Narrative Review

Role of Imaging in Renal Infections: A Narrative Review

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Abstract

Urinary tract infections (UTIs) are among the most common bacterial infections in community and hospital settings. Infections of the urinary system can range from pyelonephritis to urethritis. Acute renal infections encompass entities such as acute pyelonephritis, acute focal bacterial nephritis, renal and perinephric abscesses, emphysematous pyelonephritis, and pyonephrosis, while xanthogranulomatous pyelonephritis is a chronic granulomatous inflammatory condition that affects the kidneys.

The diagnosis of UTIs predominantly relies on clinical assessment and confirmation through abnormal laboratory results. Routine medical imaging is therefore typically reserved for complicated cases, aiming to identify contributing factors such as renal calculi, determine the type of infection, and evaluate the extent of the infection and its associated complications. Furthermore, imaging has become crucial for radiologists during interventional procedures in treating pyonephrosis and renal abscesses. Traditional imaging tools, like abdominal X-rays, are vital for identifying renal calculi and gas shadows in emphysematous pyelonephritis, while ultrasonography emerges as an excellent modality for assessing urinary infections in emergency scenarios, pregnancy, and paediatric cases. Contrast-enhanced computed tomography (CECT) or non-contrast computed tomography (NCCT) is the imaging method of choice in the most complex situations, allowing for precise assessment of the disease burden. Current magnetic resonance imaging (MRI) sequences yield promising results in specific scenarios such as pregnancy and paediatric subjects where minimising radiation exposure is a concern. This review focuses on elucidating the essential radiological modalities and their distinctive features in the context of renal infections, offering valuable guidance to microbiologists and physicians.

Keywords: *Pyelonephritis, Acute focal bacterial nephritis, Renal abscesses, Emphysematous pyelonephritis, Pyonephrosis*

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Introduction

Urinary tract infections (UTIs) are among the most common bacterial infections in the community and hospital setting.[1] In a study conducted in Sri Lanka, the incidence of UTIs in the diabetic population was 27%.[2] UTIs account for a significant portion of hospital-acquired infections in the South Asian Region. In noninstitutionalised older people, UTIs are the second most prevalent illness, accounting for about 25% of all infections.[3]

A urinary tract infection (UTI) is an infection in any part of the urinary system, which includes kidneys, ureters, bladder, and urethra. Hence, infections of the urinary system range from pyelonephritis to urethritis. Acute renal infections include pathological entities such as acute pyelonephritis (APN), acute focal bacterial nephritis (AFBN), renal and perirenal abscesses, emphysematous pyelonephritis (EPN), and pyonephrosis. In contrast, chronic renal infections include chronic pyelonephritis, xanthogranulomatous pyelonephritis (XGP), malakoplakia, and eosinophilic cystitis.[4]

The diagnoses of urinary tract infections are usually made clinically and confirmed by abnormal laboratory values.[5] Imaging is not usually performed and is reserved for complicated situations to assess the type and extent of the renal infection and its complications. This review mainly focuses on the main radiological modalities used and their radiological features in renal infections to guide microbiologists and physicians.

Acute pyelonephritis

Acute pyelonephritis (APN) is characterised by infection of the renal collecting system and parenchyma and is considered a serious entity as it has the potential for renal damage and urosepsis. Renal infection typically results from the retrograde spread of microorganisms. Eighty per cent of encountered organisms causing pyelonephritis are *Escherichia coli*, followed by other Gram-negative bacilli such as *Klebsiella* spp, *Pseudomonas* spp, and some Gram-positive cocci including *Enterococcus* spp, *Streptococcus* spp and *Staphylococcus* spp.[6]

Initial treatment of APN in the majority of patients is usually based on clinical and laboratory findings. Radiological imaging is usually reserved for complex situations, atypical symptoms, advanced age, diabetes, immunocompromised status, and patients with congenital abnormalities.[7]

Imaging modalities utilised in the diagnostic workup of acute pyelonephritis are diverse. Among them, ultrasound is a valuable initial imaging modality. It can be used in paediatric patients, emergency settings, at the bedside for critically ill patients, as a guide during interventions in complicated cases and for obtaining sequential images to monitor the progression of the disease process.[8] Advancements in ultrasound technology, including improved image resolution, better transducers, and enhanced imaging algorithms, have increased the sensitivity of detecting APN.[5,9,10.] The ultrasound features of APN and pathological reasons attributed to the ultrasound features are listed in Table 1.

