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Value of Ultrasonography in Detection of Urinary Tract Abnormalities in Children with Urinary Tract Infections

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Original Article

ABSTRACT

***Background**: Urinary tract infections (UTIs) are more frequent pathology in children and one of the most common causes of childhood and infancy morbidity worldwide . An ultrasound scan is carried out to identify abnormalities in urinary tract. Many anatomical abnormalities of the urinary tract are detected during routine ultrasound examinations as part of prenatal care. Therefore, early diagnosis and treatment of UTIs in children play an important role in prevention of adverse sequels of UTIs. Hence, there is a real need to have an accurate and reliable diagnosis of UTI in children. **Objective**: To assess the value of ultrasonography examination in Iraqi children with UTIs. **Methods:** a prospective cross sectional study conducted in our hospital during a period of 2 years, included a total of 128 child-cases with UTIs and admitted for management in our hospital. **Results**: Child-cases with UTIs aged 2 – 15 years enrolled in this study with a median age of 7 years , males were 76 (59.4%) with a male to female ratio of 1.46 to one. Ultrasonography examination revealed normal findings in 83 cases while abnormal findings in 45 (35.2%). Ultrasound showed a sensitivity of 86.1%, a specificity of 84.8%, and accuracy of 85.2%, positive predictive value (PPV) of 68.9% and the negative predictive value (NPV) was 94%. **Conclusions**: Ultrasound of the urinary system in children with UTIs is a non-invasive study that assesses the presence, size and shape of both kidneys. It allows the gross evaluation of the anatomy of the urinary tract and can also detect dilations and ureteral malformation . No significant differences reported to sex or age with regard to the findings of ultrasound.*

Keywords: Ultrasonography, Urinary Tract infection, Etiology, Epidemiology, Imaging

1.INTRODUCTION

Urinary tract infections (UTIs) are more frequent pathology in children and one of the most common causes of childhood and infancy morbidity worldwide ; UTIs observed in 7% of children younger than 6 months of life and in 5% in those aged 6 to 24 months. UTI during childhood affected in average up to 10% of girls and 3% males . The urinary tract infections in children are of special importance because the significant morbidity during the acute infection responsible, and in chronic cases may – lead to arterial hypertension , or may be a loss of renal function. The care of children with UTI by medical consultations, diagnostics, use of antibiotics and imaging- includes ultrasound examination are highly recommended.

Urinary tract infection is the umbrella term for inflammation of the urinary tract that is usually caused by bacteria, less often by viruses or fungi. These include the kidney, ureter, bladder and urethra. In boys, the prostate, spermatic duct and epididymis can also be affected. If only the bladder is affected, it is called cystitis and it is usually without a fever. If there is a fever, the kidneys are often affected, and this is called pyelonephritis (inflammation of the kidneys). (1–3)

Urinary tract infections are usually not contagious, but are among the most common childhood diseases. Girls are less often affected than boys in the first year of life, but much more often later, since they have a shorter urethra and their urethral mouth is closer to the anus. At the age of ten, about three percent of girls and one percent of boys had a urinary tract infection(3–5).

There are different causative agents contributed to the UTIs in children, most of these agent are bacteria that originate from the intestine, especially E. coli, Proteus, Pseudomonas, Klebsiella and enterococci. These can rise up in the urethra into the bladder or even into the kidney pelvis. Less often, viruses or fungi can cause urinary tract infection(6,7).

Possible risk factors of UTIs - especially for recurrent urinary tract infections - include Inadequate or incorrect stool hygiene, Bladder dysfunction, Low drinking volume, operations, Immune deficiency, Constipation , vesicoureteral reflux(Backflow of urine from the bladder into the ureters and kidneys) Urinary stones , Malformations and abnormalities of the urogenital tract: e.g. urethral valves, narrow kidney pelvis, narrowing of the foreskin(6,8) .

