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Evaluation of renal infections by computed tomography in patients attending a tertiary care centre

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Abstract
Background: Acute pyelonephritis (APN) is the most common renal infection. In most cases, infection is confined to the lower urinary tract and the diagnosis is established by clinical or laboratory studies. Imaging is not required in routine cases if the patient is better with treatment. However,when the kidney is involved by inflammatory process or when the precise diagnosis is not known renal imaging plays an important role in diagnosis and management.[1]
Aims and objectives: 1. To evaluate the CT morphological characteristics of renal infections 2. To study the role of CT in establishing the diagnosis in equivocal cases. 3. To determine the extent of disease process in severe renal and perirenal infections. 4. To evaluate the role of CT in planning and management of renal infections in high risk patients.
Materials and Methods: It was a pilot study conducted at KVG Medical College and hospital, Sullia on 50 Patients. Sampling was done by Systematic random sampling technique. Study conducted between Period 1st December 2019 to 31st may 2021.
Stastistical analysis: Statistical analysis was performed with Microsoft office excel 2007 & IBM SPPS version 17. Analysed by frequencies, percentages and means.
Results: Out of a total 50 patients there were 24 (48%) males and 26 (52%) females.Maximum no. of patients (n= 17) were in the age group 31-40 years.Pyonephrosis (30%) was identified as the most common renal infection in our study followed by acute pyelonephritis (22%).Overall diabetes is the most common predisposing factor. Among 50 cases of renal infections 24 are known Diabetics patients. Among 11 cases of acute pyelonephritis ultrasonography helped in diagnosis 8 cases and in the rest of the 3 cases ultrasonography showed only renomegaly with increased echotexture. Contrast enhanced CT is able to diagnose the rest of 3 cases as focal pyelonephritis by demonstrating non-enhancing focal hypodense lesions.
Conclusion: CT is the definitive investigation of choice in all cases of renal infections by establishing the proper diagnosis.

Keywords: renal infections-Acute pyelonephritis, diabetes, computed tomography

Introduction

Inflammatory conditions involving the urinary tract are the most common infectious disorder affecting humans. In most cases, infection is confined to the lower urinary tract and the diagnosis is established by clinical or laboratory studies.
Acute pyelonephritis (APN) is the most common renal infection. The sensitivity and specificity of CT for APN is 86% and 87.5% compared with 74.3% & 56.7% for ultrasonography respectively (Grainger and Allison) [2].
CT is considered the imaging technique of choice for diagnosis and follow up of acute pyelonephritis because of high sensitivity, low cost and availability. CT can also assess for complications or extrarenal involvement. Other renal infections include renal and perirenal abscess, emphysematous pyelonephritis, pyonephrosis, renal tuberculosis, xanthogranulomatous pyelonephritis (XGP), septic emboli, chronic pyelonephritis, and fungus ball (common in immunocompromised patients). [2]
Incidence of pyelonephritis in out-patients was 12-13 cases per 10,000 population and in-patients was 3-4 cases per 10,000 population, more common in females than males in a study. [3]
Although computed tomography (CT) is not usually advised in uncomplicated cases of renal infection, it has got a great value in establishing the diagnosis in equivocal cases, in evaluating high-risk patients, and in determining the extent of disease.
Unenhanced CT is helpful in finding out inflammatory masses, gas, calculi, hemorrhage and parenchymal calcifications. [4]
With the evolution of multi–detector row helical computed tomography (CT), the radiologic evaluation of urological cases has changed. There are many approaches to CT urography. The common approach combines

axial CT with timed excretory urography (EU) performed by using conventional radiography, digital radiography, or CT scanned projection radiography (SPR). This approach produces traditional projection urograms, and the timed imaging technique is familiar to radiologists and clinicians. When the EU findings are positive or indeterminate additional excretory phase CT can be performed. [5]

Emphysematous pyelonephritis is a life-threatening necrotizing infection of the kidneys characterized by gas formation within or surrounding the kidneys. Nearly 90 percent of patients have poorly controlled diabetes. Non-diabetic patients are typically either immunocompromised or have associated urinary tract obstruction secondary to uroliths, neoplasm, or sloughed papilla [6]. The objective of this study therefore is to evaluate renal infections by CT in patients attending a tertiary care centre.

Materials and Methods

Source of Data

The study was conducted randomly on 50 patients of all age groups in whom there was a clinical suspicion of renal infections in KVG Medical College and Hospital, Sullia, DK, Karnataka, for from December 2019 to May 2021.