Table 1: The ultrasound features of APN and pathological reasons attributed to the ultrasound features.[5,12,13]

Ultrasound feature	Pathological explanation
Generalised enlargement of the kidney (the affected kidney is ≥1.5 cm longer than the unaffected kidney).	Renal parenchymal inflammation results in parenchymal oedema and congestion.
Hypoechoic renal parenchyma.	
Loss of renal sinus fat.	
Loss of corticomedullary differentiation.	
Hyperechoic renal parenchyma.	Focal area of parenchymal haemorrhage.
Mild hydronephrosis and proximal hydroureter without obvious obstructive cause.	Inhibition of ureteric peristaltic motion, caused by bacterial endotoxins, leads to the dilatation of the pelvicalyceal system.
Hyperechoic debris within the dilated pelvicalyceal system.	Renal parenchymal inflammation results in the accumulation of dead neutrophils, bacteria, cellular debris, and proteinaceous material within the dilated pelvicalyceal system.
Power Duplex evidence of increased blood flow within the renal vascular system (Flaring kidney).	Renal parenchymal inflammation leads to dilation of the renal vasculature and increased blood flow.
Limited renal movements during respiration compared with unaffected kidney.	Inflammatory process and associated oedema result in increased stiffness and decreased compliance of the kidney.

Ultrasound is insensitive for the detection of acute pyelonephritis as it is possible to miss subtle changes in mild pyelonephritis, thereby underestimating the severity of the attack.[11] However, newer applications like tissue harmonic imaging have increased the sensitivity and specificity to 97% and 80%, respectively.[5]

Contrast-enhanced computed tomography (CECT) is the imaging technique for assessing individuals with acute pyelonephritis.[5] According to H. Stunell et al., helical and multislice CT protocol for APN includes three phases. The non-contrast first phase will detect parenchymal, calyceal and ureteric calculi, gas formation, haemorrhage, and renal enlargement. However, on most occasions, non-contrast images will appear normal. The second phase would be post-IV contrast imaging acquisition of about 50-90 seconds. The third or excretory phase (> 2 minutes post-IV contrast) is optional and only run if a ureteric obstruction is suspected.[14] The CECT features of APN and pathological explanations that are attributed to the CECT features are listed in Table 2.

CECT may reveal less common observations, such as peripheric fat standings, oedema in the ureteral wall, and the development of renal abscesses.[16] These findings are associated with increased tissue destruction, as indicated by clinical and laboratory parameters.[16]

Table 2: The CECT features of APN and pathological explanations attributed to the CT features[15]

CECT features	Pathological explanation
In diffuse pyelonephritis, generalised renal enlargement, poor enhancement of renal parenchyma and inadequate excretion of contrast in delayed images.	Renal parenchymal inflammation results in the accumulation of additional interstitial fluid, causing renal oedema.
A radial pattern of alternating high and low attenuation linear bands extends through the corticomedullary layers along the direction of the excretory tubules of the kidney. (Striated nephrogram)	Striations are areas of hyper-concentrated contrast material within obstructed renal tubules outlined against the background of the edematous renal parenchyma.
Thickening of Gerota fascia, perinephric fat stranding and obliteration of perinephric fat planes.	Due to perinephric propagation, inflammation, oedema, and thickening of Gerota fascia occur. Perinephric fat stranding and obliteration of perinephric fat planes due to swelling of perirenal space fat. This results in linear areas of soft tissue.

Certain features in CECT scans can also provide insights into the pathology of renal infections. For instance, the presence of round peripherally located poorly enhancing renal parenchymal lesions may suggest a haematogenous route of infection. Conversely, the presence of wedge-shaped areas implies an ascending route of infection. However, distinguishing between these routes can become challenging when the whole renal parenchyma is involved.[7] Contrast-enhanced ultrasound has been shown to have similar sensitivity and specificity as non-contrast CT(NCCT) in diagnosing and following up patients with pyelonephritis.[10] (Figure 1).

In magnetic resonance imaging (MRI), the observed features resemble those seen in CT scans, such as enlarged kidneys, changes in signal intensity caused by haemorrhage or oedema, perinephric fluid, and a striated nephrogram. MRI with intravenous contrast helps to highlight the areas of renal parenchymal involvement.[7]

Radionuclide cortical scintigraphy with 99mTc dimercaptosuccinic acid (Tc-99m DMSA) offers visualisation of the renal cortex and may show peripheral areas of decreased uptake related to acute pyelonephritis or scar formation. Currently, its use is limited to paediatrics for detecting renal scarring. Scar formation following acute pyelonephritis is rare in adults.[17] If left untreated, acute pyelonephritis can give rise to complications such as renal abscess formation, chronic pyelonephritis, and emphysematous pyelonephritis, the details of which will be discussed under separate subtopics further in this review.

