

Abnormal calcifications of the urinary tract

Poster No.: C-0833
Congress: ECR 2014
Type: Educational Exhibit
Authors: R. A. Costa¹, C. M. Oliveira², M. A. C. D. Abreu², F. Caseiro Alves²; ¹PT, ²Coimbra/PT
Keywords: Urinary Tract / Bladder, Kidney, Conventional radiography, Plain radiographic studies, Diagnostic procedure, Calcifications / Calculi
DOI: 10.1594/ecr2014/C-0833

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org

Learning objectives

1. Review and illustrate a variety of urinary tract calcifications and their differential diagnoses.
2. Demonstrate the important role of conventional radiology in their detection.

Background

Urinary tract calcifications are very common and can be due to a large spectrum of causes. They can be characterized according to their location (Kidney, Ureteral or Bladder), appearance and relation to various pathologic conditions.

Calculi, the most common cause of urinary tract calcification, are usually radiopaque due to their calcium content. Other common causes include Nephrocalcinosis, cystic or solid masses, and, less frequently, Xanthogranulomatous pyelonephritis, Schistosomiasis and Tuberculosis.

Findings and procedure details

Renal Calcification

Nephrolithiasis

Renal calculi are the most common cause of calcification in the kidney. It has been estimated that 12% of the population will have a urinary tract stone at some time in their lives. There are four major types of stones differentiated by their major components. Those different components induce different radiopacity (Table 1).

Composition	Frequency (%)
Calcium	70-80
Calcium phosphate (pure)	5-10
Calcium oxalate/phosphate	30-45
Calcium oxalate (pure)	20-30

Struvite	15-20
Cystine	1-3
Uric acid	5-10

Note - Stones are listed in order of decreasing radiopacity.

Table 1 - Frequency of Major Stone Types (Source - reference 4)

Renal calculi are radiopaque due to their calcium content. Calcium oxalate stones may occur in a pure monohydrate or dihydrate form. Pure calcium oxalate monohydrate stones, like pure calcium phosphate, are usually small and highly radiopaque for their size (Fig. 1 on page 6). Calcium oxalate dihydrate stones may appear spiculated (Fig. 2 on page 7) (similar to a child's toy jack) or mamillated (Fig. 3 on page 8) ("mulberry" stones).

Stones formed into small cavities such as caliceal diverticula are all of similar size and are known as "seed calculi" (Fig. 4 on page 9).

The "milk of calcium" pattern of stone (Fig. 5 on page 9) results from a suspension of calcium carbonate in a renal cyst or caliceal diverticulum. The suspension is heavier than urine and therefore layers in the most dependent portion of the cyst or diverticula.

A staghorn stone (Fig. 6 on page 10) is a branched renal calculus that resembles the antlers of a stag. They are usually composed of struvite and, less commonly, cystine or uric acid. Staghorn calculi are associated with recurrent urinary tract infections from bacterial pathogens that produce alkaline urine. Therefore it's the only type of calculus that is more common in women. These stones are less opaque than calcium ones.

Nephrocalcinosis

Deposition of calcium in the renal parenchyma is a common pathologic finding known as nephrocalcinosis. It is characterized according to the anatomic area involved, medulla or cortex.

The most common form is medullary nephrocalcinosis, and it has a wide variety of causes (table 2). Uniform and bilateral deposition of calcium in the medullary portion of the kidney is most common seen secondary to hyperparathyroidism or distal renal tubular acidosis (Fig. 7 on page 10). On the other hand, an asymmetric form of medullary nephrocalcinosis is commonly seen in medullar sponge kidney.

Cortical nephrocalcinosis (Fig. 8 on page 11) may also be attributable to a variety of causes (table 2) but, it is usually secondary to chronic glomerulonephritis or acute cortical necrosis.

