

Clinical Significance of Intraluminal Bladder Echoes on Sonography and Its Correlation with Urinary Tract Infection.

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ABSTRACT

Background: Clinical significance of intraluminal bladder echoes on sonography and its correlation with urinary tract infection. Ultrasonography can provide information relative to the capacity of the bladder, change in bladder outline, changes in the thickness and structure of the wall, identification of luminal structures and mural masses, and identification of extrinsic lesions which may displace the bladder or distort the wall. Our primary objectives are: To determine the clinical significance of intraluminal bladder echoes; and To determine the association between intraluminal bladder echoes and UTI. **Methods:** The present study was conducted on patients who were referred to the Radiology department at ACME, Pariyaram during the period of October 1 2014 to March 31 2016. These patients were referred for abdominal or KUB ultrasound and also had their urinalysis done. **Results:** 560 subjects (males and females) who were found to have urinary bladder internal echoes were included in the study. Pretest probability: 48.2%. Pretest odds: 0.92. Posttest odds: 1.28. Posttest probability: 0.56 or 56%. Posttest odds: 0.278. Posttest probability: 0.21 or 21%. **Conclusions:** In this study, this particular sonological finding showed a low specificity as well as intermediate sensitivity for making the diagnosis of UTIs.

Keywords: Ultrasonography, Urinary Tract Infection.

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INTRODUCTION

The urinary bladder is well suited for the ultrasonographic examination because of the excellent acoustic properties of the fluid nature of urine and the superficial location of the urinary bladder. Ultrasonography can provide information relative to the capacity of the bladder, change in bladder outline, changes in the thickness and structure of the wall, identification of luminal structures and mural masses, and identification of extrinsic lesions which may displace the bladder or distort the wall.^[1]

Urinary infections are a common condition in the general population and they are therefore a frequent cause of visits to the emergency department. Ultrasound is customarily requested as part of the work-up in these patients. It has been noted that particulate urine is frequently reported on abdominal and urinary tract ultrasounds conducted on patients in the emergency department at our healthcare facility and that radiologists consequently suggest a urinalysis in order to rule out urinary tract infection (UTI). Nevertheless, upon reviewing the literature on this subject, we were not able to gather sufficient information that supports this finding as a parameter for infection.^[2,3]

Objectives

Our primary objectives are:

1. To determine the clinical significance of intraluminal bladder echoes; and
2. To determine the association between intraluminal bladder echoes and UTI

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MATERIALS & METHODS

Study Population

The present study was conducted on patients who were referred to the Radiology department at ACME, Pariyaram during the period of October 1 2014 to March 31 2016. These patients were referred for abdominal or KUB ultrasound and also had their urinalysis done. 560 subjects (males and females) who were found to have urinary bladder internal echoes were included in the study. After getting informed written consent from all the participants, subjects of both sexes in the age group of 6 months to 90 years were included in our study.

Exclusion Criteria

Patients who did not give consent for the study and those who did not undergo both urine analysis and USG were excluded from the study.

Methods

Baseline examinations included a medical history and health habit inventory taken by a physician, anthropometric measurements, abdominal ultrasonic examination, pathological and biochemical investigations. The examinations were administered in the morning. Blood pressure was measured using a sphygmomanometer with the subject in a sitting position. Ultrasound was performed using a GE voluson 730 machine using 3.5-5.0 MHz curvilinear transducer. A radiologist carried out baseline ultrasound abdomen examination. In each case, probe was superiorly angulated to image the bladder and gain was increased until just below the level at which noise appeared in the bladder lumen. Measures were taken to do the scan after adequate filling of the bladder. Adequate filling was taken as at least 300 ml of urine in bladder. Urinary echoes were deemed present if floating mobile intraluminal echoes seen on real time scanning. If findings were equivocal, the probe was slightly agitated to cause any true echoes to move, analogous to what is recommended for evaluation of echoes within POD. Care was taken to perform the evaluation shortly after the inflow of ureteric jet, which often produces short lived echoes. The ages of the selected patients ranged from 6 months to 90 years and both genders were included. Subgroups for age were arranged into patients under the age of two years, older children, young adults and older adults.