Acute focal bacterial nephritis

Acute focal bacterial nephritis (AFBN), or acute lobar nephronia (ALN) is an intermediate condition between acute pyelonephritis and renal abscess, mainly seen in children with rare occurrences in adults. *E. coli* is the predominant organism in both age groups.[18] AFBN clinically resembles renal abscess, presenting with fever, flank or abdominal pain, dysuria, and pyuria. Early imaging is vital to prevent progression into renal abscesses.[18] Ultrasonographically, AFBN appears hypoechogenic or hyperechoic with a poorly defined mass. Duplex ultrasonography, with or without contrast enhancement, may reveal localised hypoperfusion.[19] Ultrasound provides 90% sensitivity and 86.4% specificity in diagnosis, making it a primary imaging choice.[18]

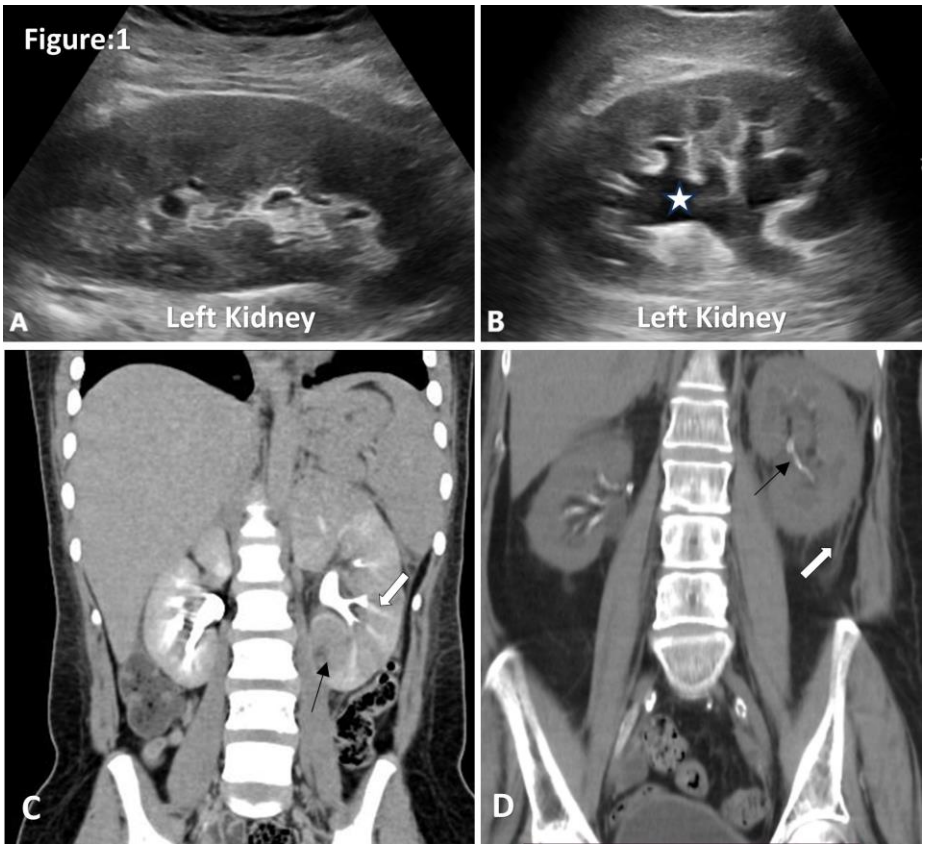

Figure 1: Ultrasound and CT images of acute pyelonephritis.

A. Ultrasonography shows an enlarged left kidney with hypoechoic renal parenchyma, loss of renal fat and loss of corticomedullary differentiation.

B. Mild hydronephrosis and proximal hydroureter without obvious obstructive cause.

C. Coronal images of contrast CT show an enlarged left kidney with a striated nephrogram(white arrow).Area of poor enhancement of left lower pole renal parenchyma (black arrow) (Image courtesy of Hani Makky Al Salam, Radiopaedia.org, rID: 18306)

D. Non-contrast CT coronal images show thickening of Gerota fascia, perinephric fat stranding and obliteration of perinephric fat planes (white arrow). Note incidentally detected intrarenal arterial calcification (black arrow).