Medullary Nephrocalcinosis

Bartter syndrome
 Bone metastases
 Chronic pyelonephritis
 Cushing syndrome (endogenous, exogenous)
 Hyperparathyroidism
 Hyperthyroidism
 Idiopathic hypercalcemia
 Malignancy
 Medullar sponge kidney
 Nephrotoxic drugs
 Primary hyperoxaluria
 Renal papillary necrosis
 Renal tuberculosis
 Renal tubular acidosis
 Sarcoidosis
 Sickle cell disease
 Vitamin D excess

Cortical Nephrocalcinosis

Acute cortical necrosis
 Alport syndrome
 Chronic glomerulonephritis
 Chronic hypercalcemic states
 Ethylene glycol poisoning
 Methoxyflurane toxicity
 Oxalosis
 Rejected renal transplant
 Sickle cell disease

Table 2 - Common causes of Medullary and Cortical Nephrocalcinosis (source - reference 1)

Cyst or Solid Mass

Simple renal cysts can show intracystic or wall calcifications (Fig. 9 on page 11). Intracystic calcifications are usually thin and peripheral and are often described as having an "eggshell" appearance.

The most common primary solid neoplasm of the kidney is renal cell carcinoma (Fig. 10 on page 12) and it calcifies in about 20% of the cases. Calcifications may also be seen in other primary renal neoplasms (e.g. renal osteosarcoma) or in metastatic lesions of the kidney. Renal masses with calcification should always lead to further investigation in order to exclude malignancy.

Miscellaneous Renal Calcifications

Several pathologic conditions such as diabetes mellitus and severe atherosclerotic disease may cause calcification of the renal vasculature (Fig. 11 on page 12).

Renal tuberculosis is a result of secondary hematogenous infection from the lungs. The genitourinary system is often affected, being the second most common site of tuberculosis infection. In the end stage of renal tuberculosis, we can see a small, totally calcified and nonfunctional kidney resulting in autonephrectomy. The radiologic appearance of this condition has been described as *putty kidney* (Fig. 12 on page 13).

Xanthogranulomatous pyelonephritis (Fig. 13 on page 14) is an uncommon complication of long term urinary tract obstruction with a superimposed chronic infection. On classic excretory urography it is characterized by an obstructing staghorn calculus that may be fragmented, renal enlargement and nonexcretion of contrast material from the involved kidney. At CT, there is replacement of the renal parenchyma by an infectious process that produces hypoattenuating masses arranged in a hydronephrotic pattern. There may be enhancement in the margins of these masses after contrast material administration. This appearance on CT scans has been described as the *bear paw* sign.

Ureteral Calcification

Stones that migrate from kidney are the most common cause of ureteral calcification. Therefore ureteral stones show the same composition as the ones from the kidneys. Stones usually become impacted at points of anatomic narrowing such as the ureteropelvic junction, the ureteral crossing of iliac vessels and the ureterovesical junction.

In the pelvis, phleboliths may be mistaken with ureteral stones but, while stones ([Fig. 14](#) on page 14, [Fig. 15](#) on page 15, [Fig. 16](#) on page 15) usually have a uniform radiopacity and are often angulated along the course of the ureter, phleboliths ([Fig. 17](#) on page 16) tend to be multiple and centrally radiolucent.

Although uncommon, inflammatory conditions like schistosomiasis and tuberculosis may cause calcification of the ureteral wall.

Bladder Calcification

Bladder calculi ([Fig. 18](#) on page 16) are the most common cause of bladder calcification. Nowadays, in developed countries, they are not as common as they used to be, and are usually associated with bladder outlet obstruction. Like renal calculi, they usually consist of a mixture of calcium oxalate and calcium phosphate. Bladder calculi radiopacity reflects their composition.

Calcifications within the bladder wall can be seen in patients with primary neoplasms of the bladder.

Other rare entities that can cause bladder calcification are schistosomiasis ([Fig. 19](#) on page 16), tuberculosis, alkaline incrustated cystitis and radiation therapy.

In the pelvic region we can also see calcifications of the prostate gland ([Fig. 20](#) on page 17) and seminal vesicles ([Fig. 21](#) on page 17).