Regarding the clinical features of UTIs it ranges between asymptomatic to mild, moderate or severe UTIs and even bacteremia and septic shock , additionally , fever in young child cases with UTIs may reflects an involvement of the kidney and might be associated with significant abnormalities and scaring of the kidney , particularly in recurrent UTIs with its adverse long term consequences such as hypertension and chronic renal diseases. If the kidney infection is accompanied by a strong

reflux of urine, kidney scarring develops in 5 to 20 percent of children. If there is little or no urinary reflux, only very few children experience such scarring of the kidneys(9,10). Renal scarring can lead to high blood pressure and reduced kidney function in adulthood. In newborns with UTIs, the only symptom is often fever(11–13). Sometimes they drink poorly and hardly grow, lethargic, vomit or have diarrhea. In newborns, UTIs can cause an overwhelmingly severe infection that affects the whole body and may lead to sepsis. Infants and children under 2 years of age with UTIs may have fever, vomiting, diarrhea, abdominal pain or foul-smelling urine. Children of more than 2 years of age with UTI usually have the same symptoms of a bladder or kidney infection as adults(9,10). Children with cystitis usually have pain or a burning sensation when urinating, feel the urge to urinate more often and more urgently, and complain of pain in the area around the bladder(14). Children with pyelonephritis typically have pain in the back or side of the affected kidney, high fever, chills, and a general feeling of illness(15). Children with abnormalities in the urinary tract may have an abdominal mass, enlarged kidneys, an abnormal opening to the urethra, or possible deformities in the lower spine. Children without a strong urine stream may have a blockage in one of the ureters, or may not be able to control their bladder due to nerve damage(16).

Diagnosis of UTI and renal disease in children are of importance for clinicians. In addition to the clinical examination findings, there are different diagnostic tests and tools to prove the diagnosis. Evidence-based recommendation guidelines recommend that every child with fever with body temperature of 38 degree Celsius or higher should be examined and investigated; Urinalysis might revealed leukocytes and bacteria in the urine , sometimes also blood , nitrite, proteins and epithelial cells, morning urine is best to use in the urinalysis test. Urine culture to cultivate any bacteria that may be present (2,17–21).

Ultrasound or x-ray may be necessary to detect, for example, congenital malformations. Urology and pediatric guidelines refer that in infancy, every urinary tract infection should be clarified using ultrasound

An ultrasound scan is carried out to identify abnormalities and blockages in the kidneys and bladder. Many anatomical abnormalities of the urinary tract are detected during routine ultrasound examinations as part of prenatal care . (2,17–21). Therefore, early diagnosis and treatment of UTIs in children play an important role in prevention of adverse sequels of UTIs. Hence, there is a real need to have an accurate and reliable diagnosis of UTI in children, the importance of such diagnosis is due to the fact that, from one side under-diagnosis may lead to immediate or long term adverse effect to the affected child while the over-diagnosis may lead to exposing a healthy child to

unnecessary treatment from the other side and a potentially invasive tests. Ultrasonography examination is widely used for examination of kidneys and excretory system, it is the safest and most effective way to diagnose many diseases of the urinary system. Ultrasound diagnosis has almost no contraindications, does not cause any pain and harm to the body. It is also recommended as screening preventative examinations from time to time for early detection of disease in urinary system(8,11,22,23).