CT appearance includes a poorly defined wedge-shaped area with reduced contrast enhancement, representing single lobe inflammation, sometimes affecting multiple lobes.[19] CT differentiates between uncomplicated and complex AFBN. Uncomplicated AFBN typically shows striated or wedge-shaped, indistinct, uniformly low-density regions, while complex AFBN presents with focal heterogeneously low-density areas during the nephrographic phases.[20] (Figure 2)

Pathological explanations of ultrasonic and CT findings are listed in Table 3.

In MRI of AFBN, the affected areas are hypointense in T2W images with poor enhancement in post-contrast T1W images.

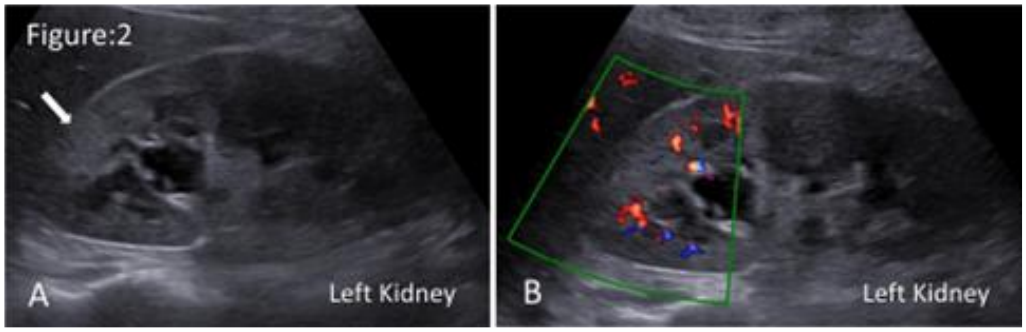

Figure 2: Ultrasound images of acute focal bacterial nephritis.
A. Grey scale ultrasonography shows a localised, poorly defined hyperechoic region in the upper pole of the left kidney(arrow).
B. Duplex ultrasonography shows a localised area of hypoperfusion in the affected region.

Table 3: The Ultrasound and CECT features of acute focal bacterial nephritis and pathological explanations attributed to the imaging features[19,20]

CECT features	Pathological explanation
In focal pyelonephritis, an Ill-defined wedge-shaped area of low attenuation radiates from the renal medulla to the cortical surface.	Renal parenchymal inflammation results in vascular spasm, tubular obstruction due to inflammatory debris, and interstitial oedema, leading to decreased flow of contrast through renal tubules.
Ultrasound features	
Focal area of hypoechogenicity Power Duplex evidence of focal absence of blood flow within a localised hypoechoic region.	

Renal and perinephric abscesses

Renal abscesses are encapsulated pus collections confined to the renal tissue, and perinephric abscesses are collections of suppurative material located between Gerota fascia and the renal capsule.[21] The main organisms involved are Gram-negative bacteria, including *E. coli, S. aureus, Klebsiella pneumoniae,* and *Pseudomonas aeruginosa*.[22]

Diabetes mellitus is the most common contributory factor for renal and perinephric abscesses, followed by other conditions such as liver cirrhosis, renal stones, chronic renal insufficiency, an immunosuppressed state, ureteral obstruction, chronic urinary retention, and iatrogenic causes.[21]

The imaging modalities used to diagnose renal and perirenal abscesses are ultrasound scan, CT scan, and MRI.[23] (Figure 3)

