ORIGINAL RESEARCH PAPER | Medical Science | Volume : 6 | Issue : 9 | September 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

Study of Imaging of Urinary Tuberculosis on Excretory Urography and Computed Tomography

KEYWORDS: Mycobacterium Tuberculosis, Computerized Tomography, IVU

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ABSTRACT ***Background:*** *Tuberculosis (TB) is the most common cause of mortality and morbidity from infectious diseases. Approximately one-third of the world's population is believed to harbor latent infection with Mycobacterium tuberculosis. Tuberculosis of the kidney results from hematogenous seeding of Mycobacterium tuberculosis in the glomerular and peritubular capillary bed from primary site of infection, usually from a pulmonary focus. This study was conducted in Department of Radiodiagnosis, Sri Sathya Sai Institute of Higher Medical Sciences, Whitefield and Department of Imaging Sciences, Sri Sathya Sai Institute of Higher Medical sciences, Prashanthigram.* ***Results:*** *The identification of imaging findings as renal parenchymal scarring ($p< 0.01$), infundibular or pelvic stenosis ($p < 0.001$), thickened ureteric wall ($p < 0.05$) and extra urinary manifestations ($p < 0.05$) on CT were significantly more frequent than on IVP. There was no significant difference on IVP and CT in detection of renal parenchymal mass, renal parenchyma calcification, renal parenchyma cavity, moth eaten calyx, autonephrectomy, ureteric stricture with HDUN, calcified ureteric wall and thickening of UB wall.* ***Conclusion:*** *CT and IVU showed a wide variety of imaging findings and all the findings, when present, were common unilaterally. Most common feature on both CT and IVU was infundibular or pelvic stenosis. CT was superior to IVU in the detection of renal parenchymal scarring, infundibular or pelvic stenosis, ureteric wall thickening and extraurinary manifestations.*

Introduction:
Tuberculosis (TB) is the most common cause of mortality and morbidity from infectious diseases. Approximately one-third of the world's population is believed to harbor latent infection with *Mycobacterium tuberculosis*[1]. India accounts for nearly one-third of global tuberculosis burden[2]. The genitourinary system is the most common site of extrapulmonary tuberculosis[3].

Tuberculosis of the kidney results from hematogenous seeding of *Mycobacterium tuberculosis* in the glomerular and peritubular capillary bed from primary site of infection, usually from a pulmonary focus[3-6]. Small granulomas form in the renal cortex bilaterally, adjacent to the glomeruli. These cortical granulomas can remain asymptomatic and dormant for decades. Breakdown of host defence mechanisms leads to reactivation of the cortical granulomas with enlargement, coalescence, caseous necrosis and cavitations[3-7]. Communication of the granulomas with the collecting system leads to regional spread of the bacilli into the renal pelvis, ureters, urinary bladder and accessory genital organs. The host's healing response induces fibrosis, calcium deposition and stricture formation, which contributes to obstruction and progressive [renal] dysfunction[3, 6,]

Patients with urinary tract tuberculosis have local symptoms such as frequency, urgency and dysuria[5, 8]. Urine analysis shows sterile pyuria, acidic p^H and hematuria[5, 6, 8]. Standard urine cultures usually show no growth. To evaluate genitourinary tuberculosis, at least three consecutive first-morning-void urine samples should be collected for acid-fast staining and Mycobacterial cultures[9]. Urinary tuberculosis is diagnosed either by identification of *Mycobacterium tuberculosis* in the urine (either by smear for acid fast bacilli or by positive culture) or histological examination of biopsy or surgical specimen[3].

Imaging findings can support the diagnosis of genitourinary [tuberculosis]. Conventional radiograph of KUB region may show renal calcification and other extrapulmonary manifestations of tuberculosis such as lymph nodal and adrenal calcifications or spinal manifestations[4-6]. Intravenous urography can detect a broad range of findings, depending on the severity of infection. Irregularity of the papillary tips (moth-eaten calyx) is the earliest finding in the kidney[5-7, 10]. Other findings in kidney are cavitation, focal or diffuse caliectasis due to infundibular strictures, phantom calyx, generalized hydronephrosis and sharp angulation of renal pelvis known as Kerr's kink[5, 10, 11]. Ureteral involvement manifests as dilatation and mucosal irregularity in early stage. Advanced disease shows strictures and can produce a "beaded ureter" or "corkscrew ureter ". Diffuse fibrosis resulting in ureteral shortening is known as "pipe-stem ureter" [4,5,6]. The bladder may be diminutive and irregular with advanced disease known as "thimble bladder" [5, 10-12].

CT scan is the most sensitive imaging modality for identifying renal calcifications[13]. Cortical granulomas are seen as non-enhancing hypodense areas. Parenchymal scarring, cortical thinning, dilated calyces filled with debris or caseous material, putty-like calcification and calculi can be readily demonstrated on CT [13,14]. Fibrotic strictures of the infundibulum, renal pelvis, and ureters can be seen on contrast-enhanced CT[13,14]. Thickening of ureteric and bladder wall can also be detected on CT. In addition, CT is useful in determining the extent of renal and extrarenal spread of infection, such as perinephric abscess and also can detect the extraurinary manifestations[11,13].