Ultrasonography pursues several goals when conducting a primary assessment of a child with UTIs. Its main task is to identify structural disorders (congenitally or acquired). In the acute process, when UTIs diagnosed in a baby or young child , kidney ultrasonography is important , the purpose of ultrasound examination of the kidneys is to identify the signs of infection and to detect congenital kidney abnormalities that may contribute to the development of infection. Among them are obstructive uropathies, urolithiasis, anomalies of the size of the kidney, anomalies of position or shape, ectopia of the ureter with or without ureterocele. Kidney size should be routinely measured and compared to normal values according to age, weight and possibly body surface area. The enlargement of the kidneys in acute pyelonephritis can be very variable. Initially, the size of the kidneys may be normal, but over time it may increase as the inflammatory process progresses. Ultrasonography can reveal many complications in renal system, such as kidney abscess, perinephral abscess, xanthogranulomatous pyelonephritis and renal calculi. Abscesses can be single or multiple, with the result of acute pyelonephritis or hematogenous infection. Small parenchymatous or perinephral abscesses may be poorly visualized on sonograms in shades of gray. Large abscesses are defined as clearly demarcated hypoechoic fluid clusters with an internal echo. In most cases, ultrasound can be supplemented by additional visualization of the renal sections in transverse projections, which may be useful for ultrasound guidance(24,25).

Many previous studies and literatures supported the role of ultrasonography in UTIs and reported its significant role not only in acute cases but also in screening and follow up of cases with UTI and renal diseases, however, in last decade, there is a debate on the uses of ultrasound examination in children with UTI particularly, younger age group, Therefore the present study tried to assess the value of ultrasonography examination in Iraqi children with UTIs (26–30).

2. PATIENTS and METHODS

This was a prospective cross sectional study conducted in our hospital during a period of 2 years, included a total of 128 child-cases with UTIs and admitted for management in our hospital.

All patients were included with informed consent from the parents or guardians (with knowledge of the study techniques and indicated follow-up, as well as the possibility of leaving the study). They were studied and treated according to a protocol developed for the present investigation.

Children with clinical suspicion of UTI were initially taken into account. Clinical suspicion of UTI was considered to be children with fever without obvious clinical focus, dysuria, polyuria, low back pain, urinary incontinence, secondary enuresis, persistent diarrhea, stationary weight curve. These were performed in the acute period of the disease: urine and urine culture test strip, both obtained under strict aseptic conditions by technique of half of urination with two operators, bladder catheterization or bladder puncture, in children without sphincter control . In the rest of the children, it was performed by means of a half-urination technique.

It was considered a diagnosis of UTI and definitive criterion of inclusion for children with clinical presumption confirmed by quantitative bacteriuria of a single uropathogenic germ according to the method of collection.

Children under 2 years of age and symptomatic children with undeveloped or contaminated urine culture were excluded.

When confirming the diagnosis of UTI, a renal and urinary tract ultrasound study was performed for all patients. The ultrasound performed in the radiology services of the hospital with the usual standard techniques and informed by the different radiologist doctors of each service.

Clinical confirmation was done by pediatric nephrologists and pediatricians doctors in our hospital

Statistical analysis:

Descriptive statisticians presented as frequencies, percentages (%) , mean, median and standard deviation with range. For the comparative analysis, the Chi-square test was applied at a significance level, P. value of <0.05 to be significant. Sensitivity, specificity and accuracy in addition to positive and negative predictive values were calculated using standard equations and 2x2 cross-tabulation.

3. RESULTS

There were 128 child-cases with UTIs aged 2 – 15 years enrolled in this study with a median age of 7 years , males were 76 (59.4%) with a male to female ratio of 1.46 to one, majority of the studied group of urban origin represented 79.7%, (**Table 1 and Figure 1**). Dysuria was the main symptom contributed for 45.3% followed by frequency and abdominal pain where they reported in 32% and 24.2%, respectively, other signs and symptoms were less frequent included polyuria (6.3%), nocturnal aneuresis (7.8%), urinary incontinence (6.3%) and hematuria (3.9%), however, some patients presented with more than one symptom, (**Table 2**).

The types of isolated pathogens among the 128 child-cases with UTIs showed that *Escherichia coli* was the more frequent pathogen found in 48 (37.5%) cases. Staphylococcus reported in 18 cases (14.1%), Klebsiella 15 (11.7%), Proteus mirabilis 12 (9.4%) and Pseudomonas aeruginosa 10 (7.8%), Candida albicans 8 (6.3%), Enterobacter aerogenes 7 (5.5%), Enterococcus spp. 5 (3.9%) and mixed pathogens 5 (3.9%), (**Table 3**).