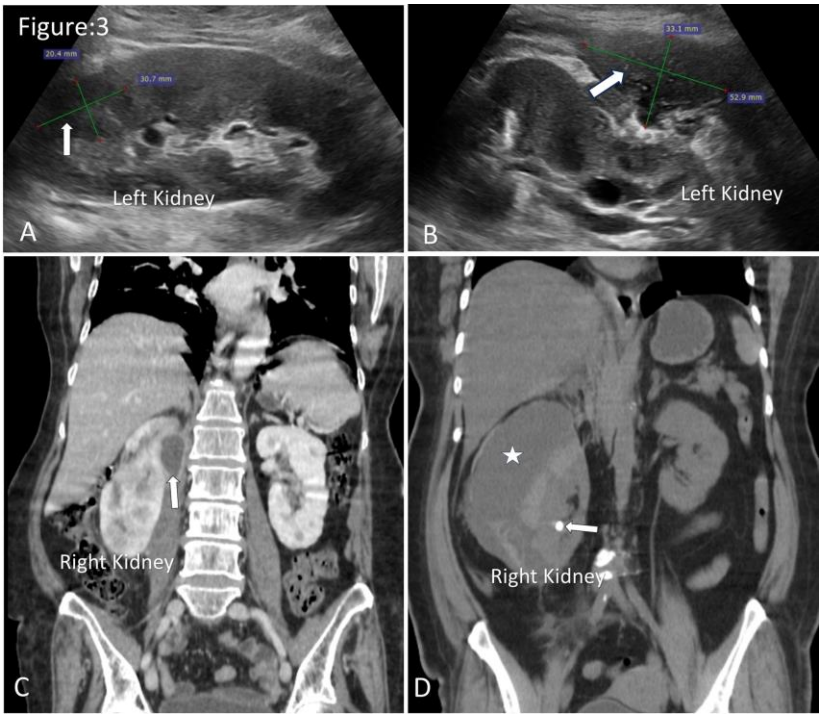

Figure 3: Ultrasound and CT images of renal and perinephric abscesses.
A. Ultrasonography shows well-defined fluid collection with internal echogenic debris in the upper pole of the left kidney (arrow).
B. Moderate-size perinephric abscess in relation to the left kidney (arrow).
C. Coronal images of contrast CT show a small perinephric abscess in relation to the upper half of the right kidney(arrow).
D. Coronal images of non-contrast CT show a large perinephric abscess(asterisk). Note incidentally detected renal calculus (arrow)

Ultrasonically, renal abscesses manifest as enlarged kidneys with distorted normal renal architecture, displaying clearly delineated fluid collections containing internal echogenic debris and having well-defined walls.. This clear wall helps to differentiate renal abscess from AFBN. There may be internal septations causing multiple loculations within the abscess.[7] Perinephric abscess is usually low or mixed echogenic, depending on the content and located outside the renal parenchyma.[7] Ultrasound guidance is useful in percutaneous drainage of abscess material for microbiological assessment and placement of pigtail catheters for therapeutic drainage. Percutaneous drainage is beneficial because it is a simple and rapid procedure, avoids general anaesthesia, and has low invasiveness, particularly when dealing with a large volume collection, in the presence of comorbidities, and when prior medical management has not been successful.[23]

CECT is considered more sensitive than ultrasonography for diagnosing renal abscesses, with a 90-100% detection rate.[23] However, one study showed no superiority of CECT over ultrasound for the diagnosis of renal abscesses, probably due to recent advances in ultrasound technology.[24] Still, the CT technique is more accurate in assessing the abscess size, rest of the renal parenchymal condition and post-therapeutic assessment.[23] In CECT scans, developing abscesses are visualised

as small, low-density, rounded, or wedge-shaped cortical lesions without significant contrast enhancement. Conversely, mature abscesses appear as well-defined and complex cystic structures.. This appearance may simulate renal malignancy.[25] However, features such as perilesional oedema within the kidney, variable degree of fat stranding adjacent to the abscess, thickening of Gerota fascia, low attenuating lesion with enhancing wall in CECT with a positive history and urine analysis indicate a renal abscess.[25] CECT is also valuable in the precise evaluation of extrarenal extension into perinephric space and involvement of psoas and the rest of the posterior abdominal wall muscles and adjacent organs.[26]

In the case of a difficult ultrasound-aided approach, CT-guided aspiration of abscess material or insertion of a drain tube is the preferred method.

MRI is recognised as more sensitive and specific than CT for surveying renal lesions. MRI is highly sensitive and specific, primarily used in pregnancy and children to avoid CT radiation. Mature abscesses display low T1W and high T2W signal intensities with enhancing walls. Heterogeneous restricted diffusion in DWI images is observed in acute stages, while resolution shows no diffusion restriction on follow-up images.[26]

Emphysematous pyelonephritis

Emphysematous pyelonephritis (EPN) is a rare, severe necrotising infection within the renal parenchyma and perirenal tissues caused by gas-forming bacteria, leading to gas formation in the collecting system, renal parenchyma or perinephric tissue.[27] Uncontrolled diabetes mellitus is a major predisposing factor in 85-100% of cases, and non-diabetics typically have urinary tract obstruction.[7] The most frequent organisms isolated in EPN are *E. coli*, *Klebsiella spp.* and *Proteus mirabilis.*[27] Timely radiological diagnosis is crucial, as clinical and laboratory findings only suggest urological sepsis. Imaging findings of EPN are typical; thus, a diagnosis is made easily with plain radiographs, ultrasound, and non-contrast CT (NCCT).[7] (Figure 4)