Inclusion criteria

All patients clinically suspected of having renal infections advised and willing for computed tomography

Exclusion criteria

- Patients with abnormal renal function test
- Patients hypersensitive or contraindicated to iodinated IV contrast.

Sampling technique: Systematic random sampling technique.

Statistical analysis: Collected data was entered in Microsoft office excel 2007 and IBM SPSS version 17 was used to analyse the data. Data was shown in the form of tables. Frequenices, Percentages and means were used to depict the data in tables

Observations and Results

A random study was done on 50 patients in our institute to evaluate the CT findings of renal infections. All these patients were clinically suspected to be suffering from renal infections and underwent screening ultrasonography of abdomen.

Table 1: Age and Sex incidence

Age in years	Male	Female	Total
< 10	0	0	0
11-20	1	1	2
21-30	2	2	4
31-40	6	11	17
41-50	5	10	15
51-60	7	3	10
61-70	1	0	1
71-80	1	0	1

Out of a total 50 patients there were 24 (48%) males and 26 (52%) females,and the average age groups being 31-40 years followed by 41-50 years.

We thus concluded that maximum no. of patients (n= 17) were in the age group of (31-40) years followed by no. of patients (n15) in the age group of (41-50).

60% of the patients are in the age group of 31-50 years. There were no patients below the age of 10 years.

Majority of the male patients in our study were in the age group of 51-60 years and majority of female patients were in the age group of 31-50 years.

Table 2: Incidence of Renal infection

Diagnosis	No.of patients	Percentage (%)
Pyonephrosis	15	30%
Acute pyelonephritis	11	22%
Renal abscess	7	14%
Renal tuberculosis	4	8%
Chronic pyelonephritis	4	8%
Perinephric abscess	4	8%
Emphysematous Pyelonephritis	4	8%
Xanthogranulomatous Pyelonephritis	1	2%

Pyonephrosis (30%) was identified as the most common renal infection in our study followed by acute pyelonephritis (22%). Next is the renal abscess (14%) followed by the renal tuberculosis, chronic pyelonephritis, emphysematous pyelonephritis, perinephric abscess. Xanthogranulomatous pyelonephritis has the least incidence among our study.

Predisposing Factors

Overall diabetes is the most common predisposing factor. Among 50 cases of renal infections 24 are known Diabetics patients. Among 15 cases of pyonephrosis calculus disease is the cause of obstruction in 8 cases, PUJ obstruction is the cause in three cases and in the rest of four cases no cause could not be found out.

Among 11 cases of acute pyelonephritis altered host resistance (diabetes) is the cause in 3 patients, vesicoureteric reflux in the cause in 2 patients. Rest of the 6 cases no obvious cause could be delineated.

Among 7 cases of renal abscess 5 patients are known cases of diabetes. Among 4 cases of chronic pyelonephritis, vesicoureteric reflux is the cause in two patients and neurogenic bladder is the cause in another case. All the cases of Emphysematous pyelonephritis and xanthogranulomatous pyelonephritis are known cases of diabetes.

CT Morphological Characteristics

CT morphological characteristics in all the 50 cases of renal infections were evaluated in detail.

Characteristic CT findings in each particular infection among the study and how the approach was made in establishing the diagnosis were depicted briefly in the next topic of discussion.

Role of CT in establishing the diagnosis in equivocal cases

Among 11 cases of acute pyelonephritis ultrasonography helped in diagnosis 8 cases and in the rest of the 3 cases ultrasonography showed only renomegaly with increased echotexture. Contrast enhanced CT is able to diagnose the rest of 3 cases as focal pyelonephritis by demonstrating non enhancing focal hypodense lesions.

Among the 4 cases of emphysematous pyelonephritis ultrasonography is able to diagnose 2 cases of emphysematous pyelonephritis, where as CT diagnosed all the 4 cases of EPN by demonstrating linear mottled air lucencies, loculated gas collections and fluid collections within renal and perinephric planes.

Xanthogranulomatous pyelonephritis - Contrast enhanced CT is the investigation of choice, where it could demonstrate the obstructing calculus, multiple non-enhancing hypodense lesions with peripheral rim enhancement and perirenal extent of the disease process.

Thus CT is the definitive investigation of choice in all cases of renal infections by establishing the proper diagnosis.