The main finding that was analysed was the presence or absence of particulate urine [Figures 1 and 2] on the ultrasound images and its correlation with a confirmed UTI diagnosed by a positive urinalysis according to the criteria established by the Colombian Society of Urology in their Guidelines for Urinary Infection. Apart from the demographic variables that were analysed, other factors that were evaluated included the initial and final diagnoses, and the findings on ultrasound. In the majority of cases the initial diagnosis was UTI, followed by abdominal pain, gastroenteritis, febrile syndrome and urolithiasis. The final diagnoses were mainly UTIs, followed by gastrointestinal pathology, other genitourinary system conditions apart from UTIs, and respiratory illnesses.

Statistical Methods

The statistical evaluation began with a descriptive analysis of the demographic variables of the population, including gender and summary, central tendency and dispersion measurements for the continuous variable of age. For the categorical variables such as recoded age, initial diagnosis, final diagnosis and ultrasound findings, frequency and percentage measurements were calculated. Furthermore, contingency tables were designed for

the categorical variables. These tables included cross tabulations for age and initial diagnosis, gender and initial diagnosis, gender and final diagnosis, gender and other findings on ultrasound, and age and final diagnosis. Confidence intervals (CI) of 95% were calculated for the described proportions.

The operating characteristics (sensitivity, specificity, predictive values and likelihood ratios) were defined for the presence of particulate urine on ultrasound for the diagnosis of UTIs. The standard of reference was a urinalysis positive for infection and the confidence interval was calculated at 95%. The prevalence established in the study was used to calculate the pretest and posttest probabilities. In order to process the information a database was constructed using Excel. The SPSS version 15 statistics program was employed to encode the variables and to produce the descriptive statistics, including the contingency tables for the cross tabulation of variables with their respective percentage and frequency distributions. The Epidat version 3.1 program was used to calculate the confidence intervals for sensitivity, specificity and predictive values. Furthermore, a review on urinary infections, their findings on ultrasound and the diagnostic value of particulate urine in UTI was conducted.

RESULTS

Evaluation of 560 patients with minimum age taken as 3 months and maximum age of 90 years was performed. The calculated average age was 36 years with a standard deviation (SD) of 22. The patients were then divided according to age into four subgroups: 7% of patients were found to be under the age of two years, 17% between the ages of 2 and 15 years, the majority of patients (65%) were between 16 and 65 years of age, and 11% older than 65 years [Tables 1 & 2].

Table 1: Median age of 36 years with SD of 22.3

	N	Minimum	Maximum	Median	Deviation
Age	560	6 months	90 years	36.2395	22.3022

Table 2: Classification of age groups

Age	Frequency	Percentage	Accumulated percentage
<2	38	7	7
2-15	95	17	24
16-65	364	65	89
>65	63	11	100
Total	560	100	

Table 3: Gender distribution

Gender	Frequency	Percentage	Accumulated percentage
Female	384	68.6	68.6
Male	176	31.4	100
Total	560	100	

Out of the patients who received an ultrasound and urinalysis, 48.2% had an preliminary diagnosis of abdominal pain, followed by UTI (45.2%), urolithiasis(15.4%),pyrexia of unknown origin (6.3%), gastroenteritis(4.2%)and blunt abdominal trauma(1%) The ultimate diagnosis in the evaluated patients was mainly UTI (49.1%), trailed by gastrointestinal pathology (33%), no definite diagnosis (12.5%) and a single case of respiratory illness [Table 4].