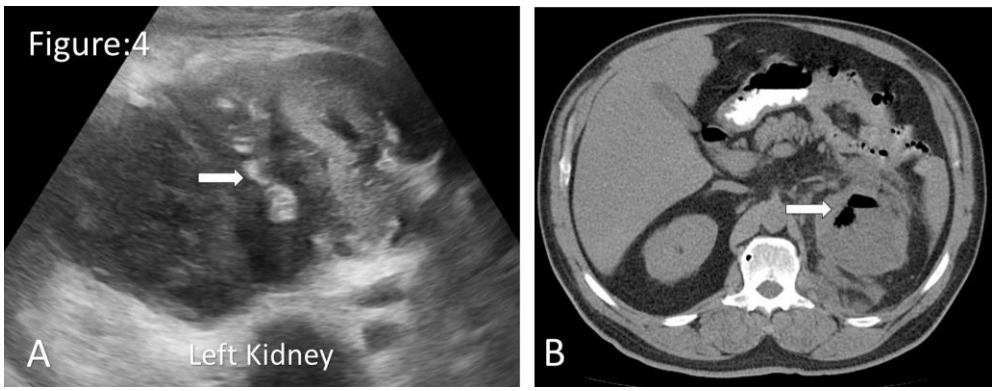

Figure 4: Ultrasound and CT images of emphysematous pyelonephritis
A. Ultrasonography shows an enlarged left kidney with few gas locules in the kidney(arrow).
B. Non-contrast axial CT shows an enlarged left kidney with internal localised gas locules. (arrow) (Image courtesy of Rafael Lourenço do Carmo, Radiopaedia.org, rID: 50118)

In an X-ray abdomen, mottled or crescent-shaped gas collections are observed within the renal parenchyma and perinephric space.[28] However, differentiating renal gas from bowel gas on X-ray is challenging, with a low detection rate of only 33%.[29]

Ultrasonically, gas locules in EPN appear as multiple non-dependent echogenic foci within the renal parenchyma or perinephric spaces. Tiny gas locules might resemble renal stones or intestinal gas, whereas large collections can produce high-amplitude echoes and posterior dirty acoustic shadowing (reverberation artefacts).These artefacts may underestimate the depth of renal parenchymal and perinephric involvement, which warrants CT.[12]

NCCT is considered the gold standard radiological investigation for EPN, providing superior diagnosis, lesion characterisation, severity evaluation, and guidance for drainage and follow-up.[4] In EPN, the value of contrast-enhanced CT scans is limited because these patients often have impaired renal functions. However, contrast-enhanced CT (CECT) is considered the best imaging modality for differentiating EPN from emphysematous pyelitis, a more benign entity in which the gas formation is limited to the renal collecting system.[29] CT findings in EPN include enlarged and destructed renal parenchyma, small gas bubbles or linear streaks, fluid collections with gas-fluid levels, and necrotic areas with or without abscesses.[31] EPN is classified into five classes, with class 4 having the worst outcomes based on the extent of air seen in CT findings.[31] **(Table 4)**

Table 4: Classification of emphysematous pyelonephritis based on CT findings[31]

Classification	Radiological features based on CT findings
Class 1	Gas in the collecting system only
Class 2	Gas in the renal parenchyma without extension to the extrarenal space
Class 3A	Extension of gas or abscess to the perinephric space
Class 3B	Extension of gas or abscess to the pararenal space
Class 4	Bilateral EPN or a solitary kidney with EPN

MRI could be useful in conditions where CT scans are contraindicated or should be used cautiously, such as during pregnancy or for children. In EPN, gas locules in renal or perinephric tissue appear as signal voids on both T1W and T2W images. MRI is utilised to evaluate renal abscesses and renal structure. Typically, abscess contents appear hypointense on T1W images and heterogeneously hyperintense on T2W images, with restricted diffusion seen in DWI images.[32]

Pyonephrosis

Pyonephrosis is a life-threatening urological emergency characterised by accumulating pus or infected material in an obstructed renal collecting system. This obstruction can result from calculi, strictures, tumours, sloughed papillae, or congenital anomalies, necessitating urgent diagnosis and intervention to prevent renal function loss and septic shock.[5,26]