Intravenous urography was the primary imaging modality used for identifying urinary tract tuberculosis. Recently, cross sectional imaging modalities like ultrasound, CT and

Volume : 6 | Issue : 9 | September 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

MRI are being used for evaluation of urinary tuberculosis. Very few studies are done comparing IVU and CT for evaluation of urinary tract tuberculosis.

This study was undertaken to examine prospectively the various manifestations of urinary tract tuberculosis with excretory urography and CT in patients with known urinary tract tuberculosis (positive acid fast bacilli in urine). Also, to see if there are additional features on CT those were not evident on urography and to provide an analysis of the urographic and CT findings in this disease.

Materials & Methods:
This study was conducted in Department of Radiodiagnosis, Sri Sathya Sai Institute of Higher Medical Sciences, Whitefield Prashanthigram. The study was conducted between 1st June 2005 to 31st May 2006.

Patients who attended Department of Radio-diagnosis with positive acid fast bacilli in any of the 3 consecutive early morning specimens of urine were included in our study. During the period of study, total number of patients evaluated were 50. Patients with history of allergy to contrast medium, patients with serum creatinine value more than 1.8 mg/dl, pregnant women, patients who already underwent surgery of urinary tract and patients who were unwilling to undergo the examination were excluded.

Detailed clinical history, Complete blood examinations, ESR, urine analysis, random blood sugar, serum creatinine and blood urea values were obtained from all patients before enrolling them into the study. Chest X-ray PA view was obtained in all patients. Informed written consent, after explaining the risks of adverse reaction to contrast was taken from both the patient and patient attendants.

Procedure for Intravenous Urography
The procedure was performed on Siemens 1000 mA X-ray equipment in Department of Imaging Sciences, Sri Sathya Sai Institute of Higher Medical sciences, Prashanthigram. Urography was performed according to a standard protocol. Prior to the study, bowel preparation was advised to the patient. No bowel preparation was given to children below 10 years of age. The patients were asked to come on fasting in the morning. A plain radiograph of Kidney Ureter and Bladder region was obtained first followed by intravenous administration of a bolus of non-ionic contrast medium containing 300mg iodine/ml. The dosage of contrast was 1ml/kg body weight in adults and 1.5 ml/kg body weight in children below 12 years. Post contrast 5 minutes,15 minutes films in supine position, 35 minutes film in prone position, full bladder and post void images were obtained. Delayed images as required were taken at 11/2, 3 and 6 hours respectively.

CT was performed using Siemens Somatom Plus 4 scanner in Department of Imaging Sciences, Sri Sathya Sai Institute of Higher Medical sciences, Prashanthigram respectively. For CT, the patients were requested to come on fasting. First, a non-contrast CT of the abdomen with 5 mm contiguous slices was obtained from the level of domes of diaphragm to pubic symphysis in spiral mode. Non–ionic contrast medium containing 300mg iodine/ml was injected into a peripheral vein in the upper limb at the rate of 2ml per second using pressure injector. Repeat scans of the entire abdomen from domes of diaphragm to the symphysis pubis were obtained in two phases after contrast injection, early phase (at 120 seconds after starting contrast injection) and a delayed phase (30 minutes after contrast injection).

The presence and frequency of the following radiological findings were assessed on IVU and CT in this study:

- Renal parenchymal masses
- Moth-eaten calyx
- Renal parenchymal cavity
- Renal parenchymal scarring
- Real parenchymal calcification
- Infundibular or pelvic stenosis
- Amputated infundibulum
- Autonephrectomy
- Thickened ureteric wall
- Ureteric strictures
- Calcified ureteric wall
- Thickened and contracted urinary bladder
- Urethral stricture
- Extraurinary manifestations of tuberculosis.

Statistical analysis: Number and percentage of patients with positive features on CT and IVU were analysed. The correlation between the IVU and CT findings were done using McNemar test and p value was calculated to know the statistical significance. Microsoft excel and word software were used to generate charts and tables.

Results: Our study included 50 patients who were diagnosed to have urinary tuberculosis (positive acid fast bacilli in urine). Among the 50 patients, only 13(26%) patients gave past history of tuberculosis. Among these, 12 (24%) had pulmonary tuberculosis and 1(2%) patient had urinary tuberculosis. Of the 50 patients, 31 were females and 19 were males (table 1). The age of the patients ranged from 3 years to 72 years and the mean age was 36.44 years. The peak age of incidence overall was in the 4th decade. However, the peak age of incidence in female patients was in 3rd decade and 4th decade in male patients (table 3).

