

Role of MDCT in Assessment of Inflammatory Renal Disease

Mohamed Abd Elaziz Ali, Yasser Ibrahim Abd Elkhalek, Amal Ghazy Ahmed Elkomy
Faculty of Medicine, Ain Shams University

ABSTRACT

Background: Renal inflammatory diseases range from mild to severe, acute to chronic and may be associated with predisposing risk factors like diabetes mellitus, human immunodeficiency virus (HIV), leukemia, vesico-ureteric reflux and staghorn calculi. Ultrasound (US) is the initial screening modality and is used for guiding interventions as well. The role of intravenous urography (IVU) has diminished lately, however it still remains the best modality to diagnose calyceal irregularity of early tuberculosis, papillary necrosis and to evaluate congenital anomalies. **Aim of Work:** The study aim to highlight the value of multidetector C.T imaging in assessment of renal inflammatory diseases.

Conclusion: C.T has the ability to diagnose and assess renal infection site and extension of infection to pararenal fascia, renal infection unilateral or bilateral and infection focal or diffused. CT has important role in assessment of complication and follow up of patients. CT guided FNAB can be done to diagnose renal infection and differentiate between infection.

Keywords: MDCT, HIV, Ultrasound, Intravenous Urography, Inflammatory Renal Disease.

INTRODUCTION

Renal inflammatory diseases range from mild to severe, acute to chronic and may be associated with predisposing risk factors like diabetes mellitus, human immunodeficiency virus (HIV), leukemia, vesico-ureteric reflux and staghorn calculi⁽¹⁾.

Acute infections include acute pyelonephritis, renal and perirenal abscesses, pyonephrosis, emphysematous pyelonephritis and emphysematous cystitis. The chronic renal infections that we routinely encounter encompass chronic pyelonephritis, xanthogranulomatous pyelonephritis, and eosinophilic cystitis. Acute pyelonephritis which may be focal or diffuse, may resolve with time or worsen to abscess formation depending on the treatment rendered and immune status of the patient⁽²⁾.

Imaging is not routinely indicated in urinary tract infections, however with severe symptoms, high risk immunocompromised state, diabetic patients and antibiotic non-responders, it becomes necessary. Plain radiography may provide evidence of gas in the renal area in emphysematous pyelonephritis or abscess and the typical mass like calcification in end stage renal tuberculosis (Putty kidney). Ultrasound (US) is the initial screening modality and is used for guiding interventions as well. The role of intravenous urography (IVU) has diminished lately, however it still remains the best modality to diagnose calyceal irregularity of early tuberculosis, papillary necrosis and to evaluate congenital anomalies. Computed tomography (CT) is the gold standard for diagnosis and assessment of severity of acute pyelonephritis and its complications. Magnetic resonance imaging (MRI) is indicated in pregnancy and patients with contraindication to iodinated contrast such as transplant recipients. Diffusion weighted MRI (DW-

MRI) has been applied to differentiate hydronephrosis from pyonephrosis as well as to detect infected cysts and tumors⁽³⁾.

AIM OF WORK

The study aim to highlight the value of multidetector C.T imaging in assessment of renal inflammatory diseases.

The study was approved by the Ethics Board of Ain Shams University.

BACTERIAL INFECTION

ACUTE PYELONEPHRITIS

Acute pyelonephritis is usually diagnosed based on clinical symptoms and laboratory data without imaging. The recommended phases of CT scan for evaluating renal infections are a non-contrast scan, nephrographic phase at 50-90 s and excretory phase at 2 min if there is obstruction⁽⁴⁾.

Striated nephrogram which is an appearance described for acute pyelonephritis shows discrete rays of alternating hypo attenuation and hyper attenuation radiating from the papilla to the cortex along the direction of the excretory tubules (Figures 1 and 2). This appearance is ascribed to the decreased flow of contrast due to stasis and eventual hyper-concentration in the infected tubules⁽⁵⁾. Pyelonephritis may manifest as wedge shaped zones of decreased attenuation or a hypodense mass in its focal form. The diffuse form of acute pyelonephritis may cause global enlargement. Poor enhancement of renal parenchyma, absent excretion of contrast and streakiness of fat. Hemorrhagic bacterial nephritis which is relatively uncommon shows hyper attenuating areas representing parenchymal bleeding on non-contrast scan⁽⁵⁾.

