Imaging in upper urinary tract infections

J. Ifergan, R. Pommier, M.-C. Brion, L. Glas, L. Rocher, M.-F. Bellin*

General Radiology Department, Bicêtre Hospital, AP–HP, University Paris Sud, 78, rue du Général-Leclerc, 94275 Le Kremlin-Bicêtre, France

KEYWORDS
Kidney; Infection; Sonography; Computed tomography; MRI

Abstract Most infections of the upper urinary tract are straightforward and do not require any emergency radiological investigations. A sonogram carried out within 48 hours will in most cases be sufficient to eliminate obstructed pyelonephritis requiring emergency drainage of urine. In complicated cases, or those affecting already weakened areas, an urgent CT scan is necessary, preferably after injection of iodinated contrast medium if renal function permits. CT scanning is far better at diagnosis than sonography as well as at investigating whether there are complications. Furthermore, it is essential that the radiologist is aware of unusual and rare forms of pyelonephritis, especially pseudotumoural forms, so that clinicians can be pointed towards the appropriate treatment, avoiding unnecessary and invasive interventions.

Infections of the upper urinary tracts (kidneys, pelvicalyceal system and ureters) must be distinguished from infections of the lower urinary tracts (bladder and urethra), which are very common and do not require radiological investigation.

Although upper urinary tract infections are usually straightforward or “uncomplicated”, they can potentially be serious if there is an obstruction or if they develop in patients who are at risk of complications in that area (Boxed text 1). The aim of imaging is to eliminate complications, the main one being obstruction requiring urgent intervention for drainage [1–3]. The majority of community-acquired urinary infections are caused by Gram-negative bacilli (GNB), usually Escherichia Coli (in 85–90% of cases of pyelonephritis) [4]. Other less common bacteria that can be responsible are the GNB Proteus and Klebsiella and the Gram-positive Cocci (GPC) enterococcus and Staphylococcus aureus. Hospital-acquired urinary infections make up 30% of all nosocomial infections and are caused by agents that are more virulent and often multiresistant, with adverse outcomes, in particular Pseudomonas aeruginosa [4]. Two physiopathological mechanisms can lead to upper urinary tract infections: ascending infection, which is most common, or haematogenous infection.

* Corresponding author.
E-mail address: marie-france.bellin@bct.aphp.fr (M.-F. Bellin).

© 2012 Éditions françaises de radiologie. Published by Elsevier Masson SAS. All rights reserved.
doi:10.1016/j.dii.2012.03.010
In ascending route infections, the infected urine from the lower urinary system reaches the papillae and then the collecting ducts. This involvement of the ducts causes vasoconstriction of the arterioles and inflammatory oedema leading to ischaemia. This mechanism explains why systematised lesions are seen on contrast-enhanced computed tomography. When, more rarely, infection is spread to the kidney by the haematogenous route, this is the result of a septic localisation in a patient with septicamia. In cases of haematogenous infection, the infective agent reaches the renal cortex and subsequently the renal medulla within 24–48 hours, in contrast to the mechanism of ascending route infection in which the bacteria reaches the papilla directly. In the former case, urinalysis may be negative as long as there is no communication with the collecting system. Lesions are rounded and peripheral, without lobulation. This type of pyelonephritis may manifest as a pseudotumour and the absence of bacteria in the urine does make differential diagnosis challenging.

**Which radiological investigations and why?**

**Uncomplicated pyelonephritis**

In the majority of cases, pyelonephritis is “uncomplicated” and does not require any emergency radiological investigations. It is desirable to carry out a sonogram of the urinary tracts as soon as possible (ideally within 24 hours) and this should be sufficient to detect any obstructions that may require urgent drainage [1].

Pyelonephritis is referred to as “uncomplicated” when it occurs in a nonpregnant woman aged between 15 and 65, with no signs of being serious, no functional or anatomical abnormalities of the urinary system, and crucially with no sign of obstruction, no recent intervention to the urinary system, no recent or recurring episodes of pyelonephritis, and no current illness affecting the patient’s immune status [1].

**Complicated pyelonephritis**

If a case does not meet all of the above criteria, it is considered to be a “complicated” infection. In men, the infection is by definition “complicated” and the cause, which could be prostate involvement or another obstructive cause of the lower urinary system, must be investigated by pelvic sonography. If there are clinical signs or laboratory results indicative of a serious infection, or where patients deteriorate, a CT scan must be carried out urgently. Plain film radiography is still indicated where dilation of the pelvicalyceal system is seen on sonography with no detectable calculi. If a plain film radiogram remains inconclusive, a CT scan is indicated urgently [5].