Table 4: Final diagnoses

Final diagnosis	Frequency	Percentage
Urinary tract infection	305	54.5
Genitourinary pathology	162	28.9
Gastro enteritis	32	5.7
Abdominal trauma	10	1.8
Psoas abscess	2	0.4
Others(abdominal pain, PUO)	49	8.7
Total	560	

With respect to age, the predominant initial diagnoses in patients under two years of age were UTIs and abdominal pain. The quantity of patients with fever was taken to be insignificant (95% CI: 0.2- 41.2). The chief initial diagnosis for patients between 2 and 15 years of age was abdominal pain (65%). For the patients amongst 16 and 65 years of age the most prevalent initial diagnosis was abdominal pain (49.3%), followed by UTI (40.3%). Of the cases with UTI as the final diagnosis, 72.8%

were women, a result taken to be statistically significant (95% CI: 63.6-82.0). Furthermore, Gynecological conditions were established in 42 patients. Urolithiasis diagnosed in 66 patients, 51.2% of which were females and 48.8%, males (95% CI: 29.0-73.4). Gastrointestinal conditions were diagnosed in 32 patients, 59.4% of which were females and 40.6%, males (95% CI: 27.4- 91.4). There were also 10 cases of blunt trauma abdomen, 30% of which were females and 70%, males (95% CI: 2.4-57.6). and, there were 2 reported cases of psoas abscess in males, a percentage well-thought-out to be of low significance given the amplitude on the confidence interval. No certain diagnosis was reached in 49 of the cases, 44.9% of which were women and 55.1% were males [Table 5].

According to the patients age groups, the end diagnosis in those under two years of age was UTI in 45.5% and gastrointestinal pathology in 54.5% of cases. Among patients between 2 and 15 years of age, 55% cases presented with gastrointestinal illness, 30% had a UTI and 10%, gynecological conditions. For patients between the age of 16 and 65 years, the most prevalent final diagnosis was UTI in 50.7% of cases, trailed by gastrointestinal conditions in 25.4%. It is of note that a good number of patients did not have a definitive diagnosis (19.4%). And in patients above 65 years of age, 70% had a final diagnosis of UTI [Table 6].

Table 5: Final diagnosis by gender contingency

Variable : Final diagnosis	Gender female N(%)	Gender Male N(%)	CI 95% Female
UTI	222(72.8%)	83 (17.2%)	(63.6-82.0)
Gynecological conditions	42(100%)	0	
Urologic conditions	66(51.2%)	54(48.8%)	(29.0-73.4)
Gastrointestinal conditions	19(59.4%)	13(40.6%)	(27.4- 91.4)
Abdominal trauma	3(30%)	7(70%)	(2.4 – 57.6)
Psoas abscess	0	2 (100%)	
No definite diagnosis(abdominal pain, PUO)	22 (44.9%)	27 (55.1%)	(14.9-74.9)
Total	374 (66.8%)	186 (33.2%)	

Table 8: Age by final diagnosis contingency

Age	UTI	Genitourinary pathology	Gastrointestinal pathology	Abdominal trauma	Psoas abscess	No definite diagnosis
<2	45	0	1	0	0	3
2-15	50	10	2	2	0	5
16 – 65	162	96	20	7	1	32
>65	48	56	9	1	1	9
Total	305	162	32	10	2	49

Particulate urine on ultrasound with a urinalysis positive for UTI was observed in 56.5% of patients. A urinalysis positive for UTI without particulate urine on ultrasound was seen in 43.5% of the cases. Absence of particulate urine and UTI was detected in 65.1% of patients and 34.9% did not present particulate urine on ultrasound, but had a UTI at the time of evaluation [Table 7].