Images for this section:

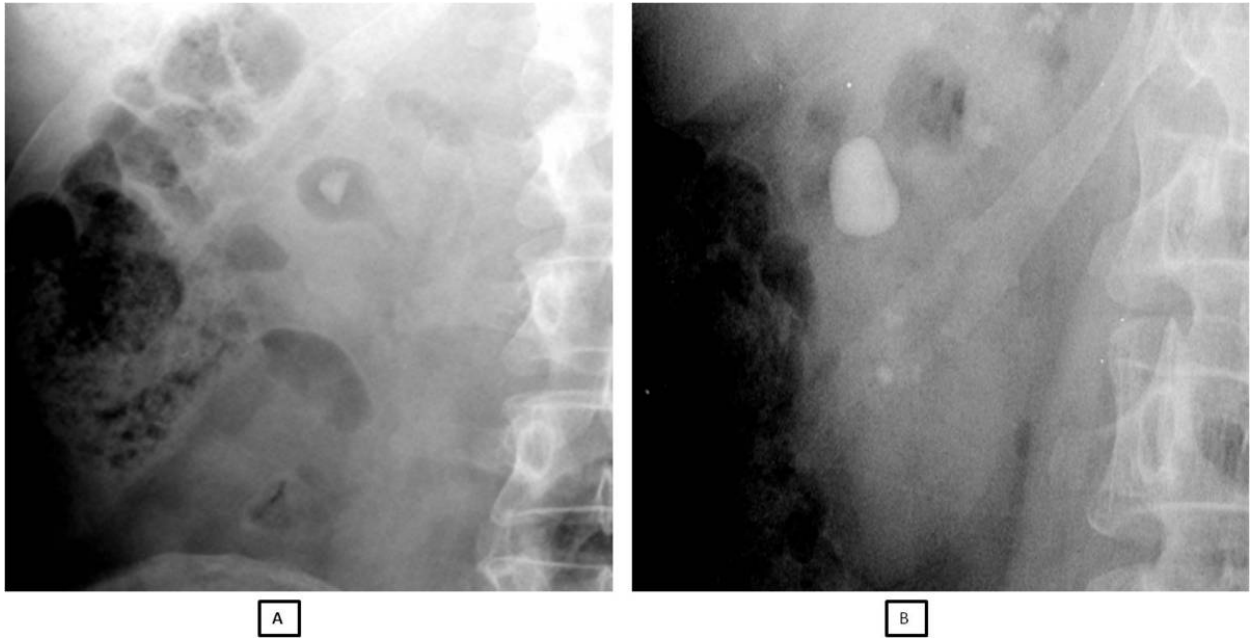


Fig. 1: Highly opaque calculus. (A) Plain radiograph shows a small and highly opaque calculus in right renal pelvis. (B) Plain radiograph demonstrates a highly opaque calculus in right renal pelvis