Ultrasonography examination revealed normal findings in 83 cases while abnormal findings in 45 (35.2%), (Figure 2), theses 45 abnormal findings were kidney calculi 13/45 (28.9%), dilated calyceal system 10 (22.2%), poor renal function 6 (13.3%), hydronephrosis and hydroureter 5 (11.1%), duplicated ureter 3 (6.7%), ureteropelvic junction obstruction 3 (6.7%), renal cortical scarring 2 (4.4%) and others such as polycystic kidney, horseshoe kidney and atrophy in 3 cases (6.7%), (**Table 4**). To assess the validity of US in prediction of abnormal findings a cross tabulation was performed for the US findings against the proved clinical findings, this cross tabulation revealed that US correctly identified (True positive) 31 abnormal cases out of 36 of those clinically proved to have abnormal findings, giving a sensitivity of 86.1%, also it correctly identified 78 cases as normal out of 92 clinically proved normal cases giving a specificity of 84.8%, moreover, the accuracy was 85.2%, positive predictive value (PPV) 68.9% and the negative predictive value (NPV) was 94%, (**Table 5**).

Further analysis revealed that neither age, gender nor the residence had a significant association with the US findings, however, child cases older than 5 years were more likely to have abnormal US findings, additionally, males and those of urban origin had relatively higher frequency of abnormal US findings in their urinary tract, nonetheless, the differences did not reach the statistical significance, (P. value > 0.05), (**Table 6**).

Table 1. Baseline characteristics of 128 UTIs child-cases

Variable		No.	%
Age (year)	≤ 5 years	34	26.6
	6- 10	53	41.4
	11 - 15	41	32.0
	Median	7	-
	Range	2 - 15	-
Gender	Male	76	59.4
	Female	52	40.6
Residence	Urban	102	79.7
	Rural	26	20.3