Table 7: Contingency of particulate urine by urinalysis results

Particulate urine	Urinalysis positive	Urinalysis negative	Total
Yes	195 56.5%	150 43.5%	345 100.0%
No	75 34.9%	140 65.1%	215 100.0%
Total	270 48.2%	290 51.8%	560 0%

Table 8: Patients with particulate urine on ultrasound and UTI diagnosis according to age group

Age	Frequency	Percentage
<2	25	9.5
2-15	30	11.0
16 – 65	165	61.0
>65	50	18.5
Total	270	100.0

Table 9: Patients with particulate urine on ultrasound and UTI diagnosis by gender and age group

Age	Male	Female
<2	8	17
2-15	6	24
16 – 65	20	145
>65	25	25
Total	59	211

Particulate urine on ultrasound holds a sensitivity of 72.22% for the diagnosis of UTI. In other words, out of 100% of patients with UTI, 72.22% will present particulate urine on an ultrasound examination. This ultrasound finding has a specificity of 48.28%, which means that 48.28% of individuals without UTI with urinalysis results that are negative for infection, will have particulate urine on ultrasound. The positive predictive value for particulate urine is 56.52%, therefore, the probability that a patient may have a UTI with a ultrasound positive for particulate urine is 56.52%. The negative predictive value for this finding is 62.12%, which signifies that the probability that a patient does not have a UTI when the ultrasound results are normal is 62.12%. The accuracy of the test is 59.82%, which implies that the percentages of all the results of the test, both positive and negative, are correct. The positive likelihood ratio was 1.40. This result means that the presence of particulate urine on ultrasound is 1.4 times more likely to be seen in patients with UTI than without. The negative likelihood ratio was 0.58, which indicates that the probability of presenting an ultrasound without particulate urine is 0.58 times more likely in patients without UTI [Table 10].

	Value	95% C I
Sensitivity(%)	72.22	(59,35-85,09)
Specificity (%)	48.28	(34,55-62,00)
Positive predictive value(%)	56.52	(44,10-68,94)
Negative predictive value(%)	65.12	(49,71-80,52)
Positive likelihood ratio(%)	1.40	(1,04-1,88)
Negative likelihood ratio(%)	0.58	(0,35-0,95)
Prevalence(%)	48.21	(38,51-57,91)
Validity Index(%)	59.82	(50,30-69,35)

Pretest probability: 48.2%. The pretest probability in this investigation is based on the prevalence results obtained from this said study and it corresponds to 48.2%.

Pretest odds: 0.92. The pretest probability was calculated based on the likelihood ratio. This value is for a positive test (ultrasound examination with particulate urine).

Posttest odds: 1.28.

Posttest probability: 0.56 or 56%. If particulate urine is seen on ultrasound, we go from a pretest probability of 48.2% for UTI diagnosis to a posttest probability of 56%. This value is for a negative test (ultrasound examination without particulate urine).

Posttest odds: 0.278

Posttest probability: 0.21 or 21%. With a negative result for particulate urine on ultrasound we go from a pretest probability of 48% to a posttest probability of 21% of not having a UTI

DISCUSSION

Urinary tract infection is a very common condition we come across. Majority of the women will have at least one episode of UTI during her lifetime. This is one of the most commonly seen causes of bacteremia among patients receiving medical health services and is considered the most common source of infections in elderly. UTIs are more common in patients who have known structural abnormalities (complicated infections) when compared to those presenting with functional disturbances of the urinary tract (uncomplicated infections).^[4-6] UTIs are considered as the main reason for seeking medical treatment and for hospitalization among patients of different age groups. Urinary infections were proven to be the most frequently observed initial and final diagnosis in our population. In over 95% of cases, UTIs have been found to be caused by a single bacterial species, the bulk of which are Gram-negative bacteria which originate from the intestine and are subsequently introduced into the periurethral area, after which the infection begins in an ascending manner. *E. coli* (75-90%) is the most commonly isolated bacteria in the general pediatric population. Other common microorganisms include *Klebsiella* sp., *Proteus* sp., *Pseudomonas* and *Citrobacter*.^[8-12] In recurrent infections, especially the ones that are seen in patients with structural abnormalities, there has been found to be a significant increase in the isolation of species such as *Proteus* sp., *Pseudomonas* sp., *Klebsiella* sp. and *Enterobacter* sp. The most common Gram-positive pathogens are *Streptococcus faecalis* and *Staphylococcus epidermidis* (5%-15%).^[13-16]