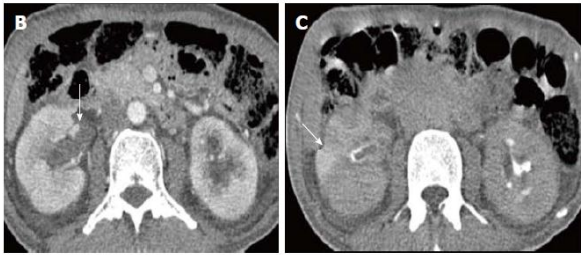


Fig. (1): Acute pyelonephritis in a 40 years old male. B: CECT nephrographic phase shows bilateral enlarged kidneys with heterogeneous enhancement. There is soft tissue thickening and abnormal enhancement of bilateral PCS and ureter (arrow); C: CECT delayed phase shows striated nephrogram (arrow) seen as linear bands of contrast extending from cortex to medulla. PCS: Pelvicalyceal system; CECT: Contrast-enhanced computed tomography.



Fig. (2): Contrast-enhanced computed tomography shows acute pyelonephritis manifesting as a focal wedge shaped hypodensity with surrounding fat stranding as seen in right kidney (arrow).

PYONEPHROSIS

On CT, high density of urine in dilated PCS with layering, parenchymal contrast or perinephric inflammatory changes and thickening of pelvic wall suggests infection (Figure 5). DW-MRI may have an additional role in distinguishing hydronephrosis from pyonephrosis as pyonephrosis tends to show restricted diffusion. Contrast enhanced MRI may show enhancement and wall thickening of the renal pelvis (Figure 3) ⁽⁶⁾.

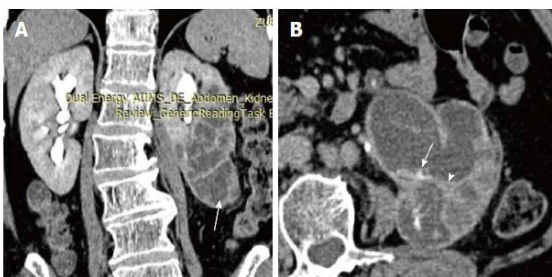


Fig. (3):Pyonephrosis in duplex left kidney. Coronal (A) and axial (B) sections of delayed phase CECT shows left duplex kidney with obstruction and hydronephrosis of lower moiety (arrow, A). Walls of the PCS shows thickening and crescentic

enhancement (arrowhead, B) suggesting pyonephrosis. PCS: Pelvicalyceal system; CECT: Contrastenhanced computed tomography.

RENAL ABSCESS

Renal and perinephric abscesses develop as a complication of focal pyelonephritis or hematogenous infection. Early abscess appears as a poorly marginated non-enhancing area of decreased attenuation. A mature abscess shows a sharply marginated, complex cystic mass with necrosis and a peripheral enhancing rim. US may show internal echoes, septations and loculations(figure 4). DW-MRI can readily pick up abscesses showing restriction of diffusion ⁽⁵⁾



Fig. (4): Mature abscess. CECT shows a sharply marginated area of low attenuation due to parenchymal necrosis with peripheral enhancing rim that suggest a mature abscess. CECT: Contrast-enhanced computed tomography.



Fig. (5): CECT of a diabetic middle aged male shows multiple peripherally enhancing lesions in bilateral kidneys (arrows). CECT: Contrast-enhanced computed tomography;

EMPHYSEMATOUS PYELONEPHRITIS

Emphysematous pyelonephritis is a life threatening, necrotising infection with gas formation and is associated with diabetes mellitus or immunocompromised state. The presence of gas is attributed to fermentation by bacteria in the presence of high glucose levels ⁽⁷⁾.