Determination of the extent of the disease process in severe renal and Perirenal Infections

Among 7 cases of renal abscess there are 3 cases with perinephric extension and among 11 cases of acute pyelonephritis there are 2 cases with perinephric extension and among the two, one with abscess formation in the right psoas muscle. Contrast enhanced CT has shown the perinephric extension in all the three cases of intrarenal abscess with perinephric component and the two cases of acute pyelonephritis with perinephric extension, which ultrasound could not show the extent of perinephric component into the muscle planes (psoas and quadratus lumborum). CT is able to delineate exactly the extent of all the four perinephric abscesses and all the cases of focal pyelonephritis (intrarenal extent of the lesion) compared to ultrasonography.

Thus both unenhanced and contrast enhanced CT are invaluable in determining the extent of disease process within the renal confines and in the peinephric planes compared to other investigations like ultrasonography.

Role of CT In Diagnosis and Management

In our study of 50 cases of renal infections (comprising 15 cases of pyonephrosis, 11 cases of acute pyelonephritis, 7 cases of renal abscesses, 4 cases of renal tuberculosis, 4 cases of chronic pyelonephritis, 4 cases of perinephric absceses, 4 cases of emphysematous pyelonephritis and one case of xanthogranulomatous pyelonephritis) Ultrasonography is able pick up all the 15 cases of pyonephrosis, 8 cases of acute pyelonephritis. Among 11 cases of APN, all the 7 cases of renal abscesses, 3 cases of renal tuberculosis among 4 cases, all the 4 cases of chronic pyelonephritis, 4 cases of perinephric abscesses, 2 cases of emphysematous pyelonephritis among 4 cases. Unenhanced and contrast enhanced CT has diagnosed all the cases (15) of pyonephrosis along with adjacent perinephric inflammation.

All the cases (11) of diffuse and focal pyelonephritis by demonstrating perinephric extension and inflammation in some cases, all the cases (7) of renal abscesses by demonstrating both the intrarenal and extrarenal component. All the cases (4) of renal tuberculosis by demonstrating pelvic fibrosis and caliectasis, All the (4) of chronic pyelonephritis by demonstrating cortical atrophy and adjacent dilated bulbous calyces, all the cases (4) of perinephric abscesses. All the four cases by emphysematous pyelonephritis by classifying it into Wan type I and type II, which helps in determining the prognosis and there by in the management part. Contrast enhanced CT is able to make up the correct diagnosis of xanthogranulomatous pyelonephritis by demonstrating obstructing calculus in the pelvis and multiple hypodense areas with minimal peripheral enhancement. Thus computed tomography (plain and contrast) helps both in the diagnosis and management in acute cases like emphysematous pyelonephritis and chronic cases like xanthogranulomatous pyelonephritis.

Ultrasound vs Computed Tomography

Table 3

	USG	CT
True + Ve	45	50
False -Ve	5	none
False +Ve	none	none

Ultrasound failed in establishing the diagnosis in 3 cases of acute pyelonephritis and 2 cases of emphysematous pyelonephritis.

Discussion

We did a random study on 50 patients in our hospital who were clinically suspected to be suffering from renal infections and underwent screening ultrasound. CT was performed on these patients on Siemens Somatom Emotion 16 Slice CT Scan.

CT protocol for evaluation of the kidneys consists of both non enhanced and contrast-material enhanced CT scans obtained in suspended respiration, to overcome the motion artifact. To avoid artifactual differences in attenuation values, the same peak kilo voltage, milli ampere-second setting, section thickness, and field of view were used for both pre contrast and post contrast scans when small renal masses are being evaluated.

Images were acquired with 1 to 3 mm collimation, subsecond scan time, and a pitch of up to 2:1 to allow coverage of the area of interest in single breath-hold. Scans were performed in both the cortico medullary phase and excretory phase.

The data of the present studies are discussed as follows

1. **Age Incidence:** In the present series age of the patients varied from as less as 18 years to as old as 80 years. The maximum numbers of cases 32 (60%) were in the age group of 31- 50 years.

Table 4

	Year	Age group
Present series	2020	31-50yrs(maximum no of patients)
Michael C. Soulen et. al	1996	30-55yrs

The present study matches with the study of Michael C. Soulen *et al* [9].

2. Sex Incidence

In the present series there were 26 (52%) females and 24 (48%) males.

Table 5

	Year	Study group	Male	Female
Present series	2005	50	24(48%)	26*(52%)*
Soulen *et al*	1986	62	20(32.2%)	42(68%)

According to Dunnick [10], women have a higher incidence of lower urinary tract infection owing to the short length of the female urethra. Bacterial infections of the kidney are much more common in women than in men younger than 50 years of age. Beyond this age, however, the incidence of urinary tract infection in men increases, as a result of urinary stasis caused by benign prostatic hypertrophy and other factors.