The criteria which is used to say that a urinalysis is positive for infective pathology is the presence of at least five or more leukocytes per field, ten or more leukocytes per cubic millimeter, a bacteria with or without showing Gram staining properties, leukocyte esterase and a nitrite test showing positive. All the above parameters call for a complementary urine culture. Evidence from current studies reveal that the true value of urinalysis is in its negative predictive value, given that the absence of these criteria virtually rules out the presence of a UTI. The standard of reference for the diagnosis of UTI continues to be the urine culture, and no other

test has been proven to have greater diagnostic performance. UTI is a clinically apparent illness which is confirmed using urinalysis and urine culture. Imaging is generally not required to establish or confirm the diagnosis.^[17,18]

The role of diagnostic imaging in the evaluation of UTIs is in discovering probable structural or anatomical abnormalities which may be treated so as to prevent further recurrences and consequently, lower the morbidity. The prime aim of ultrasound examination in this population is in evaluating the morphological characteristics of the kidneys and in determining the presence of vesico-ureteral reflux (VUR), a condition which facilitate the ascent of infection from the urinary bladder to the kidneys, identify calculi and detect any signs of urinary obstruction.^[19,20] One must know that all questions arising due to UTI cannot be answered with a single imaging modality. However the greatest advantage of ultrasound imaging is the fact that it is a technically non-invasive modality which does not expose the patient to ionizing radiation.^[21-23]

In general practice, imaging is not necessary for diagnosing and treating acute pyelonephritis. In uncomplicated cases ultrasound examination is normal most of the times. However in approximately 20-25% of cases, ultrasound may detect the presence of generalized renal edema which may be caused by congestion and inflammation.^[24-27] Renal edema is defined as an rise in renal longitude (>15 cm) or an enlargement of the infected kidney (minimum 15 cm) when compared to that of the contralateral side.^[28,29]

The sonographic examination of bilateral kidneys and urinary tract in real time is a widely available noninvasive, easy to perform procedure and has turned into a crucial tool in the urological evaluation of patients. The usage of ultrasound in the assessment of the lower urinary tract is instant and includes the thorough observation of the morphologic characteristics of the bladder walls as well as its content. In addition to the above, ultrasound also allows for the quantification of post void residue, the detection of lesions within the lumen, as well as calculi, bladder wall diverticulae and masses. The standard technical parameters for a trans-abdominal ultrasound examination are the use of transducers with frequencies ranging from 3.5 to 5 MHz in order to ensure adequate penetration of tissues without compromising on the quality as well as resolution of the images. Likewise, the evaluation of the urinary bladder can be completed via a transvaginal, transurethral or trans-rectal approach. Urinary bladder is cited in the pelvis and visually it a rounded or spherical structure which is lined by thin walls. The intraluminal content, under normal conditions, is predominantly anechoic. The bladder wall is a smooth, linear structure that is well-defined with a 5 mm thickness when empty and 3 mm thickness when distended. The structural appearance

of the urinary bladder varies according to the quantity of liquid or urine in it, the positioning of the patient and the direction of the transducer. In children, the average thickness of the bladder wall is taken as 2 mm. The sonographic findings constant with UTI include an increase in kidney size, either in a focal or global manner, loss of normal cortico-medullary differentiation and hyper or hypoechoic areas in the renal parenchymal tissue.^[16,19,30]

Epithelial thickening of the pyelo-calyceal system or ureter may be seen in infections (pyelitis) and in VUR. One may also detect dilatation of the collecting system even in the absence of obvious causes for obstruction. This is produced by the release of bacterial endotoxins, that are capable of hindering the normal peristalsis of the ureter, which eventually leads to the development of hydronephrosis and hydro-ureter. The usage of color Doppler could help to identify pyelonephritis cases by making regions of low or absent perfusion more evident.^[31-34] These less perfused areas maybe the result of the presence of vasculitis or constriction of the peripheral arterioles caused by the underlying bacterial infection. Ultrasound is also capable of detecting complications associated with urinary tract infections such as renal and perinephric abscesses, renal stones and xanthogranulomatous pyelonephritis. Abscesses may be the product of pyelonephritis or hematogenous spread of a distant infection.