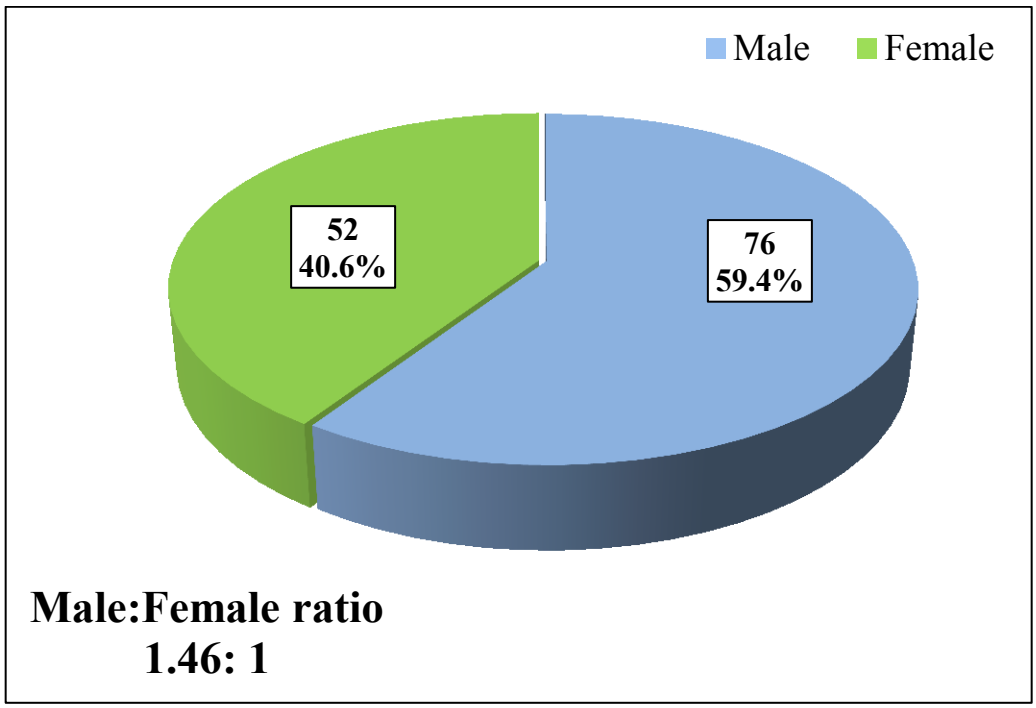

Figure 1. Male to female ratio of 128 child cases with UTIs

Table 2. Presenting signs and symptoms of UTI among the studied group

Sign/Symptoms*	No.	%
Dysuria	58	45.3
Frequency	41	32.0
Abdominal Pain	31	24.2
Polyuria	8	6.3
Nocturnal aneuresis	10	7.8
Urinary incontinance	8	6.3
Hematuria	5	3.9
Total signs/symptoms is 161, some cases had more than one symptoms at the same time		

Table 3. Types of Isolated pathogens among 128 child-cases with UTIs

Isolated pathogens	No.	%
Escherichia coli	48	37.5
Staphylococcus	18	14.1
Klebsiella	15	11.7
Proteus mirabilis	12	9.4
Pseudomonas aeruginosa	10	7.8
Candida albicans	8	6.3
Enterobacter aerogenes	7	5.5
Enterococcus spp.	5	3.9
Mixed pathogens	5	3.9
Total	128	100.0

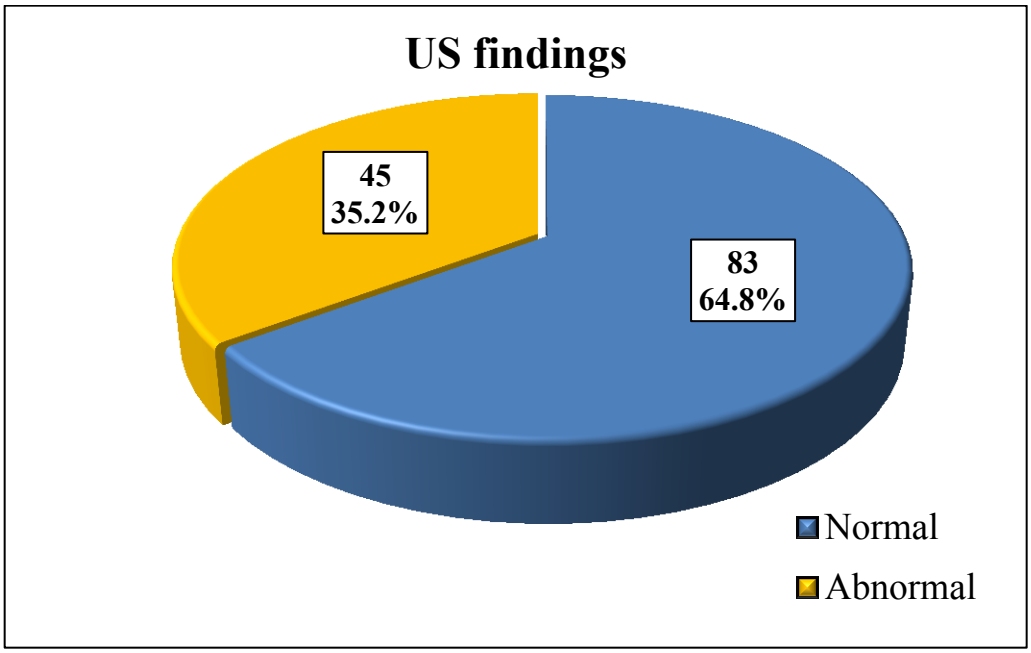

Figure 2. Ultrasound findings of the studied group

Table 4. Abnormal ultrasound findings of the studied group

Findings	No.	%
Kidney calculi	13	28.9
Dilated calyceal system	10	22.2
Poor renal function	6	13.3
Hydronephrosis and Hydroureter	5	11.1
Duplicated ureter	3	6.7
Ureteropelvic Junction obstruction	3	6.7
Renal cortical Scarring	2	4.4
Others*	3	6.7
Total	45	100.0
Others*: Kidney Atrophy , polycystic and horseshoe kidney		