Table 1: Age and sex distribution of the patients

Age group	Males (%)	Females	Total
0-10	0 (0%)	1 (2%)	1 (2%)
11-20	0 (0%)	4 (8%)	4 (8%)
21-30	4 (8%)	11 (22%)	15 (30%)
31-40	8 (16%)	8 (16%)	16 (32%)
41-50	1 (2%)	2 (4%)	3 (6%)
51-60	5 (10%)	1 (2%)	6 (12%)
61-70	1 (2%)	3 (6%)	4 (8%)
71-80	0 (0%)	1 (2%)	1 (2%)
Total	19	31	50

Plain radiograph of the chest was normal in 35 patients and showed healed tuberculous lesions in 12 patients and active disease in 3 patients.

Table 2. Findings of urinary tuberculosis on IVU

Findings	Unilateral	Bilateral	Total
Renal parenchymal mass	1 (2%)	0 (0%)	1 (2%)
Moth eaten calyx	1 (2%)	0 (0%)	1 (2%)
Renal parenchymal cavity	3 (6%)	3 (6%)	6 (12%)
Renal parenchymal scarring	7 (14%)	1 (2%)	8 (16%)
Renal parenchymal calcification	7 (14%)	1 (2%)	8 (16%)

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Infundibular or pelvic stenosis	10 (20%)	2 (4%)	12 (24%)
Amputated infundibulum	0 (0%)	0 (0%)	0 (0%)
Autonephrectomy	9 (18%)	0 (0%)	9(18%)
Thickened ureteric wall	1 (2%)	0 (0%)	1 (2%)
Ureteric stricture	4 (8%)	0 (0%)	4 (8%)
Calcified ureteric wall	0 (0%)	0 (0%)	0 (0%)
Thickened and contracted UB	-	-	8 (16%)
Urethral stricture	-	-	0 (0%)
Extraurinary manifestations	-	-	0 (0%)

The most common finding on IVU was infundibular or pelvic stenosis which was seen in 12(24%) patients. The frequency of rest of the findings in descending order was autonephrectomy in 9(18%), renal parenchymal calcification in 8(16%), thickened bladder wall in 8(16%), renal parenchymal scarring in 8(16%), renal parenchymal cavity in 6(12%), ureteric stricture in 4(8%), renal parenchymal mass in 1(2%), moth eaten calyx in 1(2%), thickened ureteric wall 1(2%). Amputated infundibulum, ureteric wall calcification, urethral stricture and extraurinary manifestations were not detected in any of the patients studied (table 2).

Table 3. Findings of urinary tuberculosis on CT

Finding	Unilateral	Bilateral	Total
Renal parenchymal mass	1 (2%)	1 (2%)	2 (4%)
Moth eaten calyx	2 (4%)	0 (0%)	2 (4%)
Renal parenchymal cavity	6 (12%)	2 (4%)	8 (16%)
Renal parenchymal scarring	14 (28%)	4 (8%)	18(36%)
Renal parenchymal calcification	7 (14%)	1 (2%)	8 (16%)
Infundibular or pelvic stenosis	20 (40%)	3 (6%)	23(46%)
Amputated infundibulum	0 (0%)	0 (0%)	0 (0%)
Autonephrectomy	9 (18%)	0 (0%)	9 (18%)
Thickened ureteric wall	11 (22%)	0 (0%)	11 (22%)
Ureteric stricture	7 (14%)	1 (2%)	8 (16%)
Calcified ureteric wall	1 (2%)	0 (0%)	1 (2%)
Thickened and contracted UB	-	-	11 (22%)
Urethral stricture	-	-	0 (0%)
Extra urinary manifestations	-	-	9 (18%)

On CT, the commonest finding was infundibular or pelvic stenosis seen in 23(46%) patients. The frequency of rest of the findings in descending order was renal parenchymal scarring in 18(36%) patients, thickened ureteric wall in 11(22%), thickening of bladder wall in 11(22%), autonephrectomy in 9(18%), extraurinary manifestations in 9(18%), renal parenchymal calcification in 8(16%), renal parenchymal cavity in 8(16%), ureteric stricture in 8(16%), moth eaten calyx in 2(4%), renal parenchymal mass in 2(4%) and calcified ureteric wall 1(2%). An amputated infundibulum and urethral stricture could not be detected in any of our cases. (table 3). In 15 (30%) patients, IVU and CT were normal.

Findings were more frequently present unilaterally than bilaterally on both CT and IVU (tables 2 and 3). Infundibular or pelvic stenosis was the most common feature on both IVU and CT. Second most common feature detected on IVU was autonephrectomy and on CT was renal parenchymal scarring (tables 2 and 3). Amputated infundibulum and urethral stricture was not detected in any of the patients studied on either IVU or CT (tables 2 and 3).

Table 4. Extraurinary manifestations

Feature	frequency
Para-aortic lymphadenopathy	4 (8%)
Calcified lesions in liver	2 (4%)
Psoas abscess with cutaneous sinus	1 (2%)
Vertebral body destruction	1 (2%)
Pleural calcification	1 (2%)
Total	9 (18%)

Table 5. Distribution of cases according to presence of findings of urinary tuberculosis on CT and IVU.