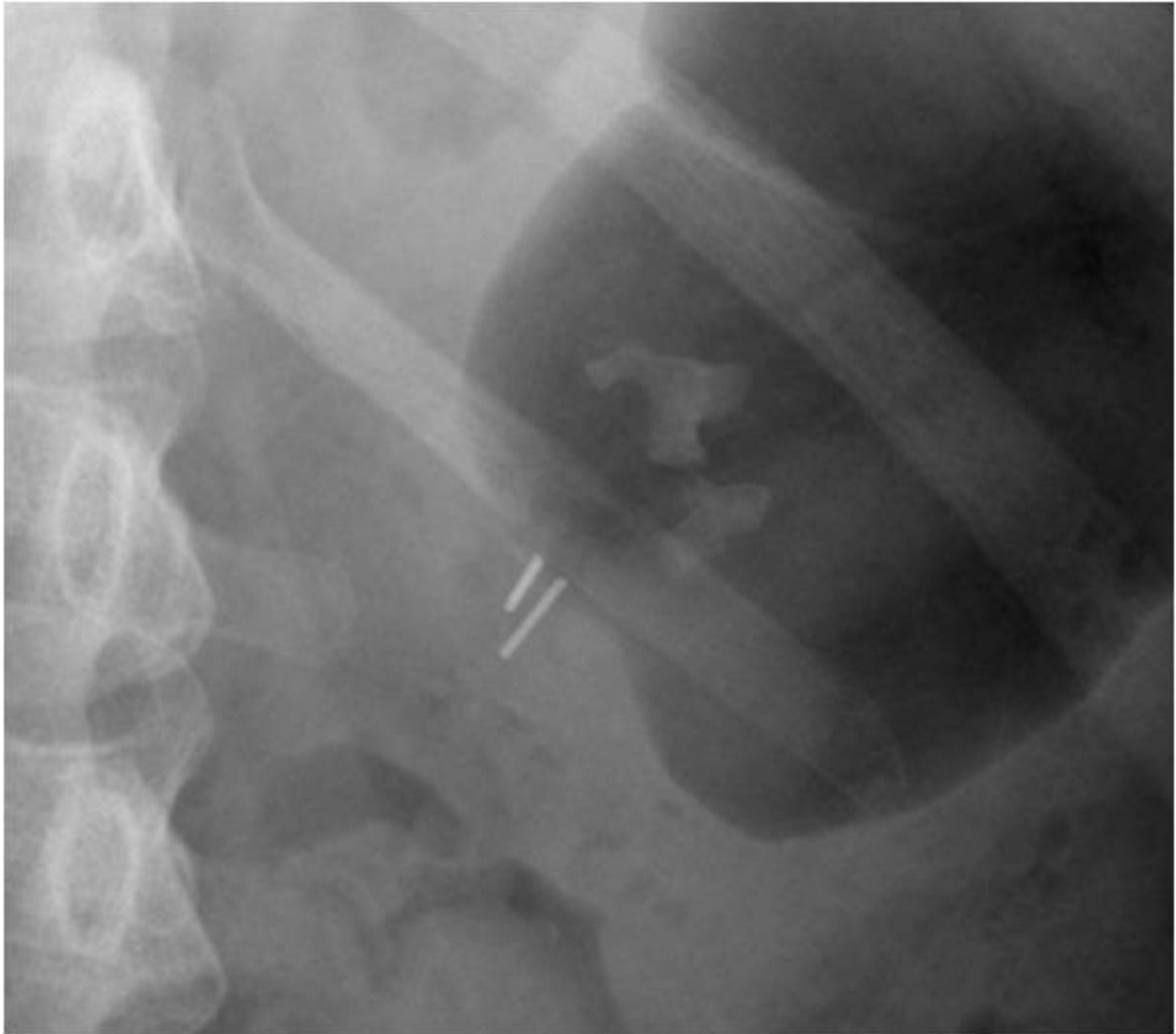


Fig. 2: Spiculated Stone. Plain radiograph demonstrates two spiculated stones in left renal pelvis