CT is performed for evaluating severity, extent of disease, parenchymal destruction, fluid collections and abscess formation. It is divided into two forms depending on severity and prognosis ⁽⁵⁾

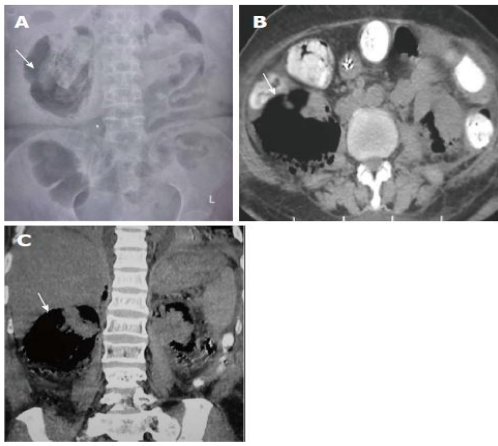


Fig. (6): Type 1 emphysematous pyelonephritis. A: Plain abdominal radiograph shows large amount of gas outlining the right kidney (arrow); B, C: Contrast-enhanced computed tomography axial (B) and coronal (C) images show gas pockets and parenchymal destruction destroying and replacing almost the entire right kidney. No perirenal collections are noted.



Fig. (7): Type 2 Emphysematous pyelonephritis. Contrast-enhanced computed tomography shows extensive inflammatory changes in right kidney and perinephric space with presence of gas within along with perirenal collection. The patient responded to antibiotics and percutaneous drainage.

Table (1): Emphysematous pyelonephritis

	TYPE1-33%	TYPE 2 -66%
Parenchymal destruction	Severe – streaky gas radiating from medulla to cortex with crescent of subcapsular gas	Less
Fluid collection	None as the reduced immune response limits pus collection	Renal or perirenal fluid collection is characteristic
Mortality	80%	20%
Treatment	Nephrectomy	Aggressive medical treatment with percutaneous drainage

It is important to make the distinction between emphysematous pyelitis and pyelonephritis as the former is a less aggressive infection and does not require nephrectomy. In pyelitis, air is limited to PCS while in pyelonephritis it enters the parenchyma⁽⁵⁾.

CHRONIC PYELONEPHRITIS

Chronic pyelonephritis may be caused by reflux of infected urine in childhood, recurrent infections or as a result of a remote single infection. Imaging shows focal polar scars with underlying calyceal distortion with global atrophy and hypertrophy of residual tissue (Figure 8). Lobar infarcts can be differentiated by their lack of calyceal involvement. Fetal lobulations are differentiated by depressions lying between calyces rather than overlying calyces⁽⁵⁾.



Fig. (8): Coronal contrast-enhanced computed tomography shows atrophic right kidney with multiple cortical scars overlying the dilated calyces. This appearance is typical of chronic pyelonephritis.

Granulomatous infections of the Kidney

Xanthogranulomatous Pyelonephritis

It can manifest as either diffuse (80%) or focal (15%) forms which are treated by nephrectomy and partial nephrectomy respectively. Typical features of xanthogranulomatous pyelonephritis are presence of a central calculus, expansion of the calices with hypodense material in a non-functioning enlarged kidney and inflammatory changes in the perinephric fat. Atypical features include absence of calculi (10%), focal instead of diffuse involvement (10%) and renal atrophy instead of enlargement⁽⁵⁾.

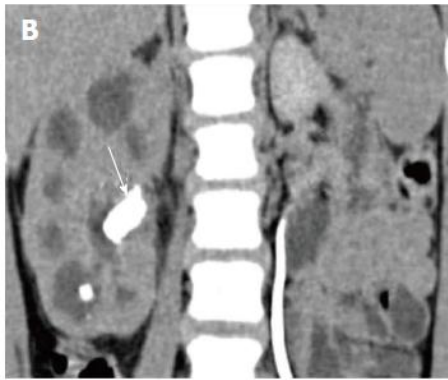


Fig. (9): Xanthogranulomatous pyelonephritis. B: Computed tomography shows multiple low-attenuation rounded masses, corresponding to either dilated calyces or focal areas of parenchymal destruction with a central staghorn calculus (arrow, B).