**Objectives of imaging investigations**

The diagnosis of pyelonephritis rests solely on clinical criteria (fever, functional urinary signs, lumbar fossa pain, urine dipstick positive for leukocytes and nitrites) and laboratory results (positive urinalysis, and sometimes blood cultures are also done) (boxed text 2) [4]. The two purposes of imaging are:

- to look for any complications that would need specific therapeutic management (obstruction of the collecting system requiring diversion of the urine, an abscess or perirenal fluid collection leading to drainage or a change of antibiotic regimen);
- to identify rare forms of pyelonephritis in an atypical clinical presentation or with atypical laboratory results.

**What is the role for the different imaging techniques?**

**Doppler sonography**

The main purpose of sonography is the detection of dilation in the pelvicalyceal system, although this finding is not always synonymous with an obstruction. Hypotonia of the urinary tracts can be seen in pregnancy, together with vesico-ureteric reflux, megaureter or hyperdiuresis. On the other hand, if dilation is not seen, this does not necessarily eliminate an obstruction, because the appearance of obstructions can be delayed in relation to the onset symptoms.

Sonography is of minimal value to detect foci of nephritis. However, this can be improved by using high frequency and Doppler waves. Foci of nephritis will then appear as perfusion defects on colour Doppler, using low velocity scales.
Increased kidney size and perirenal infiltration cannot be readily assessed and are often missed. Although intrarenal or perirenal abscesses can be visualised on a Doppler sonogram, the CT scan remains the reference examination for detecting them. In our experience, using a contrast medium in sonography does not significantly improve detection of foci of nephritis or potential complications.

CT scan [6]

CT investigation of pyelonephritis requires a precontrast spiral CT scan, followed by, assuming there are no contraindications, a contrast-enhanced spiral CT scan, in the tubulo-interstitial phase, preferably 90 to 120 seconds after the injection (tubular venous phase acquisition). A delayed phase acquisition at the excretory phase is not usually necessary. The CT scan without contrast injection enables calculi, wall calcifications (encrusted pyelitis and bilharziasis), and the presence of gas (emphysematous pyelonephritis) or blood to be detected. This examination is very sensitive to dilatation of the pelvicalyceal system, and it is all the more useful in patients who present challenges to sonographic exploration.

The tubulo-interstitial phase is the most sensitive for detecting abnormalities of the parenchyma and it is important to use narrow windows to read the examination. This is because when windows are set too wide this tends to blur the slight differences in density and therefore runs the risk of missing abnormalities.

MRI

MRI is useful where there is a contraindication to iodine-containing contrast injection, such as renal failure or in pregnant women, and it provides the same information as CT scanning. Diffusion MRI is very sensitive for the noninvasive detection of focal areas of pyelonephritis.

Intravenous urography (IVU)

Intravenous urography is no longer indicated in acute pyelonephritis [4]. It has increasingly been replaced by CT urography. It is still used by some to investigate infectious and inflammatory urothelial pathologies and urothelial tumours.

Retrograde and urinary urethrocystography

This allows vesico-ureteric reflux to be investigated when there is clinical suspicion as well as looking for any obstruction to the lower urinary tracts.

The different forms of acute pyelonephritis and their complications

Pyelitis

Isolated pyelitis and pyeloureteritis point to inflammation of the mucosa and the collecting system (Fig. 1 a, b). On sonography this appears as echogenic and even thickening around the circumference of the walls of the collecting system. This thickening is also seen on CT and MRI scans, but sonography is usually sufficient to put forward this diagnosis.

Uncomplicated pyelonephritis

When the urinary epithelium is affected this can spread to the renal parenchyma (Fig. 2). We have seen that diagnosis is usually made clinically and that sonography is normally sufficient to investigate whether there is any obstruction in the urinary tracts. However, there are numerous descriptions of the urinary tracts. However, there are numerous descriptions of the urinary tracts.
pyelonephritis rests on contrast-enhanced CT scanning. Multiple areas can readily be affected, and in most cases lesions are well-defined, wedge-shaped areas with their bases at the periphery and apexes towards the renal sinus, with the renal parenchyma sometimes demonstrating a striated appearance. These abnormalities indicate hypoperfusion secondary to arteriolar vasoconstriction and inflammatory response. However, there is a delay in the lesions taking up the contrast, which can sometimes be several hours after the injection, as shown by a delayed nephrogram (Fig. 3).