Symptoms

Fever associated with or without chills was the major symptom seen in 46 (92%) cases out of 50. Lower urinary tract symptoms, like dysuria, frequency and urgency were seen in most of the cases. Loin swelling was seen in gross degree pyonephrosis cases.

Flank pain was seen in cases of renal abscess XGP, emphysematous pyelonephritis. Three of the cases of chronic pyelonephritis are asymptomatic. Most of the clinical symptoms pertaining to each renal infection correlated well with the study of Michael Soulen *et al* [9].

CT morphological characteristics of renal infections

In our present study CT has diagnosed all the 50 cases of renal infections by its characteristic morphological features.

Parameters considered in diagnosing pyonephrosis by CT include

a. Pelvic wall thickness : ≤ 2mm - Grade I
b. 3- 5mm - Grade II

c. 5mm - Grade III
d. Renal pelvic contents.
e. Parenchymal and perirenal findings.

CT has diagnosed all the 15 cases of pyonephrosis considering the above findings.

Parameters considered in diagnosing acute pyelonephritis

a. Wedge shaped zones of decreased attenuation with straight borders radiating from the collecting system to the renal capsule and are widest at the periphery of the kidney.
b. Hypodense masses with rounded or irregular contour and bulging of the renal F surface.
c. Renal enlargement.
d. Perinephric stranding and edema.

CT diagnosed all the 11 cases of acute pyelonephritis by the above findings.

CT findings renal abscess

a. a well-defined or indistinct non-enhancing low attenuation (HU: 10-20) rounded or ovoid lesion.
b. Gas within the lesion is pathognomonic of an abscess
c. Thickening of gerota's fascia and increased attenuation of Perinephric fat.
d. In case of chronic abscess, the inferior of lesion is avascular with a hypervascular rim, which on contrast administration shows peripheral rim enhancement.

CT diagnosed all the 7 cases of intrarenal abscess, some with perinephric extension by its characteristic findings. Cortical atrophy with underlying distorted or dilated bulbuous calyx is the characteristic CT finding in chronic pyelonephritis which is seen in all the four cases of chronic pyelonephritis.

CT characteristic in renal tuberculosis

Early Disease

a. Hydrocalyx formation with or without stones.
b. Granulomas with calcifications
c. Ulceration of the collecting system

Advanced disease

a. Large granulomas
b. Focal or diffuse cortical scarring
c. Cavities which communicate with the system
d. Dystrophic amorphous calcifications
e. Wall thickening and fibrosis of collecting system
f. Strictures of infundibulum, renal pelvis, and ureter
g. Various patterns of hydronephrosis

End stage disease

a. Small calcified non-functioning renal remnant (autonephrectomy)
b. Enlarged calcified kidney (significant hydronephrosis associated with tuberculous involvement of collecting system.

CT diagnosed all the 4 cases of renal koch's by the characteristic CT findings of pelvic and infundibular stricture and autonephrectomy.

The strength of CT is its ability to define precisely the boundaries of the process, so that extension into the psoas muscle, posterior para renal space and the true pelvis may all be accurately detected. Peripheral rim enhancement is seen even with perinephric abscess CT demonstrated all the four cases of perinephric abscess not only in establishing the diagnosis but also by defining the precise extent of the lesions.

Emphysematous pyelonephritis -CT characteristic

Wan type I EPN - gas is found diffusely throughout the renal parenchyma in a streaked or mottled pattern with tissue destruction and little or no fluid.

Wan type II EPN - any renal or perinephric fluid collecctin with a bubbly or loculated gas collections either in the renal parenchyma or in the collecting system. CT aids in the diagnosis of EPN and in distinguishing gas containing renal abscesses from gas in the collecting system or in the renal parenchyma.

CT diagnosed 3 of the four cases of EPN as type II and one case as type I EPN there by helping in the determination of prognosis.

Xanthogranulomatous pyelonephritis -C**T Characteristics**

- Diffusely enlarged kidney, retaining its reniform shape (55-60%).

- Associated calculi (75-86%)
- Hydronephrosis (80%)
- Hypodense areas with density values (-15 to +20) representing focal areas of parenchymal destruction filled with pus and debris.
- Rim enhancement of hypodense lesions and extrarenal involvement (15-20%)

CT has diagnosed one case of XGP by demonstrating obstructing calculus in the renal pelvis, and non-excreting kidney with peripheral rim enhancing hypodense area.