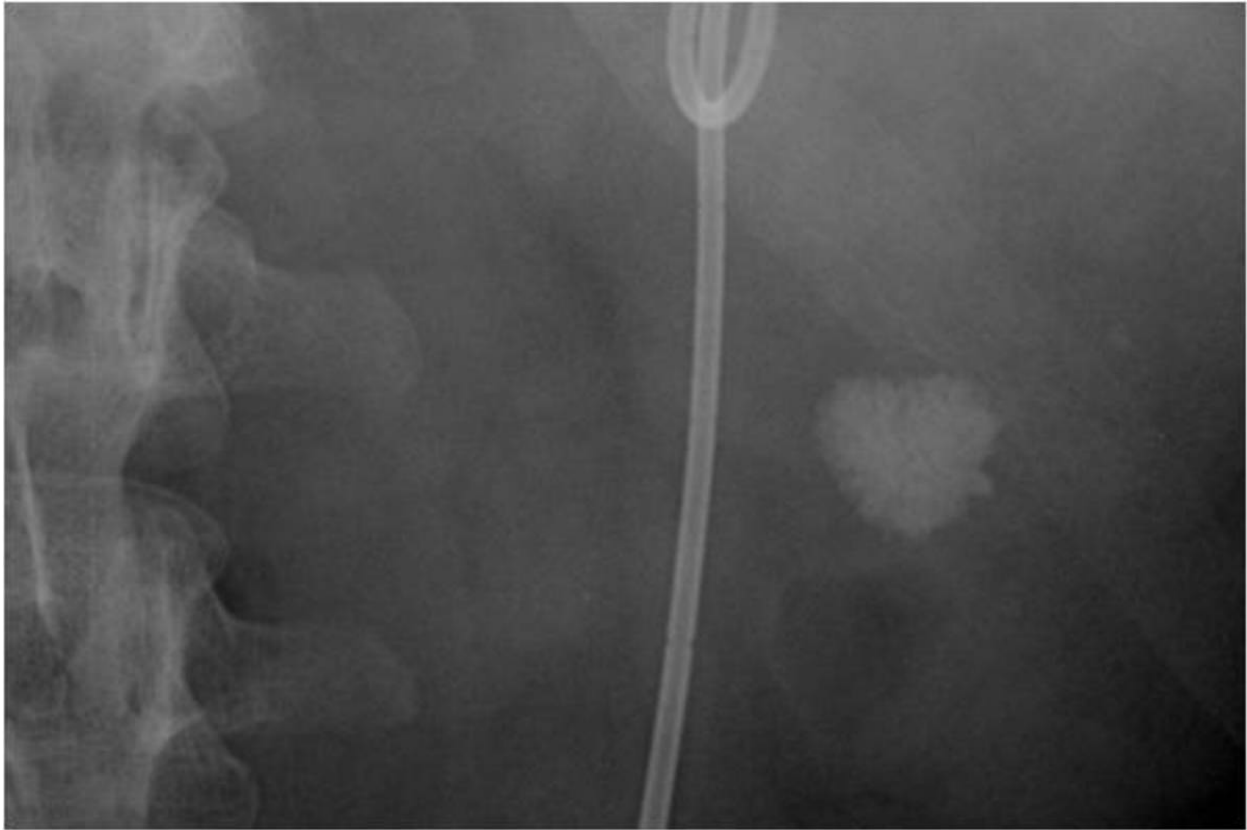


Fig. 3: Mulberry stone. Plain radiograph demonstrates a finely spiculated stone in left renal pelvis. The contour irregularities give the stone the appearance of a mulberry.



Fig. 4: Seed calculi. (A) Plain radiograph demonstrates clustered seed calculi with smooth margins in the right upper quadrant of the abdomen. (B) Urogram shows pooling of contrast material in the calicial diverticulum containing the calculi. (C) Ultrasound image of the same patient demonstrates, in the upper pole of the right kidney, multiple calculi in a calicial diverticulum measuring 2,38cm longitudinal length.