The main differential diagnosis to be eliminated is renal infarction (Fig. 4 a, b). The clinical context is very different in these cases (cardio- or polyvascular disease, sudden onset of lumbar pain preceding a low-grade fever 24 to 48 hours later) [7]. There are no clinical, microbiological or biological signs of urinary infection (although sometimes microscopic haematuria with no bacteria is reported). A fine layer of cortical enhancement, the “cortical rim sign”, is highly suggestive of this diagnosis. The outer renal cortex is in this case vascularised by capsular perforating vessels, which are in turn fed by the inferior phrenic arteries, the middle suprarenal arteries and the gonadal arteries.

In difficult cases, only the finding of minimal or absent infiltration of the perirenal fatty tissue, which contrasts to the significance of the lesions, can point diagnosis in the right direction [8].

### Differential diagnosis of a renal abscess

- Superinfected kidney cyst.
- Infected congenital renal diverticulum.
- Superinfected kidney tumour.
- Papillary necrosis.

**Pyelonephritis through haematogenous spread**

In cases of haematogenous spread to the renal parenchyma, the lesions are as a rule rounded, located in the cortex, often bilateral, sited at a distance from the collecting system, and without segmentation or lobulation.

**Acute focal bacterial nephritis (AFBN) [9]**

This is a form of pyelonephritis with adverse outcomes that can be caused by ascending or haematogenous infection. A pseudotumoural inflammatory mass forms, that takes up contrast, and sometimes shows an element of necrosis [10] (Fig. 5 a–d). In the absence of any clinical sign-posting, it can be difficult to distinguish from a tumour. The finding of an atypical renal mass must lead the clinician to suspect AFBN as this could avoid an unnecessary nephrectomy, since the majority of patients progress well on antibiotics.

**Renal abscess [11]**

Unless an infection is serious, it is rare for abscesses to develop (Fig. 6 a, b). Only renal sonography can make the diagnosis for certain when the finding is a mass containing some degree of fluid. On colour Doppler, peripheral increased vascularity is demonstrated, with the mass causing backflow into the interlobular and arcuate arteries. An abscess can, however, also present as an echogenic mass: in this case diagnosis on sonography is difficult and a contrast-enhanced CT scan is essential for diagnosis to be made [12]. In all cases, sonography is less sensitive than CT for assessing spread to the perirenal space. On views without contrast medium injection, an abscess appears as a fluid-filled renal mass with attenuation coefficients varying between 0 HU and 30 to 40 HU. Sometimes the presence of gas is detected. After injection of contrast medium, the capsule of the abscess is thick and enhanced, although the fluid inside does not enhance. The external part of the capsule of the abscess can appear irregular due to associated inflammatory infiltration. On delayed studies (an hour or more), a ring or strip of delayed nephrogram can surround the fluid collection. This delayed nephrogram has the same meaning as those seen in acute pyelonephritis and corresponds to blocked tubules with backflow.

The main differential diagnoses are diverticula, cysts (Fig. 7 a, b) and infected necrotic tumours (boxed text 3). In the absence of any relevant history, the diagnosis is usually
made retrospectively: after treatment with antibiotics, the inflammatory signs regress and expose any underlying cysts, tumours or diverticula [13].

When the abscess is small (<3 cm diameter), treatment with antibiotics should lead to resolution; otherwise, ultrasound–or CT-guided drainage is indicated in combination with antibiotics [7]. If left untreated, the abscess could spread to the perirenal space: this is a perinephric abscess.

**Perinephric abscess [14,15]**

This is when a renal abscess ruptures out of its capsule. It moves readily into the perirenal space and, by diffusion, into other retroperitoneal space and the abdominal wall. A CT scan is required for diagnosis in order to identify its precise location and assess its spread. The specific treatment usually involves percutaneous drainage.

**Pyonephrosis [16]**

Pyonephrosis is a concomitant suppuration of the parenchyma and the collecting system, and in most cases it leads to compromise renal function. It is usually secondary to a calculus and more rarely to other causes of obstruction (Boxed text 4). Sonography and CT scan without contrast injection demonstrate dilation of the pelvicalyceal system. Other signs can help lead the diagnosis, such as thickening of the walls of the renal pelvis and the presence of fine mobile or sloping echoes in the calyces on sonography. But these signs may not be present and, in cases with strong suspicion based on clinical examination or laboratory tests, microbiological examination of the urine and then urine drainage will allow this diagnosis to be made.