MYCOBACTERIAL INFECTION

MALACOPLAKIA

Imaging characteristics of malacoplakia are varied, and most commonly observed within the bladder, although plaques may also occur in the ureters. Malacoplakia may present as multiple, polypoid, vascular, solid masses or as circumferential wall thickening, associated with vesicoureteral reflux and dilatation of the upper urinary tract. These masses vary in size from a few millimetres to several centimetres. Occasionally, malacoplakia can be locally aggressive and invades surrounding structures even causing bone erosions⁽⁸⁾.

TUBERCULOSIS

Renal tuberculosis (TB) may occur due to hematogenous dissemination. In half of the affected patients of genitourinary TB, there may be no lung involvement. The earliest finding in TB which can be picked up on Intravenous Urography (IVU) is caliectasis with a feathery contour, later appearing as a phantom calyx or a cavity communicating with a deformed calyx (Figure 10A). These findings can also be picked up on CT. Over the course of the disease, the granulomas coalesce forming mass like lesions (tuberculoma) which may rupture into the PCS⁽⁹⁾.

Eventually as the disease evolves, fibrosis ensues leading to infundibular stenosis. In the late stage, the kidney either becomes calcified or shrunken (putty kidney) (Figure 10B) or an enlarged sac with caseous material (case cavernous type autonephrectomy). Ureteric involvement may manifest as wall thickening causing strictures and shortening leading to a beaded appearance. Bladder involvement results in a contracted thimble shape with multiple diverticulae (Figure 10C)⁽⁹⁾

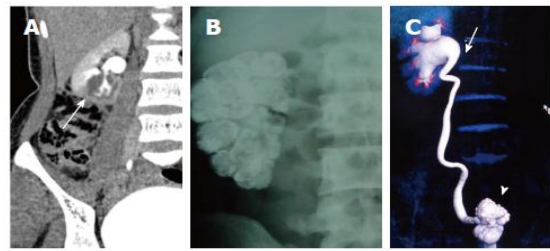


Fig. (10): Renal tuberculosis. A: Delayed CECT shows a cavitation at the lower pole of right kidney communicating with the PCS. This finding is fairly typical of GU TB. This adolescent male was a known case of pulmonary tuberculosis; B: Plain abdominal radiograph in a different patient shows diffuse parenchymal calcification of right kidney suggestive endstage. Auto- nephrectomy or putty kidney; C: Volume rendered technique image of delayed phase CECT shows a contracted thimble bladder (arrowhead), hiked up right pelvis (arrow) and hydronephrosis. This patient had acid fast bacilli cultured from urine. PCS: Pelvicalyceal system; CECT: Contrast-enhanced computed tomography; TB: Tuberculosis.

PARASITIC INFECTION

Schistosomiasis

Schistosomiasis can be imaged by radiography or sonography and, in the later stages, by CT scanning or MRI. Plain film radiography of the abdomen is not helpful until calcification has developed. The classic presentation of a calcified bladder, which looks like a fetal head in the pelvis, is pathognomonic of chronic urinary schistosomiasis⁽¹⁾.

The seminal vesicles, prostate, prostatic urethra, and distal ureters may be calcified, or striated renal pelvis and ureters may be observed. With intravenous urography, the earliest changes are seen in the ureters, with persistent filling of the lower segments throughout the urogram. At this stage the ureters are not always dilated, but this develops next. At first, it results from dysfunction rather than tissue damage. The dilatation will be asymmetrical and may be slight or severe, sometimes without visible stenosis. Later, ureteric constriction will occur, initially within the bladder wall. As the disease progresses, the lower ureters become beaded in appearance, secondary to bilharzial granulomas in the submucosa of the ureter. Mucosal ureteric edema may result in luminal narrowing and striations in the ureter. Air bubble-like filling defects are seen in ureteropyelograms and are suggestive of ureteritis and pyelitis cystica⁽¹⁾.



Fig. (11): Axial contrast-enhanced CT scan image at the lower pelvis clearly demonstrates calcifications of both seminal vesicles (stars)



Fig. (12): Axial contrast-enhanced CT scan of the urinary bladder shows mural calcification at the posterior and right lateral wall with enhancing tumor (arrows) at the anterior wall, which was a transitional cell carcinoma proven by biopsy

Hydatid Disease

Hydatid disease (HD) is a unique parasitic disease that is endemic in many parts of the world; it can occur almost anywhere in the body and demonstrates a variety of imaging features that vary according to growth stage, associated complications, and affected tissues. Radiologic findings range from purely cystic lesions to a completely solid appearance. Calcification is more common in HD of the liver, spleen, and kidney. It

can be quite large in compressible organs and can be solitary or multiple ⁽¹⁰⁾.