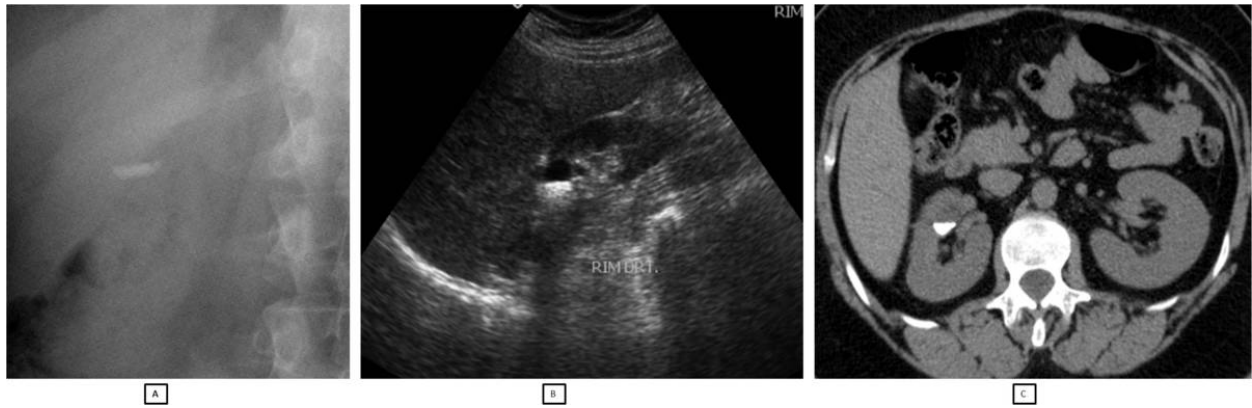


Fig. 5: Milk of calcium stones in a renal cyst. (A) Plain radiograph shows a calcify density in the right upper quadrant. (B) Ultrasound and (C) CT scan of the same patient demonstrates, in the right kidney, a cyst with a calcified image inside that makes a liquid-calcium level.