### Boxed text 4 Causes of obstruction of the urinary collecting system.

- Endoluminal obstruction: urinary calculi, papillary necrosis, blood clots in the urine, mycelial accumulation.
- Wall abnormality: tumour stenosis, infections (tuberculosis, bilharziasis), postradiation.
- Extrinsic obstruction: pregnancy, pelvic tumours (such as a cervical tumour invading the pelvis), retroperitoneal fibrosis.

**Emphysematous pyelonephritis [17–22]**

This particularly serious form of pyelonephritis most often occurs in patients with diabetes. It often has adverse outcomes and may lead to a nephrectomy. The bacterium that is most commonly the cause is *E. coli* (70% of cases), but other bacteria can be responsible. The bacteria cause glucose fermentation, which leads to the formation of gas, and this process is encouraged by the presence of sugar in necrotic tissue and in the urine.

The clinical picture is one of a case of acute pyelonephritis that does not respond to treatment and that can quickly progress to septic shock. A varying degree of renal failure is often reported. A CT scan without contrast injection is the key examination for diagnosis, based on the presence of gas in the renal parenchyma (Fig. 8 a, b), the urinary tracts and sometimes the perirenal tissue. Contrast medium injection is often contraindicated due to diabetes or renal failure, but it does allow an assessment of the extent of renal parenchyma destruction. If gas is only present in the collecting system, this could point to a case of emphysematous pyelitis, which has a less severe prognosis.
Figure 5.  AFBN of the left kidney. Pseudotumoural left kidney mass, made up of tissue combined with multiple hypodense microabscesses: a: on sonography; b: on contrast-enhanced ultrasonography; c: on contrast-enhanced CT scan in the tubular venous phase; d: on contrast-enhanced CT scan in the arterial phase.

Figure 6.  Renal abscess: a: axial view; b: coronal view. Fluid-filled collection in the left kidney, with septations and thick walls seen on a contrast-enhanced CT scan.
Figure 7. Superinfected right kidney cyst. Even thickening and contrast uptake in the wall of a right kidney cyst: a: fine septations within the cyst (white arrow); b: oedema of the perilesional parenchyma (arrow-head).

Figure 8. Early emphysematous pyelonephritis. Intraparenchymal gas bubbles found (white arrow) on CT scan: a: CT scan of the abdomen and pelvis without contrast medium; b: wide window (pulmonary parenchyma).

Alternatively, the isolated presence of gas in the collecting system can sometimes relate to a recent catheterisation or a uro-intestinal fistula.

Pyelonephritis in pregnancy

Pyelonephritis in pregnancy can have a poor prognosis because of maternal complications (severe sepsis) and foetal complications (threat of premature birth) (Fig. 9 a–d). A sonogram is the first-line investigation used to look for an obstruction. In cases of physiological dilation of the collecting system due to pregnancy, the ureter is dilated as far as the crossing with the iliac vessels and no obstruction is found. This dilation is predominantly right-sided in 85% of cases and is seen in 90% of pregnant women in the third trimester of pregnancy (Boxed text 5). However, if sonography confirms the presence of an obstruction, especially a calculus, the calyces should be drained urgently. To diagnose pyelonephritis in pregnancy, a Doppler sonogram is carried out as a first-line investigation. If there is any doubt or if an obstruction needs to be better visualised, MRI should be used because it does not emit radiation. Acquisitions without contrast injection are prioritised, in particular diffusion imaging, which can readily visualise the zones of pyelonephritis.

Boxed text 5 Causes of hypotonia of the urinary collecting system without obstruction.

- Pregnancy (pelvi-ureteric dilation as far as the cross with the iliac vessels and more commonly on the right).
- Vesico-ureteric reflux.
- Hyperdiuresis.
- Megaureter.

Papillary necrosis [23]

This is a rare complication of ischaemic origin that is encouraged by infections, usually occurring in diabetic patients [24] and more rarely in patients with sickle cell anaemia. The diagnosis rests mainly on IVU and CTU, which shows one or several images of accumulation in the pelvicalyceal system corresponding to necrotic
renal papillae sloughed off from the rest of the renal parenchyma.

**Chronic pyelonephritis**

When acute pyelonephritis occurs repeatedly, usually in relation to occult vesico-ureteric reflux, this can lead to the patient developing fibrosing interstitial nephritis (Fig. 10 a, b). Very often it progresses slowly into renal failure. On sonography, atrophied kidneys appear small in size, with dedifferentiation of the renal cortex and medulla and the presence of cortical notches. If the patient’s renal function permits, a contrast-enhanced CT scan will lead to diagnosis. It demonstrates the pyelonephritis scar tissue, which combines cortical retraction with deformities of the calyces, with areas in between that are comparatively healthy. If there is no specific affected area, a retrograde cystography must be carried out to investigate whether there is vesico-ureteric reflux.