Table 5. Validity of ultrasound in detection of anomalies of urinary tract in 128 child-cases with UTIs

		Proved Clinical diagnosis		Total
		Abnormal	Normal	
Ultrasound findings	Abnormal	31	14	**45**
	Normal	5	78	**83**
Total		**36**	**92**	**128**

Validity parameters	
Sensitivity	**86.1%**
Specificity	**84.8%**
Accuracy	**85.2%**
PPV	**68.9%**
NPV	**94.0%**

Chi square test = 57.3, P. value , 0.001, significant,
PPV: positive predictive value, NPV: negative predictive value

Table 6. Distribution of abnormal US findings by age and gender of the child-cases of UTIs

Variable		**US findings**				**P. value**
		Normal		**Abnormal**		
		No.	**%**	**No.**	**%**	
Age (year)	≤ 5 years	25	73.5	9	26.5	0.443 ns
	6 - 10	32	60.4	21	39.6	
	11 - 15	26	63.4	15	36.6	
Gender	Male	48	63.2	28	36.8	0.768 ns
	Female	35	67.3	17	32.7	
Residence	Urban	65	63.7	37	36.3	0.592 ns
	Rural	18	69.2	8	30.8	

DISCUSSION

The infections in the urinary tract are common in pediatrics, many children admitted to the hospitals with this diagnosis and, for instance in USA, UTIs in children contributed for one million office visit and 500,000 emergency department visits, almost 50000 children admitted per year, represented almost 5 % of hospital admissions. The correct management implies sometimes difficult decision making in several aspects. On the one hand, problems related to the etiological diagnosis and the best treatment, on the other, the choice of the most rational and useful imaging evaluation strategy (5,31)

UTI in children is often a biological marker of anatomical or functional urinary tract disease . It is classically stated by many authors that timely detection, chemoprophylactic treatment and strict follow-up of children with underlying disorders, decreases the risk of arterial hypertension or chronic renal failure. These concepts are currently questioned by other authors and there is still no strong evidence to resolve these controversies (13,32). There are many diagnostic tools used in diagnosing anomalies in urinary tract in children.

The literature refers to the presence of fever and nonspecific markers of infection: erythrosedimentation rate , C-reactive protein (CRP) and increased leukocytosis for age, as suggestive of renal infectious compromise, however, some of these tests are low sensitive and nonspecific and may biased with other disorders (33–36). Imaging studies are indicated in children under three to five years of age with positive urine culture; They are also indicated in school girls or adolescents with recurrent UTIs, particularly after the first febrile UTIs (2,13) . Therefore, a specific and sensitive tool is necessary for the diagnosis of accompanied anomalies in children with UTIS. Ultrasound proved to play an important role in examination and diagnosis of renal system abnormalities in adults (37). In our country, few studies concerned with UTIs in pediatric age cases, and these studies either with small sample size or did not concerned with value of diagnostic tests, however, urine culture, pyelography and clinical approval are the gold standard for the diagnosis of anomalies associated with UTI (1,6,38).

Hence the present study tried to assess the value of ultrasound as a diagnostic tool in child-cases with UTIs, therefore, a total of 128 cases with positive urine cultures aged 2-15 years of both genders were enrolled in this study during a period of 2 years.