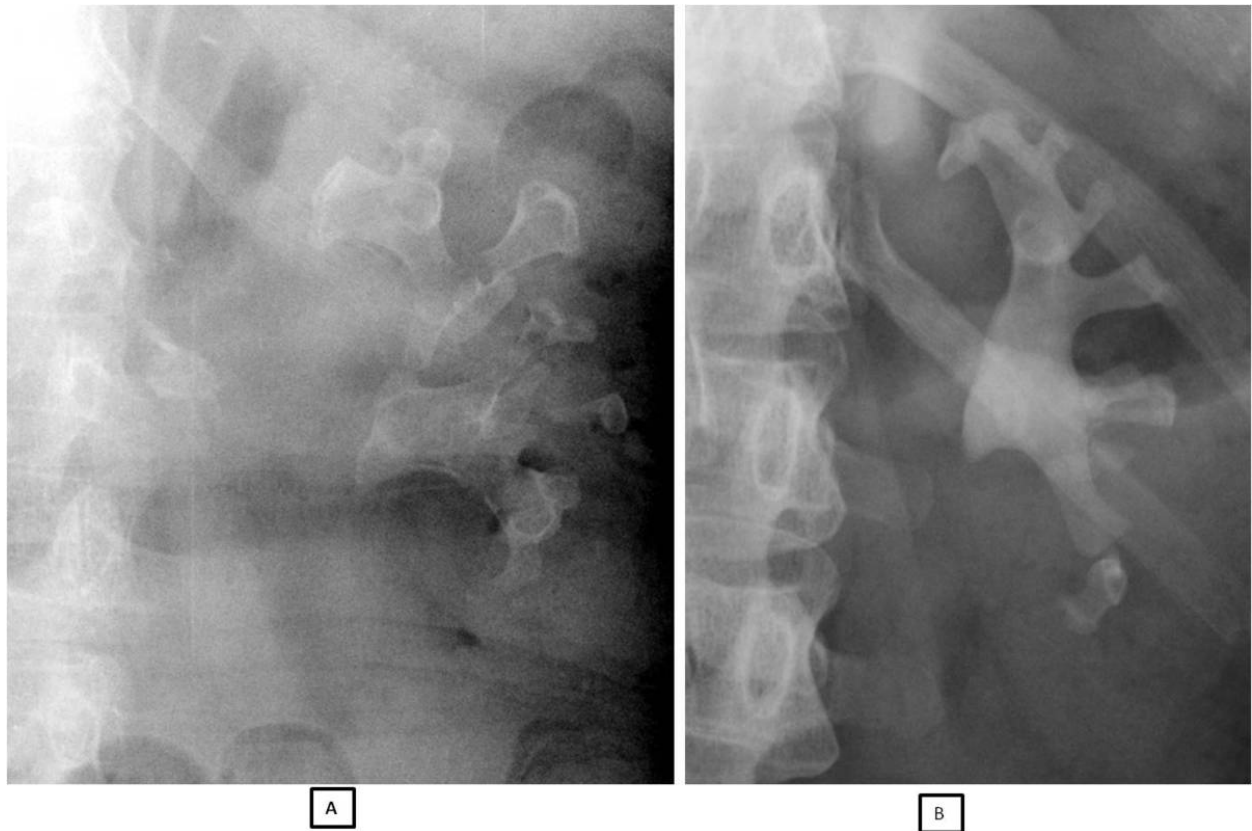


Fig. 6: Staghorn calculus. (A) Plain radiograph shows a staghorn calculus in left renal pelvis. (B) Plain radiograph of a different patient also shows a staghorn calculus in left renal pelvis and collecting system.

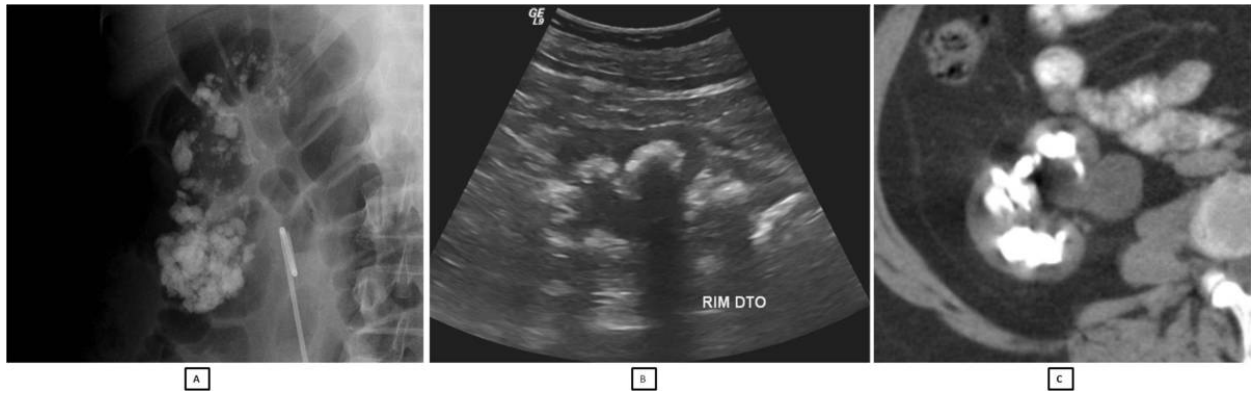


Fig. 7: Medullary nephrocalcinosis in a patient with distal renal tubular acidosis. Patient had history of left nephrectomy. (A) Plain radiograph shows nephrocalcinosis of the right kidney (B) Ultrasound image of right kidney shows preservation of the cortical parenchyma and several hyperechoic areas with posterior shadowing located in the medulla. (C) CT scan demonstrates medullary nephrocalcinosis.