---

**Figure 9.** Pyelonephritis in pregnancy. Pyelonephritis of the right kidney of a pregnant woman 31 weeks since LMP: a: focal nephritis on sonography (white arrow): slightly hyperechoic and nonhomogenous cortical lesion of the mid right kidney (white arrow); b: the focal area is shown to be hypoperfused on a power Doppler scan. The zone before the ureters cross the iliac vessels (head of white arrow) does not show an obstruction: it is a physiological dilation due to pregnancy; c: on sonography; d: on colour Doppler sonography.

**Figure 10.** Chronic pyelonephritis: a: axial view; b: coronal reconstruction. Pyelonephritis scar tissue combining cortical retraction (white arrows) and deformation of the calyces with areas in between that are comparatively healthy seen on contrast-enhanced CT scan.
**Rare forms of urinary infection**

Imaging can also lead to a precise diagnosis of some rare kinds of upper urinary tract infection, which may have an atypical presentation on clinical examination or laboratory tests.

**Xanthogranulomatous pyelonephritis [25,26]**

This is a rare form of chronic kidney infection that can be identified histologically, combining the lesions of chronic pyelonephritis and xanthogranulomatous foam cells. The main cause of this type of infection is chronic obstruction of the collecting system by lithiasis that often forms in the shape of staghorns. The bacteria that cause it, when they are found, are *Proteus Mirabilis* and *E. Coli*. The obstruction can also be due to ureteral stenosis of infectious origin (tuberculosis, bilharziasis), to stenosis of the pelvi-ureteric junction secondary to malformative uropathy, or more rarely, to a tumour of the collecting system. It manifests in two forms, the most common being diffuse involvement and the other, focal pseudotumour. In the diffuse form, the symptomatology is often the same as that of pyonephrosis. The presence of staghorn calculi possibly in the calyces is also suggestive. The renal architecture can be entirely destroyed. The CT scan can also be useful to assess the perirenal spread of the infectious process and any fistulae complicating it. In the localised form, CT scan findings are a nonenhancing or minimally enhancing renal mass, usually combined with staghorn calculi. This finding can mimic that of a renal tumour.

**Urinary tuberculosis [27]**

The kidneys can be affected in miliary tuberculosis due to the dissemination of Koch’s bacillus through the haematogenous route. It can progress to form areas of ulcerating parenchyma in the calyces, making “cavities”. The spread of bacilli in the urine can then lead to urothelial ulceration, followed by scar tissue stenosis. When these stenoses arise, they are usually located at either extremity of the ureter: the pelvi-ureteric junction or vesico-ureteric junction. CT scan urography demonstrates accumulation in the calyces corresponding to fistulated cavities, calyx stem stenosis with proximal ball-shaped hydrocalyx, ureteral stenosis and, more rarely, calcifications of the parenchyma with a “putty kidney” appearance.

**Bilharziasis or urinary schistosomiasis [28]**

In this condition parasites and their eggs are present in the walls of the bladder and ureters, leading to the formation of multiple granulomas with reactive fibrosis. Recurrent episodes of haematuria are suspicious for this diagnosis. In later stages ureteric stenosis develops, as well as calcifications of the bladder and ureter walls that are readily identified on CT urography or IVU views without contrast injection. If it remains untreated, disease progression leads to a reduced bladder capacity, to the point of a “microbladder” appearance combined with an enlarged meatus that encourages reflux, visible on retrograde cystography. Bilharziasis encourages squamous cell carcinoma tumours to develop in the bladder, which differ from the transitional cell carcinomas that are more usually encountered in the bladder.

**Corynebacterium infection: pyelitis and encrusted cystitis [29,30]**

This is a nosocomial infection that is caused by *Corynebacterium urealyticum* D2 or more rarely *Ureaplasma urealyticum* bacteria colonising the urinary tracts of immune suppressed patients. It can develop in kidney transplant patients; it is also encouraged by the prolonged presence of medical equipment (urinary catheter, ureteric stent or nephrostomy). It leads to the formation of ammonium magnesium phosphate calculi that become encrusted in the mucosa of the renal pelvis and ureter. CT scanning without contrast medium is the best technique for visualising these wall calcifications. The urothelial wall is thickened and, in severe infections, the periurethric and periureteric regions have a striated appearance.