Involvement of the kidney is rare and usually located in the upper or lower poles. Hydatid cysts are frequently solitary, located in the cortex, and may reach 10 cm in diameter before any clinical symptoms are noted ⁽¹⁰⁾

CT scans are very accurate at demonstrating renal hydatid cysts that may be unilocular, similar to simple cysts, but with thicker walls, or a multilocular structure with curvilinear septae (Fig. 13). CT can easily detect the calcifications even if minor or faint. If scolices are present, the wall usually shows marked irregularities. Daughter cysts are usually arranged peripherally within the mother cyst. Ring enhancement on contrast-enhanced CT scan or the presence of air bubbles within the lesion is suggestive of secondary infection and abscess formation. However, in some cases, hydatid cysts may have a complex nature and cannot be differentiated from other atypical renal cystic masses ⁽¹⁾



Fig. (13): Renal hydatid cysts. a Contrast-enhanced CT scan shows a large multilocular cyst displacing the right kidney posteriorly. Uniform mural thickening and enhancement are identified with calcification at the lateral wall. c Contrast-enhanced CT scan showing a large type left renal hydatid cyst containing peripheral internal daughter cysts.

FUNGAL INFECTION

Fungal infection of the urinary tract is a severe life threatening infection particularly affecting patients with diabetes mellitus, haematological malignancy, HIV or other immunocompromised status. The common fungal organisms are *Candida* and *Aspergillus* which may be acquired by

hematogenous or ascending urinary tract infection. There is formation of multiple renal abscesses appearing as hypoattenuating lesions with a striated nephrogram signifying acute pyelonephritis (Figure 14A). There can also be conglomeration of fungal hyphae and inflammatory cells into a fungal ball which appears as an irregular filling defect in the collecting system⁽⁵⁾.

Diagnosis requires demonstration of fungi in tissues. Mucor is a rare organism which has a tendency to invade vessels and cause infarction with high mortality requiring combined surgical and aggressive medical management to improve outcome (Figure 14B, C)⁰. Pneumocystis carini infection in HIV patients presents as diffuse punctate calcifications in kidneys and organs of the reticuloendothelial system⁽⁵⁾.

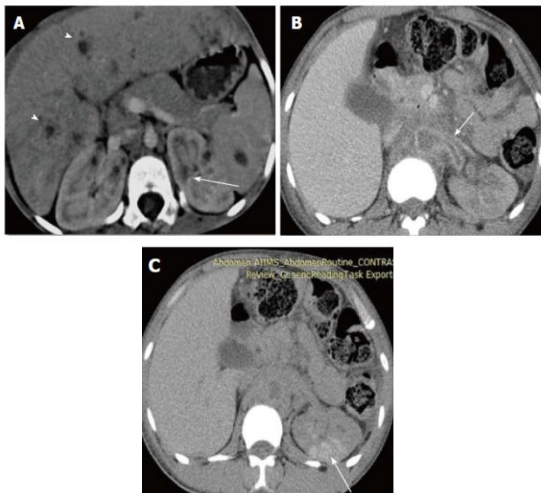


Fig. (14): Fungal infection. A: CECT shows liver, spleen and bilateral kidneys studded with small hypodense lesions in a 10 years old leukemia patient who was proven to have Aspergillus infection on aspiration cytology.

The patient also had lung involvement with contiguous cardiac thrombus (not shown); B, C: Nephrographic (B) and delayed (C) phase CECT in a 26 years old aplastic anemia patient reveal a poorly enhancing, non-excreting left kidney with perinephric inflammation. Aorta and left renal artery are almost completely occluded by a non-enhancing thrombus (arrow B). On delayed image (Figure C), patchy areas of enhancement (arrow) noted in left kidney are characteristic of acute pyelonephritis. FNAC from the perirenal soft tissue revealed fungal hyphae and diagnosis of angioinvasive fungal infection (mucor) was made and Amphotericin B was started. However patient expired two days later. CECT: Contrast-enhanced computed tomography.

