10.5</td>
</tr>
<tr>
<td>Posed kidney</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Solitary kidney</td>
<td>1</td>
<td>5.3</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>100</td>
</tr>
</tbody>
</table>

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**Figure 1.** Sex of the studied patients.

**Figure 2.** The isolated organisms in culture and sensitivity results. Cons, coagulase-negative staphylococcus; *E coli*, *Escherichia coli*.
imaging studies like VCUG, DMSA in abnormal US cases.

The age of the studied patients was ranging from 1 to 14 years old with a mean age of 3.83 ± 2.48 years. Sixteen patients (53.33%) were females and 14 (46.66%) were males. The mean age of the male patients was 3.21 ± 1.84 years while the mean age of the female patients was 4.38 ± 2.60 years.

In our small sample, females had higher incidence of UTI than males. Shaikh et al10 found that female infants with fever had a relatively high prevalence rate of UTI, especially during the first year of life. Ghadage et al11 found that UTI was more common in the first year of life among males, while among females, UTIs were more commonly seen after 2 years of life. Winberg et al12 found that the total morbidity risk at 1 year of age of symptomatic UTI was 3% for girls and 1.1% for boys and the male/female ratio starts at 2:5:1 during the first month and then successively changes to 1:20.

All the studied patients had fever with a mean of 38.96°C ± 0.44°C, the mean duration of illness was 6.23 ± 5.64 days. The studied patients had different urinary symptoms; the most common symptom was dysuria, followed by frequency, then pain, and last, polyuria. Mahmoudi et al13 found that UTIs were one of the most commonly diagnosed conditions in patients with fever of unknown origin.

Hoberman et al1 state that children with pyelonephritis tend to present with fever but it can be difficult on clinical grounds to distinguish cystitis from pyelonephritis, particularly in children younger than 2 years. Regarding the commonest organisms in urine culture and sensitivity, E coli was the commonest in our study and it represented 43.3% of the organisms isolated from UTI patients, followed by Klebsiella, which represented 30%, then P aeruginosa (13.3%), and last, coagulase-negative staphylococcus (13.3%).

Our results were in concordance with Qureshi,14 who found that the organisms infecting the urinary tract in his study were E coli (71%), followed by Klebsiella pneumoniae (13%). Edlin et al15 also found that E coli was the most common bacterial cause of UTI accounting for approximately 80% of UTI in children.

Regarding the most common antibiotics found in the culture and sensitivity results, the third-generation cephalosporins were the most common antibiotics found (36.7%). Amikacin was the second most common antibiotic representing 33.3% of the results.

Ghorashi et al16 found in their study that isolated pathogens were highly sensitive to ciprofloxacin, amikacin, and nitrofurantoin, and intermediate sensitivity to third-generation cephalosporins. Gallegos et al17 also found that the most frequently isolated microorganism was E coli showing high susceptibility to aminoglycosides, third-generation cephalosporins, ciprofloxacin, and nitrofurantoin and low susceptibility to cephalothin and trimethoprim/sulfamethoxazole.

Regarding imaging studies done, 19 of the studied patients had an ultrasound abnormality, representing about 63.3% of the studied patients, of whom, only 2 patients had VUR on VCUG (P = .85). The commonest ultrasound abnormalities found in our study were kidney stones (15.8%), followed by atrophic kidney (10.5%), hydronephrosis (10.5%), and nephrocalcinosis (10.5%).

These results are in concordance with larger cohorts studied by Zamir et al,18 in which 255 children with first UTI were included. Thirty-three (12.9%) children had an ultrasound abnormality suggesting VUR, of whom only 9 had VUR on VCUG. On the other hand, in 36 children with VUR on VCUG the ultrasound was normal.

Nineteen patients (63.4%) had abnormal ultrasound results. Among the 19 patients who had abnormalities detected by ultrasound, 10 patients (55.6%) were older than 2 years and 9 patients (75%) were younger than or equal to 2 years. Ten out of the 19 patients with abnormal ultrasound were males (71.4% within male sex) and 9 females (56.3% within female sex). This was in concordance with Richter-Rodier et al,19 who found in their study that the prevalence was significantly higher in male infants and hydronephrosis was found to be the most frequent obstructive nephropathy (83.3%).