The most common isolated organisms in pyonephrosis are *E. coli, Proteus* spp, and *Pseudomonas* spp.[33] Various imaging modalities are used to diagnose and manage pyonephrosis.
Abdominal plain X-ray films show an enlarged silhouette of the kidney, the absence of the psoas shadow, and the presence of dense urinary tract stones.[34]Ultrasound findings typically include a dilated pelvicalyceal system with internal echogenic debris, fluid-fluid levels, and, occasionally,

incomplete (dirty) shadows with gas accumulation. Floating echogenic debris is a reliable diagnostic sign (sensitivity 90%, specificity 97%).[5,12]

CECT helps to diagnose pyonephrosis, detect the cause of the obstruction, and assess renal function. CT findings include renal enlargement, dilatation, obstruction of the renal pelvicalyceal system, hyperenhancement, oedema of the renal pelvic wall (>2mm), and perirenal fat stranding. Gas-fluid or fluid-fluid levels and layering of contrast material overlying purulent fluid confirm an infected system.[7,5] Furthermore, high Hounsfield units (HU) value within the dilated collecting system on non-contrast CT can differentiate infected from uninfected hydronephrosis. This distinction is especially valuable when CT contrast cannot be used.[8] (Figure 5)

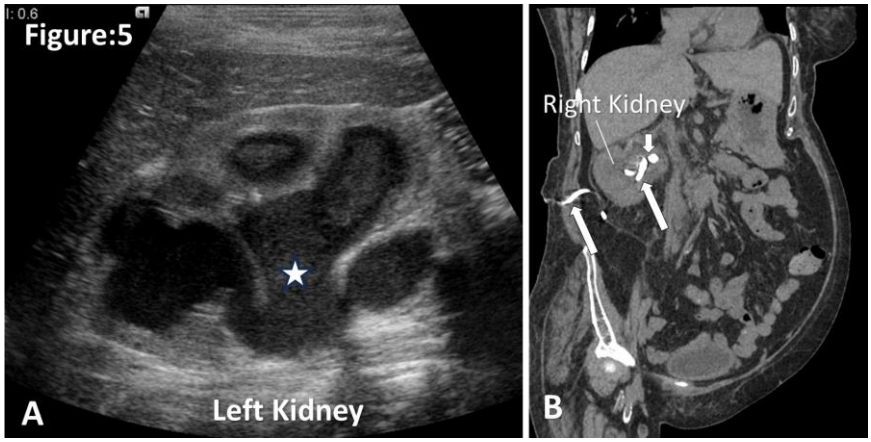

Figure 5: Ultrasound and CT images of pyonephrosis
A. Ultrasound of left kidney shows dilated pelvicalyceal system with floating echogenic debris (asterisk). (Image courtesy of Andrew Dixon, Radiopaedia.org, rID: 10432).
B. Non-contrast coronal CT shows a nephrostomy tube in situ for a patient with complicated pyonephrosis. Note obstructed calculus at the right ureteropelvic junction (short arrow).

MRI reveals findings similar to those observed on CECT. However, MRI is the preferred imaging method over CECT when distinguishing between simple hydronephrosis and pyonephrosis without contrast agents. The DWI sequences may show diffusion restriction of pyogenic material within the collecting system.[5]

Upon pyonephrosis diagnosis, immediate decompression of the infected dilated system is essential through image-guided percutaneous nephrostomy (PCN) placement. This intervention prevents permanent renal function loss and life-threatening bacteremia.

Xanthogranulomatous pyelonephritis
Xanthogranulomatous pyelonephritis (XGP) is a rare chronic granulomatous inflammatory condition resulting from chronic urinary tract obstruction, recurrent bacterial infections, and an atypical immune response, causing renal destruction.[35] The inflammation initiates within the renal pelvis and spreads to the renal medulla, cortex, perinephric space, and retroperitoneum. The primary organisms responsible are typically *P. mirabilis* and *E. coli*.[35]

Although histological examination post-nephrectomy offers a definitive diagnosis of XGP, imaging plays a crucial pre-operative role.[35]However, imaging features can be misleading, resembling malignancy, tuberculosis, or malakoplakia.[35] Renal stones, particularly staghorn calculi, are observed in an X-ray KUB. However, not all patients with XGP have renal calculi, nor do all patients with staghorn calculi have XGP.[35]

The value of USS for the diagnosis of XGP is limited, but it is an option for the initial evaluation. On ultrasound, XGP typically shows an overall enlargement of the kidneys with intact renal contours, thinning of the renal cortex, multiple low echogenic areas caused by dilated calyces containing internal echogenic debris or solid granulomatous material, and the presence of renal pelvic Staghorn or parenchymal calculi, suggestive of diffuse XGP.[12,35]However,focal XGP may be mistaken for other renal conditions, such as renal malignancy.[12]
CECT is the gold standard in diagnosing XGP, showing specific findings and extrarenal extension, which is important in surgical planning.[7,36] Classic CECT signs include non-functioning enlarged kidney, staghorn calculus, contracted renal pelvis, dilated multi-loculated calyces, and thinning renal cortex, resembling the "Bear Paw" sign found in 67% of patients.[36] **(Figure 6)**