Urinary candidiasis

On CT scanning, the mycelial accumulation does not take up the contrast medium. It has a rolled appearance when it contains gas between the layers of fungal colonies. When gas is absent, it appears as an aspecific but mobile solid mass. On an excretory phase CT scan, a filling defect in the collecting system can be seen. This is also visible on IVU or pyelography. Lesions of the renal parenchyma do not show any specific features⁽¹²⁾.

6-Nephrological Disease

CT has insignificant role in diagnosis of glomerulonephritis. In acute stage the parenchyma of both kidneys become edematous and enlarged with smooth outline border. The enhancement decreased after contrast administration if renal insufficient is presented. Unlike chronic glomerulonephritis which shows shrinking of the cortex of both kidneys with smooth countours and normal calyces and papillae. Small cortical calcification and peripelvic fat proliferation can occasionally be detected by CT imaging. They are, however, not characteristics of the disease⁽⁵⁾.

Acute and chronic non- bacterial interstitial nephritis

There is no specific diagnosis can be made. The size of the kidney may be normal or enlarged. With loss of kidney function, the excretion of the contrast medium may be reduced. This is similar to other nephrological disease⁽⁵⁾

ILLUSTRATIVE CASES

Right Acute Diffuse Nephritis with Left Renal Abscess

A 41-year-old woman was admitted with signs and symptoms of a subarachnoid hemorrhage. During her hospitalization she became febrile.

Abdominal Ct scan

A mass in the right kidney was thought to be either an abscess on a tumor with hemorrhage. In addition, multiple low-density zones were noted in the left kidney. These areas had a suggestive wedge-shaped configuration and appeared to involve most of the width of the visible parenchyma (fig. 15).

Fine Needle aspiration followed by open drainage showed the right renal mass to be an E. coli abscess. Appropriate antibiotic therapy was instituted. Follow-up CT several weeks later showed resolution of the mass in the right kidney and return of the left kidney to normal⁽¹²⁾.



Figure (15): Multiple wedge-shaped, low-density zones in left kidney (arrows) represent acute, diffuse bacterial nephritis in patient with *E. coli* sepsis and *E. coli* abscess in right kidney.

Right Emphysematous Pyelonephritis

A 34-year-old woman was admitted with a one-day history of right flank pain, persistent vomiting and ankle swelling for the past six months. She was a type 1 diabetic on insulin that was first diagnosed at the age of 10 years. She had recurrent attacks of vaginal candidiasis over the past two months and one episode of pyelonephritis 14 years ago.

Examination

She was pale and dehydrated. Her temperature was 37.2°C; she was tachycardic at 105 bpm. She had right loin tenderness and mild pedal oedema. Her blood tests showed she was anaemic with mild renal impairment.

Urine dipstick testing revealed 2+ of glucose, blood and protein with trace of leucocytes.

Plain abdominal radiograph

(kidney, ureter and bladder) was normal, with no stones. She was started on cefuroxime as empirical treatment but over the next three days became increasingly septic and hypotensive with further derangement of renal function (creatinine rose to 222 $\mu\text{mol/L}$).

Renal ultrasound

Showed a mildly hydronephrotic right kidney. As the pain was not settling.

Abdominal (CT) scan

This demonstrated gas in the upper right ureter associated with moderate right-sided hydronephrosis with no parenchymal involvement (Figure 16). It was at this point a diagnosis of EPN was made. The admission mid-stream urine culture later grew *Escherichia Coli* (*E. coli*). At this stage her urine protein: creatinine ratio was 580 mg/mmol, roughly equivalent to a proteinuria of 5.8 g/24 hrs. After 14 days she remained febrile and symptomatic. A right nephrostomy was performed and frank yellow pus was aspirated from her right renal tract. Her clinical condition improved remarkably over the next few days and she began to pass clear urine through the nephrostomy tube⁽³⁾.