Finding	Present only on CT	Present only on IVU	Present on both IVU and CT
Renal parenchymal mass	1 (2%)	0 (0%)	1 (2%)
Moth eaten calyx	1 (2%)	0 (0%)	1 (2%)
Renal parenchyma cavity	2 (4%)	0 (0%)	6 (12%)
Renal parenchymal scarring	10(20%)	0 (0%)	8 (16%)
Renal parenchyma calcification	0 (0%)	0 (0%)	8 (16%)
Infundibular or pelvic stenosis	11(22%)	0 (0%)	12 (24%)
Autonephrectomy	0 (0%)	0 (0%)	9 (18%)
Thickened ureteric wall	10(20%)	0 (0%)	1 (2%)
Ureteric stricture	4 (8%)	0 (0%)	4 (8%)
Calcified ureteric wall	1 (2%)	0 (0%)	0 (0%)
Thickened and contracted UB wall	3 (6%)	0 (0%)	8 (16%)
Extraurinary manifestations	9 (18%)	0 (0%)	0 (0%)

McNemar test on paired proportions

This study used McNemar test for calculation of 'p value' for comparison of each finding on IVU and CT.

Finding	Present on IVU	Absent on IVU	Total
Present on CT	A	B	A+B
Absent on CT	C	D	C+D
Total	A+C	B+D	A+B+C+D

A is both positive in IVP and CT; B is positive only in CT; C is positive only in IVP;

D is negative in both CT and IVP

Note: Values on the right upper corner of each box indicate the percentage of horizontal total and that in the left lower corner indicates the percentage of vertical total in Tables No:6– 15.

Table 6. Distribution of subjects for renal parenchymal mass on CT and IVP

Renal parenchymal mass	Present on IVU	Absent on IVU	Total
Present on CT	(50.00%) 1 (100.00%)	(50.00%) 1 (2.04%)	2 (4.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 48 (97.96%)	48 (96.00%)
Total	1 (2.00%)	49 (98.00%)	50

p > 0.05 (not significant)

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One subject was positive in both IVP and CT; One subject was positive in CT only but not in IVP

No subject was positive in IVP only; Forty eight subjects were negative in both CT and IVP

Table 7. Distribution of subjects for moth eaten calyx on CT and IVP

Moth eaten calyx	Present on IVU	Absent on IVU	Total
Present on CT	(50.00%) 1 (100.00%)	(50.00%) 1 (2.04%)	2 (4.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 48 (97.96%)	48 (96.00%)
Total	(2.00%) 1	(98.00%) 49	50

p = 0.5 (not significant)

One subject was positive both in IVP and CT; One subject was positive in CT only but not in IVP

No subject was positive in IVP only; Forty eight subjects were negative in both CT and IVP

Table 8. Distribution of subjects for renal parenchymal cavity on CT and IVP

Renal parenchyma cavity	Present on IVU	Absent on IVU	Total
Present on CT	(75%) 6 (100.00%)	(25%) 2 (4.76%)	8 (16.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 42 (95.24%)	42 (84.00%)
Total	(12.00%) 6	(88.00%) 44	50

p = 0.135 (not significant)

Six subjects were positive both in IVP and CT; Three subjects were positive in CT only but not in IVP; No subject was positive in IVP only; Forty one subjects were negative in both CT and IVP

Table 9. Distribution of subjects for renal parenchymal scarring on CT and IVP

Renal parenchymal scarring	Present on IVU	Absent on IVU	Total
Present on CT	(44.44%) 8 (100.00%)	(55.56%) 10 (23.80%)	18 (36.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 32 (76.2%)	32 (64.00%)
Total	(16.00%) 8	(84.00%) 42	50

p < 0.01 (significant)

Eight subjects were positive both in IVP and CT; Ten subjects were positive in CT only but not in IVP; No subject was positive in IVP only; Thirty two subjects were negative in both CT and IVP

Table 10. Distribution of subjects for renal parenchymal calcification on CT and IVP

Renal parenchyma calcification	Present on IVU	Absent on IVU	Total
Present on CT	(100.00%) 8 (100.00%)	(0.00%) 0 (0.00%)	8 (16.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 42 (100.00%)	42 (84.00%)
Total	(16.00%) 8	(84.00%) 42	50

p = 1 (not significant)

Eight subjects were positive both in IVP and CT; No subject was positive in CT only

No subject was positive in IVP only; Forty two subjects were negative in both CT and IVP

Table 11: Distribution of subjects for infundibular or pelvic stenosis on CT and IVP

Infundibular or pelvic stenosis	Present on IVU	Absent on IVU	Total
Present on CT	(52.20%) 12 (100.00%)	(47.80%) 11 (28.90%)	23 (46.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 27 (71.10%)	27 (54.00%)
Total	(24.00%) 12	(76.00%) 38	50

p < 0.001 (significant)