The present study found that the incidence of UTIs increased with the age and more frequent in males than females , these findings consistent with epidemiological studies that mention UTIs more

frequent in older age children particularly at the age 7 – 9 years, in our study the median age was 7 years, additionally previous studies reported higher frequency of UTIs in male children than females (1). Conversely, a previous Iraqi study conducted by Abbas and Mahdi found that the more affected age group was at 1 – 5 years, and that Female sex, lack of circumcision, vesico-ureteral reflux , neurogenic bladder , urinary tract abnormalities and inadequate water intake had significant effect on recurrent UTI(6) . An earlier Iraqi study conducted by Al-Mendalawi found no significant difference in the incidence of UTI across the age or gender (38).

In our study according to the results of urine culture , the types of isolated pathogens among the 128 child-cases with Escherichia coli was the more frequent pathogen found in (37.5%) cases followed by Staphylococcus reported in (14.1%), Klebsiella (11.7%), Proteus mirabilis (9.4%) and Pseudomonas aeruginosa (7.8%), Candida albicans (6.3%), Enterobacter aerogenes (5.5%), Enterococcus spp. 5 (3.9%) and mixed pathogens (3.9%). The isolated pathogens varied in different studies , however, almost all literatures agreed that E. coli is the commonest cause of UTIs in children and almost similar pathogens were isolated but in different rates (6,7,39,40)

The present study found that according to the proved diagnosis (urine culture and clinical approval), a total of 36 cases had clinically proved to have urinary tract anomalies and 92 cases did not, according to ultrasound examination, 45 cases detected to have anomalies including kidney calculi , dilated calyceal system , poor renal function , hydronephrosis and hydroureter , duplicated ureter , ureteropelvic junction obstruction , renal cortical scarring , polycystic kidney, horseshoe kidney and atrophy , the overestimation of US in detection of abnormal findings , 45 compared to 36 (proved cases) with 9 false positive results could be attributed to the nature of these reported anomalies, for instance some calcifications and scaring could be erroneously reported in normal kidneys , additionally , US could be affected by inter and intra-observer, variation as it is subjective method, however, these false positive results are accepted when take into account the age of the studied group, particularly the younger children less than 3 years. In our study, US showed a good sensitivity, specificity and accuracy , with values of 86.1%, 84.8% and 85.2%, respectively, these values were higher than that reported in some previous studies, Alshamsan et al . from Saudi Arabia found that US had a sensitivity , specificity and accuracy of 50% and 76.9%, 52.6%, respectively, in detection of vesicoureteral reflux , however, Alshamsan et al. compared US with voiding cystourethrogram (VCUG) as a gold standard, which different than our study where approval by nephrologist used as gold standard. Johnson et al found a sensitivity of 66.7%, but specificity was

as high as 92% (26). Bellah et al. from USA documented that sensitivity and specificity of US varied between 10% to 100% according to the type of anomalies, furthermore, Stokland et al. concluded that early ultrasound determined renal swelling in infants with a UTI and may be a valuable non-invasive way of identifying infants with renal parenchymal involvement.(29) . Another study was conducted by Ghobrial (2015) found that US had a sensitivity of 66.7%, specificity of 37.5% (22), which was lower than ours, however, the higher sensitivity and specificity reported in our study contributed to the fact that in our design any abnormality reported by US considered as true positive and the findings categorized to be normal or abnormal regardless the type of these anomalies, while previous studies concerned with each anomaly alone, nonetheless, further studies in multiple centers are still highly suggested for further assessment of US and its effectiveness in detection of renal system anomalies in pediatric population.

CONCLUSIONS

Ultrasound of the urinary system in children with UTIs is a non-invasive study that assesses the presence, size and shape of both kidneys. It allows the gross evaluation of the anatomy of the urinary tract and can also detect dilations and ureteral malformation . No significant differences reported to sex or age with regard to the findings of ultrasound .

Ethical Clearance

Ethical clearance and approval of the study was confirmed by the author, verbal and signed consents were obtained from all parents\guards of the participated children. Study protocol confirmed by the department of radiology and the administration office of the hospital

Conflict of interest

Author declare no conflict of interest.

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