Thus unenhanced and contrast enhanced together were able to diagnose all the 50 cases of renal infections and helped in determining the extent of disease process within and beyond the confine of the gerotas fascia.

According to Triller J, Scheidegger J *et al* [11], Computer tomography of the kidneys was performed on 30 patients with acute renal infections (acute suppurative pyelonephritis, acute renal abscess, infected cyst, pyonephrosis, calculus perforation, retroperitoneal abscess). Computer tomography provided more accurate information concerning the extent of the renal and extra-renal inflammatory process than did the urogram or sonogram. This may significantly affect the choice of treatment, particularly concerning the use of drugs or of surgery.

According Senn E, Zaunbauer W *et al* [12], The computed tomographic findings in nine female patients with acute pyelonephritis were reviewed. The major impact of CT was the demonstration of renal enlargement, abnormal contour, perirenal inflammatory extension and, on contrast-enhanced scans, abnormal nephrograms and impaired renal function. It was concluded that CT scan provide specific information about the nature and extent of the inflammatory process, thus complementing intravenous urography so that appropriate therapy may be selected. Follow-up studies can be helpful in monitoring the progress of a patient.

According Rauschkolb EN, Sandler CM *et al* [13], The value of computed tomography (CT) in patients with severe renal inflammatory disease has not been previously emphasized. They presented their experience using this modality in 17 patients with acute intrarenal inflammatory conditions. A spectrum of various renal abnormalities and their CT appearance ranging from lobar nephronia (focal pyelonephritis) to xanthogranulomatous pyelonephritis is presented.

These cases demonstrate that CT provides more precise anatomic information than does urography and is helpful in distinguishing uncomplicated patterns of renal infection from other types of renal inflammatory disease. In this way, patients who may be managed medically can be differentiated from those who require surgical intervention.

According Soulen MC, Fishman EK *et al* [14], The imaging studies done on 62 patients hospitalized for acute renal infections were retrospectively reviewed. Thirty-six (58%) had one or more abscesses, 17 (27%) had focal or diffuse acute bacterial nephritis, five (8%) had pyonephrosis, and four (6%) had pyelonephritis. All had prolonged fever (greater than or equal to 72 hours) and leukocytosis. Among 25 patients examined with both ultrasound (US) and computed tomography (CT), US failed to depict three of five (60%) cases of acute bacterial nephritis and seven of 15 (47%) intrarenal and extrarenal abscesses. One renal abscess was misdiagnosed as a tumor at CT.

US is not an adequate screening test for detecting lesions that may require invasive therapy. CT is more sensitive for the detection of acute renal inflammatory disease and for defining the extent of disease for planning of radiologic or surgical intervention.

According to Bova JG, Potter JL *et al* [15], Predisposing factors, onset of symptoms to diagnosis interval, computerized tomography findings and the impact of computerized tomography on the outcome were studied retrospectively in 24 patients with renal or peri renal infections. The most common predisposing factors were diabetes mellitus and urinary tract calculi. The mean interval from the onset of symptoms to diagnosis was 6.8 days.

The most common computerized tomography findings were thickening of Gerota's fascia, renal enlargement, focal decreased renal attenuation, peri renal fluid and focal gas. Four patients died despite early diagnosis and appropriate therapy. Computerized tomography aided in the diagnosis, assessment of the extent of disease, treatment and followup. Computerized tomography is the most direct method to evaluate patients with suspected renal or peri renal infection, although mortality may not be altered significantly.

Ultrasound vs Computed Tomography

Table 6

	USG	**CT**
True + Ve	45	50
False - Ve	5	none
False + Ve	none	none

Ultrasound failed in establishing the diagnosis in 3 cases of acute pyelonephritis and 2 cases of emphysematous pyelonephritis.

Conclusion

Although computed tomography is not routinely indicated in uncomplicated renal infections. It is of value in establishing the diagnosis in equivocal cases in the evaluation of high risk patients and in determining the extent of disease. Unenhanced CT is useful in demonstrating gas, calculus, parenchymal calcifications, haemorrhage and inflammatory masses.

However a contrast material enhanced study is essential for complete evaluation of patients with renal inflammatory disease to demonstrate alterations in renal excertion of contrast material that occur as a result of the inflammatory process disease.

CT is more sensitive for the detection of acute renal inflammatory disease and for defining the extent of disease for planning of Radiologic or surgical intervention

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