Twelve subjects were positive both in IVP and CT; Eleven subjects were positive in CT only but not in IVP; No subject was positive in IVP only; Twenty seven subjects were negative in both CT and IVP

Table 12. Distribution of subjects for autonephrectomy on CT and IVP

Autonephrectomy	Present on IVU	Absent on IVU	Total
Present on CT	(100.00%) 9 (100.00%)	(0.00%) 0 (0.00%)	9 (18.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 41 (100.00%)	41 (82.00%)
Total	(18.00%) 9	(82.00%) 41	50

p = 1 (not significant)

Nine subjects were positive both in IVP and CT; No subject was positive in CT only

No subject was positive in IVP only; Forty one subjects were negative in both CT and IVP

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Table 13. Distribution of subjects for thickened ureteric wall on CT and IVP

Thickened ureteric wall	Present on IVU	Absent on IVU	Total
Present on CT	(9.09%) 1 (100.00%)	(90.91%) 10 (20.41%)	11 (22.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 39 (79.59%)	39 (78.00%)
Total	(2.00%) 1	(98.00%) 49	50

$p < 0.05$ (significant)

One subject was positive both in IVP and CT;Ten subjects was positive in CT only but not in IVP

No subject was positive in IVP only; Thirty nine subjects were negative in both CT and IVP

Table 14. Distribution of subjects for ureteric stricture on CT and IVP

Ureteric stricture	Present on IVU	Absent on IVU	Total
Present on CT	(50.00%) 4 (100.00%)	(50.00%) 4 (8.70%)	8 (16.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 42 (91.30%)	42 (84.00%)
Total	(8.00%) 4	(92.00%) 46	50

$p = 0.0625$ (not significant)

Four subjects were positive both in IVP and CT;Four subjects were positive in CT only but not in IVP; No subject was positive in IVP only;Forty two subjects were negative in both CT and IVP

Table 15. Distribution of subjects for calcified ureteric wall on CT and IVP

Calcified ureteric wall	Present on IVU	Absent on IVU	Total
Present on CT	(0.00%) 0 (0.00%)	(100.00%) 1 (2.00%)	1 (2.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 49 (98.00%)	49 (98.00%)
Total	(0.00%) 0	(100.00%) 50	50

$p = 0.5$ (not significant)

No subject was positive both in IVP and CT; One subject was positive in CT only but not in IVP

No subject was positive in IVP only; Forty nine subjects were negative in both CT and IVP

Table 16. Distribution of subjects for thickened and contracted UB on CT and IVP

Thickened and contracted UB	Present on IVU	Absent on IVU	Total
Present on CT	(72.73%) 8 (100.00%)	(27.27%) 3 (7.14%)	11 (22.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 39 (92.86%)	39 (78.00%)
Total	(16.00%) 8	(84.00%) 42	50

$p = 0.125$ (not significant)

Eight subjects were positive both in IVP and CT; Three subjects were positive in CT only but not in IVP; No subject was positive in IVP only; Thirty nine subjects were negative in both CT and IVP

Table 17. Distribution of subjects for extraurinary manifestations on CT and IVP

Extra urinary manifestations	Present on IVU	Absent on IVU	Total
Present on CT	(0.00%) 0 (0.00%)	(100.00%) 9 (18.00%)	9 (18.00%)
Absent on CT	(0.00%) 0 (0.00%)	(100.00%) 41 (82.00%)	41 (82.00%)
Total	(0.00%) 0	(100.00%) 50	50

$p < 0.05$ (significant)

No subject was positive both in IVP and CT; Nine subjects were positive in CT only but not in IVP; No subject was positive in IVP only; Forty one subjects were negative in both CT and IVP

The identification of imaging findings as renal parenchymal scarring ($p< 0.01$), infundibular or pelvic stenosis ($p < 0.001$), thickened ureteric wall ($p < 0.05$) and extra urinary manifestations ($p < 0.05$) on CT were significantly more frequent than on IVP. There was no significant difference on IVP and CT in detection of renal parenchymal mass, renal parenchyma calcification, renal parenchyma cavity, moth eaten calyx, autonephrectomy, ureteric stricture with HDUN, calcified ureteric wall and thickening of UB wall.

Discussion:

Approximately one-third of the world's population is believed to harbor latent infection with *Mycobacterium tuberculosis*[1]. Tuberculosis is a major health problem in India and it is estimated to kill approximately 5 lakh individuals per annum[2]. India accounts for nearly one-third of global tuberculosis burden[2]. It can affect virtually any organ system in the body and can be devastating if left untreated. The genitourinary system is the most common site of extrapulmonary tuberculosis[3] and comprises 30% of non-pulmonary TB[3].