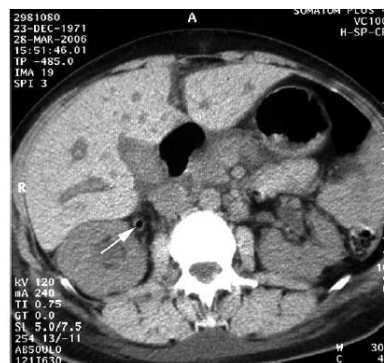


Figure (16): CT scan demonstrating gas in the right ureter and a moderate hydronephrosis.

Right Xanthogranulomatous Pyelonephritis

A 40-day-old male child presented with excessive crying, fever and failure to thrive. The child was clinically pale and had a lump in the right flank which was ballotable and bimanually palpable.

Systemic examination was otherwise normal

Laboratory investigations

Revealed microcytic hypochromic anaemia with a haemoglobin of 8 g/dl and leucocytosis. C reactive proteins were raised 102 mg/l and renal profile was normal.

Renal Ultrasound: Revealed a hypoechoic mass lesion replacing the right kidney while the left kidney was normal. Mesoblastic nephroma or Wilm's tumour of the right kidney was suggested.

The postoperative histopathology however, revealed lipid laden foamy macrophages, accompanied by diffusely scattered both chronic and acute phase inflammatory cells. Normal renal parenchyma was seen at places along the perimeter. The CT with contrast of the abdomen

Showed 6.74×5.60×4.5 cm sized heterogeneous mass lesion arising from the posterior surface of the right kidney (figure 58). The mass appeared to push renal parenchyma anteriorly. There was evidence of loss of fat planes at places. The renal function was significantly reduced on the right side. Left kidney appeared normal. A possibility of mesoblastic nephroma or Wilm's tumour of the right kidney was suggested.

The postoperative histopathology however, revealed lipid laden foamy macrophages, accompanied by diffusely scattered both chronic and acute phase inflammatory cells. Normal renal parenchyma was seen at places along the perimeter.

The final diagnosis was of XGP.

XGP is a severe, atypical form of chronic renal parenchymal infection. Its manifestations mimic those of neoplasia (mesoblastic nephroma, Wilm's tumour) and other chronic inflammatory

renal parenchymal diseases including tuberculosis. As a result it is often misdiagnosed clinically.

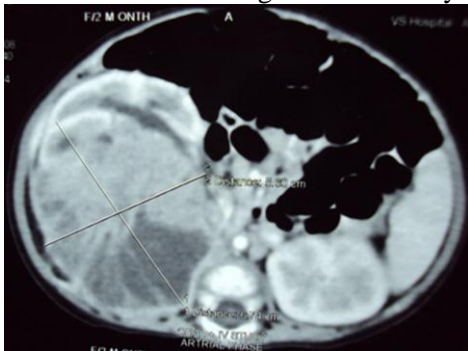


Figure (17): CT scan of the abdomen with contrast showing heterogenous right renal mass with poor function on the right side.

SUMMARY AND CONCLUSION

In the study normal anatomy of the kidney, CT anatomy of the kidney, pathology of renal inflammatory diseases, CT technique and CT finding in inflammatory renal disease were discussed.

The aim of this was to demonstrate the value of CT examination in the diagnosis of renal inflammatory diseases.

Renal inflammatory diseases classified into:

1. Bacterial infections
2. Granulomatous infections
3. Micobacterial infections
4. Parasitic infections
5. Fungal infections
6. Nephrological diseases

Most of acute renal infection diagnosed without imaging.

Imaging modalities indicated in acute infection with complication, acute infection not improved with treatment and immunocomprimized patients.

C.T has the ability to diagnose and assessment of renal infection site and extension of infe fascia, renal infection unilateral or bilateral and infection focal or diffused.

CT has important role in assessment of complication and follow up of patients.

CT guided FNAB can be done to diagnose renal infection and differentiate between infection and tumours.

CONCLUSION

Computed tomography has become the imaging modality of choice for complicated disease courses and also for some chronic inflammatory processes, not only in adults but also in children. CT has also

considered the ideal first study of choice for hospitalized patient in whom renal infection is suspected. CT also can determine the ideal time for intervention if an abscess is present and under CT guidance F.N.A.B. can be done.

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