Hoberman et al1 conducted a prospective trial including 309 children aged 1 to 24 months using ultrasound and found that ultrasound results were normal in 88% and the identification of abnormalities did not modify the patient management. They conclude that renal ultrasound at the time of acute UTI is of limited value.

Regarding the VCUG done for all our patients, 80% of the results were free, while 6 patients had VUR (20% of the studied patients). Out of the 6 patients who had VUR on VCUG, 4 patients (22.2%) were older than 2 years and 2 patients (16.7%) were younger than or equal to 2 years. Four out of the 6 patients with VUR were males (28.6% within male sex) and 2 were females (12.5% within female sex). This means that males were affected more than females.

Out of the 19 patients with abnormal ultrasound, 15 patients (78.9%) were free after doing VCUG and only 4 patients (21.1%) had VUR. This states that we cannot predict abnormality in VCUG from the ultrasound done routinely for all patients.

Nine patients had abnormalities on DMSA scan (30%), of whom, 5 patients were older than 2 years and 4 patients were younger than or equal 2 years. Six patients out of the 9 patients with abnormal DMSA were males (42.9% within male sex) and 3 were females.
18.8% within female sex). This means that males were affected more than females. Only 2 out of the 9 patients with abnormal DMSA scan (22.2%) had VUR detected by VCUG and 4 cases out of the 21 patients with normal DMSA scan (19%) had VUR by VCUG. Out of the 11 patients with normal ultrasound, only 1 patient (11.1%) had abnormalities detected by DMSA scan.

Printza et al19 found that DMSA scan was abnormal in 16 (16.3%) of the studied 98 patients. They concluded that an abnormal acute DMSA scan is a moderate predictor for dilated VUR and its ability to exclude VUR is restricted. In the study done by Zhang et al20 75.9% of cases had abnormal DMSA results and 34% were identified as VUR on VCUG.

Juliano et al22 found in their study that of the 154 ultrasounds performed, 59 (38%) were abnormal. Of the 95 patients with normal ultrasound, 84 underwent VCUG. VUR was more likely in patients who were female ($P = .02$) and older ($P = .04$). Despite normal ultrasound, 23 of 84 patients (24%) had VUR.

Finally, according to our results, we found that ultrasound sensitivity was 66.7%, specificity was 37.5%, positive predictive value was 21.1%, negative predictive value was 81.8%, and total accuracy was 43.33%, which means that ultrasound accurately can detect 66.7% of abnormalities and these findings question the value of ultrasound in the management of first attack of febrile UTI.

This was in concordance with Zamir et al18 who found that the sensitivity, specificity, positive predictive value, and negative predictive value of abnormal ultrasound for detecting VUR were 17.7%, 87.6%, 23.5%, and 83.25%, respectively, and recommended routine ultrasound after first febrile UTI but in concomitance with other imaging modalities. Hoberman et al1 state that ultrasound is neither sensitive nor specific and need other investigations such as VCUG and DMSA scan. Furthermore, our studied sample is small in contrast to other studies and so, our results may be changed on a larger scale of patients.

A major limitation of this study was the small sample size and lack of follow-up.

Conclusions

Our study concluded that renal ultrasound and DMSA scanning at the time of acute illness are not of much value alone and recommends the routine use of VCUG to identify children with reflux. It is recommended that combined investigations are the best way to confirm diagnosis of urinary tract anomalies.

Further studies are recommended on larger number of the children to correlate between ultrasound, VCUG, and DMSA after first attack of febrile UTI.

Authors’ Note

This study was approved by the Ethical Scientific Committee at the Cairo University Hospital and was conducted in accordance with the university bylaws for human research. All caretakers have given their informed consent.

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Author Contributions

EEG participated in searching the literatures, followed the results; prepared the final manuscript, he is also the corresponding author. DMA participated in choosing the issue of the study; followed the results and prepared the final manuscript. MFS participated in choosing the issue of the study, followed and interpreted the results. YSAA participated in searching the literatures and followed clinical and laboratory data and statistics of the patients.

Declaration of Conflicting Interests

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