The sonographic findings of UTIs have not been described as commonly. What little bibliographic evidence we have reports give limited findings related to cystitis which include particulate content or fine echoes within urinary bladder, thickened bladder wall, and air within the bladder lumen. Numerous clinical conditions such as nephritic and nephrotic syndrome, acute tubular necrosis and drug related crystalurias have been associated with the development of urinary sediments. In nephrotic syndrome, urine has a particulate appearance due to the removal of lipids and casts by the kidneys. Infrequently, this condition might present with hematuria as well.^[35] On the other hand, leukocyturia and elimination of renal tubular epithelial cells are the predominant abnormalities seen in nephritic syndrome. Necrotic tubular epithelial cells and tubular fragments are seen in acute tubular necrosis. Furthermore, particulate urine is also seen in patients who consume amoxicillin, ciprofloxacin, acyclovir and indinavir due to drug-related crystalurias. Other causes of urinary detritus include clinical conditions that lead to urinary stasis such as neurogenic bladder, prostatic hyperplasia, prostate, bladder or urethral cancer, prostatitis, bladder neck contracture, phimosis or meatal stenosis, and pregnancy.^[36-38]

Neurogenic bladder is the loss of normal bladder function owing to a partial damage to the nervous system. This condition may further cause the bladder to become hypoactive, may not efficiently contract

and thus may not empty completely. And the micturition process becomes dysfunctional and urine may present with detritus. Pregnant women may develop urinary stasis due to diminished muscular tone in the bladder and significant compression of the bladder and ureters by the enlarged uterus. In our population, 39 patients (56.5%) presented particulate urine on ultrasound and a urinalysis positive for infection, 30 patients (43.5%) with this finding did not have a diagnostic confirmation of UTI, 15 patients (34.9%) had a urinalysis positive for infection but did not present particulate urine on ultrasound, and 28 patients (65.1%) did not present either finding. With these results, we have established that particulate urine as a criterion for UTI has a sensitivity of 72%, a specificity of 48%, a positive predictive value of 56%, and a negative predictive value of 65%, with a CI of 95%. A pretest probability was projected at 48.2% and a posttest probability of 56%. Particulate urine on ultrasound is a finding which has proven to have an intermediate sensitivity and low specificity and, as seen in our population of patients with UTIs, as well as genitourinary and gastrointestinal pathologies. In addition, it was an absent finding in some patients that presented UTIs with urinalyses that were positive for infection. Wachsberg and colleagues concluded that particulate urine detected by ultrasound was a normal finding, not indicative of urinary infection, and that was currently more easily identified due to the employment of high-resolution transducers used during transvaginal ultrasound.^[39,40]

CONCLUSION

The particulate appearance of urine is repeatedly mentioned in ultrasound study reports performed on patients who come to the emergency department with abdominal symptoms. In this study, this particular sonological finding showed a low specificity as well as intermediate sensitivity for making the diagnosis of UTIs. For this particular reason, this sign is not be considered as a reliable indicator of infection as it can be present as a result of the numerous conditions mentioned in this article. It is also important to note that the low specificity of this finding can be attributed to the fact that other conditions such as nephrotic and nephritic syndrome, drug-related crystaluria, acute tubular necrosis and conditions that lead to urinary stasis, such as prostatic hyperplasia, neurogenic bladder and pregnancy show similar findings. However, ultrasonography can always A larger sample size can be employed in the future investigations so as to improve the confidence interval. This amendment would be useful to determine if substantial differences exist between the variables that are present in the current study and also to conduct a study with crossed variables.

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