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Tuberculosis of the kidney results from hematogenous seeding of *Mycobacterium tuberculosis* in the glomerular and peritubular capillary bed from primary site of infection, usually from a pulmonary focus[3-6]. Small granulomas form in the renal cortex bilaterally, adjacent to the glomeruli. These cortical granulomas can remain asymptomatic and dormant for decades. Breakdown of host defence mechanisms leads to reactivation of the cortical granulomas with enlargement, coalescence, caseous necrosis and cavitations[3-7]. Imaging findings can support the diagnosis of genitourinary tuberculosis. Communication of the granulomas with the collecting system leads to regional spread of the bacilli into the renal pelvis, ureters, urinary bladder and accessory genital organs. The host's healing response induces fibrosis, calcium deposition and stricture formation, which contributes to obstruction and progressive renal dysfunction[3, 6,]

Patients with urinary tract tuberculosis have local symptoms such as frequency, urgency and dysuria[5, 8]. Urine analysis shows sterile pyuria, acidic p^H and hematuria[5, 6, 8]. Standard urine cultures usually show no growth. To evaluate genitourinary tuberculosis, at least three consecutive first-morning-void urine samples should be collected for acid-fast staining and Mycobacterial cultures[9]. Urinary tuberculosis is diagnosed either by identification of *Mycobacterium tuberculosis* in the urine (either by smear for acid fast bacilli or by positive culture) or histological examination of biopsy or surgical specimen or by polymerase chain reaction[3].

Imaging findings can support the diagnosis of genitourinary tuberculosis. Conventional radiograph of KUB region may show renal calcification and other extrapulmonary manifestations of tuberculosis such as lymph nodal and adrenal calcifications or spinal manifestations[4-6]. Intravenous urography can detect a broad range of findings, depending on the severity of infection. Irregularity of the papillary tips (moth-eaten calyx) is the earliest finding in the kidney[5-7, 10]. Other findings in kidney are cavitation, focal or diffuse caliectasis due to infundibular strictures, phantom calyx, generalized hydronephrosis and sharp angulation of renal pelvis known as Kerr's kink[5,10,11]. Ureteral involvement manifests as dilatation and mucosal irregularity in early stage. Advanced disease shows strictures and can produce a "beaded ureter" or "corkscrew ureter ". Diffuse fibrosis resulting in ureteral shortening is known as "pipe-stem ureter" [4,5,6]. The bladder may be diminutive and irregular with advanced disease known as "thimble bladder" [5, 10-12].

CT scan is the most sensitive imaging modality for identifying renal calcifications[13]. Cortical granulomas are seen as non-enhancing hypodense areas. Parenchymal scarring, cortical thinning, dilated calyces filled with debris or caseous material, putty-like calcification and calculi can be readily demonstrated on CT [13,14]. Fibrotic strictures of the infundibulum, renal pelvis, and ureters can be seen on contrast-enhanced CT[13,14]. Thickening of ureteric and bladder wall can also be detected on CT. In addition, CT is useful in determining the extent of renal and extrarenal spread of infection, such as perinephric abscess and also can detect the extraurinary manifestations[11,13].

In our study, 13 (26%) patients gave history tuberculosis in the past. Of these 12(24%) had pulmonary tuberculosis and 1(2%) patient had urinary tuberculosis. Gibson MS et al[6] described that about 25% of patients with urinary tuberculosis have past history of pulmonary tuberculosis, which corresponds with our study. The age of patients in our study ranged from 3 to 72 years with a mean age of 36.44 years. The mean age was 35.2 years in the series of Najar MS et al[22], 40 years in a study by El Khader et al[20] and 38 years in the study of Benchekroun et al[21]. Urinary tract tuberculosis is rare in pediatric age group. In our study group, only one patient was in the pediatric age, a 3 year old child. Very few reports exist in literature regarding urinary tract tuberculosis in children. Najar et al reported 4 cases in pediatric age group in a series of 63 patient[22]. Kothari PR et al reported a case of renal tubercular abscess in a 3 year old child[24]. Chatopadhyay et al had reported genitourinary tuberculosis in 9 patients of pediatric age group[23]. Because it usually takes 2 to 20 years for latent foci of tuberculosis in the urinary tract to reactivate, the disease is usually not seen in the children[23].

Highest incidence of urinary tuberculosis in 50 patients we studied was in the 4th decade, in females it was in the 3rd decade and in males it was in the 4th decade (table 1). In our study, the number of female patients was 31 (62%) and number of male patients was 19 (38%). Female preponderance in our study corresponded with study by Wang LJ et al in 53 patients, out of which 30 were females and 23 were males[25]. However, the earlier literature gives a contrary view and most studies reported preponderance in males. Our study differed from previous studies by female preponderance. This may be due to different population groups studied. Our study found evidence of pulmonary tuberculosis in 15 (30%) of patients in the chest radiograph, of which healed pulmonary lesions were seen in 24% and active disease in 6%. Leder RA et al described that approximately 50% of patients with genitourinary tuberculosis have abnormal chest radiographic findings, of which healed TB will be seen in approximately 40% and active disease in 10% of cases[4]. Kenney PJ mentioned that 30% of patients presenting with renal TB have an abnormal chest radiograph, and only 10% show signs of active pulmonary TB[7].