**Urinary candidiasis [31,32]**

The urinary system can be colonised by *Candida Albicans* either by the ascending or haematogenous route in immune suppressed patients. Based on the clinical presentation and laboratory results, it is sometimes difficult to distinguish a colonisation from an infection. However, the presence of Candida is always pathological. If it is present this points to systemic candidiasis and renal involvement is likely where it is also present in the urine. Sonography detects accumulation of mycelia with a variable appearance: hyper-echoic, minimally echoic or slightly echoic. 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.

**Renal hydatidosis [33]**

It is rare for hydatidosis to affect the kidneys. Different stages, corresponding with those described by Gharbi concerning the liver, may be encountered. A contrast-enhanced CT scan is the investigation of choice: it demonstrates a fluid-filled mass that sometimes contains septations (daughter cysts) and later calcifications.

**Pyeloureteritis cystica [34]**

Pyeloureteritis cystica is a rare disease, secondary to deterioration of the walls of the ureters, usually alongside a chronic urinary tract infection. On IVU or CT urography it appears as multiple nonobstructive small filling defects of the ureter wall.

**Malakoplakia [35,36]**

Histologically, this is the development of an inflammatory granuloma secondary to a chronic infection with *E. Coli*. It is
more common in women than in men and it usually affects the urinary tract. Other forms of this condition (gastrointestinal, retroperitoneal etc.) are rare. This disease usually presents in the form of plaques and less commonly as a mass. The diagnosis is usually made retrospectively, and it rests on histological examination of biopsy tissue.

**Conclusion**

The majority of cases of pyelonephritis do not require any additional imaging investigations as an emergency. It is desirable for sonography of the urinary system to be carried out as soon as possible (preferably within 24 hours), because this will be sufficient to detect most obstructions that require urgent intervention for drainage [1]. If serious clinical signs or laboratory results are found, the first-line investigation (except in pyelonephritis in pregnancy) is a CT scan, which should preferably be contrast-enhanced if the patient’s renal function permits. This performs better than sonography at detecting and identifying most complications. It is essential that the radiologist is aware of unusual forms of pyelonephritis, especially certain pseudotumoural forms (xanthogranulomatous pyelonephritis, AFBN etc.), so that clinicians can be pointed towards the appropriate treatment, avoiding invasive and often unnecessary interventions.

**Clinical case study**

**History of the illness**

A 57-year-old female, with a history of recurrent urinary infections, presents a two-month history of right loin pain radiating to the right hypochondrium and right shoulder. Urinalysis leads to a diagnosis of urinary infection. In spite of a suitable antibiotic regimen, the pain persists and her general condition deteriorates. A contrast-enhanced CT scan of the abdomen and pelvis is carried out (Fig. 11).

**Questions**

1. What is your diagnosis?
2. Based on the imaging, what kind of bacteria usually causes this type of upper urinary infection?
3. Briefly describe the chronology of this complicated urinary infection.
4. How would you manage this patient?

**Answers**

1. Diagnosis: xanthogranulomatous pyelonephritis of the upper pole of the right kidney with a contiguous nephrohepatic fistula proximal to staghorn calculi obstructing the pelvicalyceal system [37–39].
2. *Proteus mirabilis*. This Gram-negative urease positive bacillus is the bacterium that is most often involved in the formation of ammonium magnesium phosphate (or struvite) urinary calculi.
3. Chronic urinary infection with a urease positive bacterium leading to the formation of an ammonium magnesium phosphate urinary calculi in the pelvicalyceal system of the right kidney. Chronic obstruction to urine excretion in the pelvicalyceal system, causing an inflammatory mass to form in the adjacent renal parenchyma. Extra-renal development of renal parenchyma inflammation, in the form of a fistula opening with a neighbouring organ, specifically, in the perirenal fatty tissue, the renal fascia, the pararenal fatty tissue, then the hepatic parenchyma in segment VI.
4. Appropriate long-term antibiotic therapy based on antibiogram is always indicated. An ultrasound- or CT-guided fine-needle aspiration of the abscess may be an alternative to surgery. The advantage of surgery is that the calculi can also be extracted. A specimen should automatically be sent to pathological anatomy in order to confirm the diagnosis and eliminate a malignant renal tumour.

---

**Figure 11.** Contrast-enhanced abdominal CT scan: a: axial view; b: coronal view.
Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References