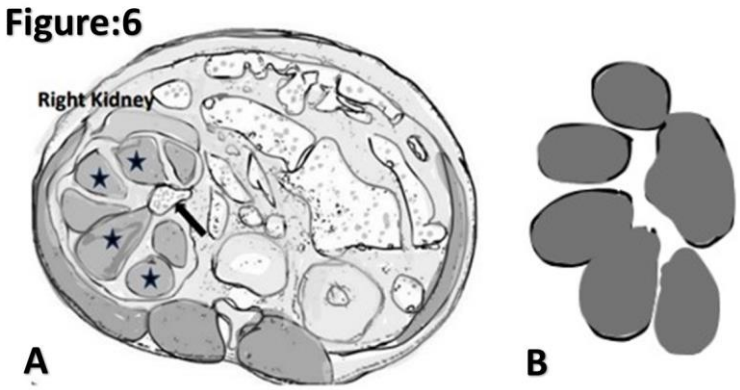

Figure 6: Illustrated diagram of xanthogranulomatous pyelonephritis based on axial CT.
A. dilated multi-loculated calyces (asterisk) with thinning of renal cortex and a staghorn calculus (arrow) giving rise to a classic "Bare Paw" appearance**.**
B. Illustrated diagram of a " Bare Paw".

Dilated calyces may have negative HU numbers due to xanthomatous material.[7] According to Malek et al., XGP has originally been classified into three stages based on the degree of involvement of nephric and perinephric tissues within a paediatric population. Nevertheless, this classification can also be applied to adults. Stage I (confined to the kidney), Stage II (Gerota fascia infiltration), and Stage III (extension into perinephric space and retroperitoneal structures).[37]

MRI findings for XGP are non-specific, with varying signal intensity in different xanthomatous reactions, often overlapping with tuberculosis and renal malignancy.[35] MRI is not a routine investigation, but post-IV gadolinium (Gd-DTPA) imaging can reveal perinephric extension.[35]

Furthermore, Tc99m MAG3 or DMPA scintigraphy imaging assesses whether the affected kidney retains residual function. The complete loss of unilateral function indicates diffuse XGP, whereas a kidney with residual function suggests focal XGP.[38]

Conclusion

Urinary tract infections are mainly diagnosed based on clinical assessment and confirmed by laboratory tests. Radiological examinations are usually reserved for complex renal infections to identify predisposing factors like renal calculi, determine the infection type, and evaluate the extent and complications of the renal infection. Additionally, imaging has become essential for radiologists during interventional procedures for managing pyonephrosis and renal abscesses. Traditionally, abdominal X-rays identify renal calculi and gas shadows in emphysematous pyelonephritis. Ultrasonography offers an excellent imaging modality for evaluation in emergency settings, pregnancy, and paediatric cases. CECT or NCCT is preferred for imaging in the most challenging cases, providing an accurate evaluation of disease severity. Modern MRI sequences show encouraging outcomes in certain situations, like pregnancy and paediatric cases, where reducing radiation exposure is a priority.

Declarations

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Conflicts of Interest: The authors declare that they have no competing interests...
Funding: None declared **Ethics statement**: As this is a retrospective study analysing laboratory isolate characteristics ethical clearance was not sought.
Ethical Approval and Consent: Ethical approval was not considered, as our work is a narrative review. However, we have secured informed consent to publish radiological images from each patient (Figure numbers: Figure 1 A, B and D, Figure 2, Figure 3 A, B, C and D, Figure 4 A, Figure 5B). For Figures 1C,4B and 5A, credit has been provided, and the reference is mentioned in the relevant image legend. Additionally, we have intentionally removed identifying information from the radiology images. Consent was obtained in the local and English language, and fully completed consent forms are available upon request.
Authors' contributions: SRS formulated the concept, designed the review, conducted the literature review, and contributed to the manuscript writing. CP conducted the literature review and contributed to the manuscript writing. All authors reviewed the manuscript.
Availability of data and materials: Acquired DICOM medical images during the current review are available from the corresponding author upon reasonable request. The subject's identifying information was removed in radiology images.

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