In our study, a total of 15 (30%) patients had normal findings on both CT and IVU. . In early stages, rupture of small cortical tubercles into the collecting system can cause urine positive for AFB, when the imaging findings are normal. In study by Najar MS et al, out of 56 intravenous urograms, 8% were normal[22]. Benchekroun A et al reported normal IVU in 5% of their cases[21]. A normal excretory urogram does not rule out renal tuberculosis[16.]

However, rest of the patients in our study demonstrated a wide variety of features on CT and IVU. All the findings were more commonly present unilaterally (tables 2 and 3). Elkin M described that urinary tract tuberculosis usually presents unilaterally and even if it is bilateral, it is asymmetrical[15]. Lu P et al reported that unilateral disease is more common[28]. Renal parenchymal mass was found in 1(2%) patient on IVU and 2(4%) patients on CT in our study (tables 2 and 3). Wang LJ et al described renal parenchymal masses in 13% cases on IVU and 55% on CT[25]. Renal parenchymal mass is an early feature of renal tuberculosis. Late presentation may be cause for reduced frequency of this feature in our study.

Moth eaten calyx was detected in 1 (2%) on IVU and in 2 (4%) patients on CT in our series (tables 2 and 3). Wang LJ et al found moth-eaten calyx in 6% patients on IVU and in none of the patients on CT[25]. This feature was less frequently found in our study probably due to late presentation of patients where disease has advanced and pelvicalyceal system was dilated in most of the patients. Our studies corresponded with that of Wang LJ et al[25] in that this feature is less frequently seen.

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Renal parenchymal cavities were seen in 6(12%) on IVU and in 8 (16%) patients on CT in our series (tables 2and 3). Wang LJ et al reported parenchymal cavities in 11% on IVU and in 12% on CT[25]. The frequency of detection of parenchymal cavities in our study was in accordance with the earlier study by Wang LJ et al[25] and IVU was almost as efficient as CT in detection of this feature.

Renal parenchymal scarring was seen in 8(16%) on IVU and in 18(36%) patients on CT in our study (tables 4 and 5). Parenchymal scarring was the second most common abnormality detected on CT in our study and it was superior to IVU in identifying this feature (table 11). Wang LJ et al reported renal parenchymal scarring in 23% on IVU and in 76% on CT [25]. Premkumar A et al reported parenchymal scarring in 4 cases on both IVU and CT in their series of 14 patients with advanced urinary tract tuberculosis[26]. CT was more efficient than IVU in demonstrating renal parenchymal scarring similar to study by Wang et al, as CT can demonstrate even mild scarring, whereas IVU can show only gross scarring.

Renal parenchymal calcification was seen in 8(16%) on IVU and in 8(16%) patients on CT in our series (tables 4 and 5). Parenchymal calcification was detected with same frequency by CT and IVU. Premkumar A et al, in their study on 14 patients reported calcification of entire kidney in 3 cases on IVU and 2 cases on CT, and calcification of part of kidney in 9 and 12 cases respectively on CT and IVU[26]. Wang LJ et al detected urinary tract calcification in 26% on IVU and 42% on CT[25]. Goldman et al reported calcification of parenchyma in 3 cases, in a series of 8 patients with renal tuberculosis studied by CT[27]. Our study corresponded with that off Premkumar A et al in that CT and IVU were equally sensitive in detection of calcification. However, in comparison with other studies[8,25,26], this feature was less frequently found on both CT and IVU in our series.

Infundibular or pelvic stenosis was seen in 12 (24%) patients on IVU and in 23 (46%) on CT (tables 4 and 5). This finding was better identified on CT than IVU (table 13). IVU can demonstrate stenosis with proximal tract dilatation only in functioning kidneys when collecting system is opacified with contrast. CT can demonstrate wall thickening, strictures and proximal tract dilatations even in non-functioning kidneys. Premkumar et al[26] in their series of 14 cases, reported infundibular strictures in 8 and pelvic strictures in 6 cases on CT and correspondingly in 3 and 5 cases on IVU. Our study corresponded with study by Premkumar A et al[26] who reported CT to be more sensitive in detecting infundibular strictures.

Autonephrectomy was seen in 9 (18%) cases on IVU and CT in our study (tables 4 and 5). Autonephrectomy was the second most common feature detected on IVU in our study. Wang LJ et al found autonephrectomy in 36% on IVU and 52% on CT[25.] Goldman SM et al reported contracted and atrophic kidneys in 4 out of 8 cases of renal tuberculosis studied on CT[27]. Our study found IVU and CT to be equally effective in detecting autonephrectomy probably due to late presentation of patients and differed from earlier studies where CT was superior to IVU in detecting this feature.

Thickened ureteric wall was seen in 1 (2%) patient on IVU and in 11 (22%) patients on CT (tables 2 and 3). In our study, CT was more sensitive than IVU in detecting thickening of ureteric wall (table 15). Thickening of collecting system is best appreciated on CT scan as this modality can show cross sectional anatomy better than IVU.

Ureteric stricture was seen in 4(8%) on IVU and in 8(16%) patients on CT in our study (tables 4 and 5). Though ureteric stricture was relatively commonly seen on CT compared to IVU, there was no significant difference ($p < 0.05$) between these two imaging modalities (table 14). Stricture of ureter is a late manifestation of tuberculosis[22]. Najar MS et al[22] found hydroureter due to ureteric stricture in 12% of their cases which corresponds with our study. Calcified ureteric wall was seen in 1(2%) patient on CT and was not detected in any of the patients studied on IVU (tables 2 and 3). Premkumar A et al, in their study on 14 patients found ureteral calcification in 2 out of 14 cases studied on both IVU and CT[26].

Ureteric calcification is rare in tuberculosis and is seen in advanced cases. CT is the most sensitive imaging modality in detection of calcification and hence was able to show calcification of ureter in one case in our study which IVU failed to detect.

Thickened and contracted bladder was seen in 11 (22%) patients and in 8(16%) patients on IVU in our series (tables 2 and 3). El Khader et al found thimble bladder in 11 of the 40 patients studied by IVU[20]. Najar MS et al found thimble bladder in 3(6%) in 56 patients studied on IVU[22]. Premkumar A et al in their study on 14 patients found scarred urinary bladder wall in 4 cases on IVU and 2 cases on CT[26].Thickened and contracted bladder (thimble bladder) was relatively commonly seen on CT in our study similar to the study of Premkumar et al[26]. But there was no significant difference between IVU and CT in identifying this feature (table 18). Frequency of detecting thimble bladder on IVU in our study corresponded with that of El Khader et al[20].

Amputated infundibulum was not seen in any of our patients on IVU or CT (tables 2 and 3). Similarly urethral stricture was not found in any of the patients studied. Stricture urethra is very rarely seen in urinary tract tuberculosis and only a few case reports exist in the literature [17, 18, 19]. Extraurinary manifestations were seen in 9 (18%) patients on CT (table 5). This feature was not seen any of the patients on IVU (table 4).

Various extraurinary manifestations seen in descending order of frequency in this study on CT were retroperitoneal lymphadenopathy in 4(8%), calcified lesions in liver in 2 (4%), vertebral destruction with paravertebral abscess in 1(2%), and pleural calcifications in 1(2%). Retroperitoneal lymphadenopathy was the most common extraurinary manifestation in our study (table 4). CT shows the morphology of all the abdominal viscera and retroperitoneal structures. Hence, involvement of spine, other organs, abscesses, fistulous and sinus tract tracts can detected in addition to urinary tract pathology on CT better than IVU, as in our study (table 17). Lu P et al, reported extraurinary manifestations in 13 out of 42 patients of renal tuberculosis on CT (lymph nodal calcification in 2 patients, paraverterbral abscess in 6, calcification and low density nodes in the liver and spleen in 4 , abdominal abscess in 1 patient)[28]. Wang LJ et al detected extraurinary manifestations in 2% of patients on IVU and in 24% on CT[25]. Our study corresponded with earlier studies in which extraurinary manifestations were more commonly detected on CT compared to IVU.

The gross pathologic and urographic abnormalities pro-

Volume : 6 | Issue : 9 | September 2016 | ISSN - 2249-555X | IF : 3.919 | IC Value : 74.50

duced by urinary tract tuberculosis are well known. In our study, there were differences between CT and IVU in the identification of various features of urinary tract tuberculosis. The frequency of each finding on IVU and CT reflects the frequency of different pathological changes of urinary tract tuberculosis but they were also affected by the varying abilities of IVP and CT to demonstrate this condition. CT showed more details than IVU and almost all the findings detected in IVU were detected on CT, but renal parenchymal scarring, infundibular or pelvic stenosis, thickened ureteric wall and extra urinary manifestations were identified significantly better on CT than on IVP. There was no significant difference on IVP and CT in the detection of renal parenchymal mass, renal parenchyma calcification, renal parenchyma cavity, moth eaten calyx, autonephrectomy, ureteric stricture, calcified ureteric wall, and thickened and contracted urinary bladder.

Conclusion:

Urinary tuberculosis was more common in younger females. Relatively more number of patients had normal findings on imaging by IVU and CT.CT and IVU showed a wide variety of imaging findings and all the findings, when present, were common unilaterally. Most common feature on both CT and IVU was infundibular or pelvic stenosis. CT was superior to IVU in the detection of renal parenchymal scarring, infundibular or pelvic stenosis, ureteric wall thickening and extraurinary manifestations. A high degree of clinical suspicion and familiarity with the various radiologic manifestations of urinary tuberculosis helps in early diagnosis and timely initiation of appropriate therapy, thereby reducing patient morbidity. If identified early, urinary tuberculosis is a completely curable condition[22].

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