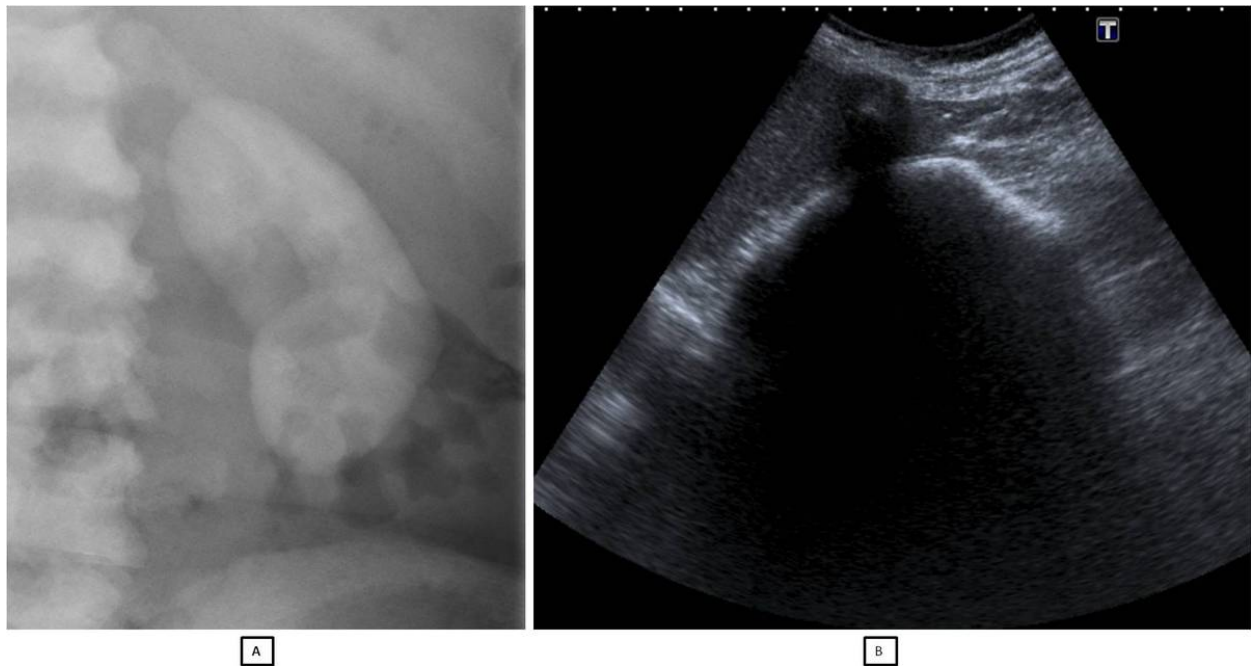


Fig. 8: Cortical nephrocalcinosis in a patient with primary hyperoxaluria. Patient had history of right nephrectomy. (A) Plain radiograph shows cortical nephrocalcinosis of the left kidney (B) Ultrasound shows, in the topography on the left kidney, a thin hyperechoic line with posterior shadowing.

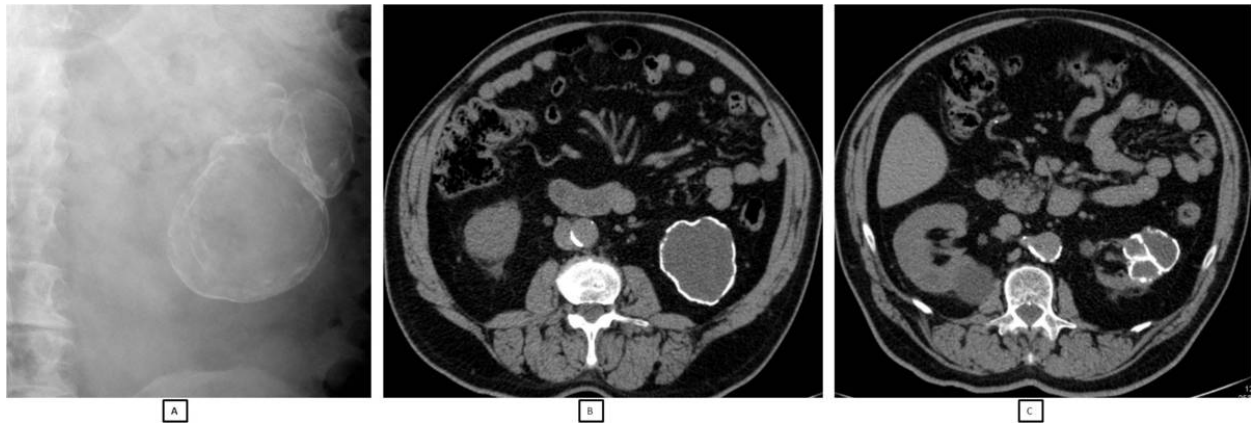


Fig. 9: Cyst Calcifications (A) Plain radiograph shows multiple rim calcifications in the left kidney. (B) (C) CT scan shows multiple cysts with rim calcification in the left kidney.

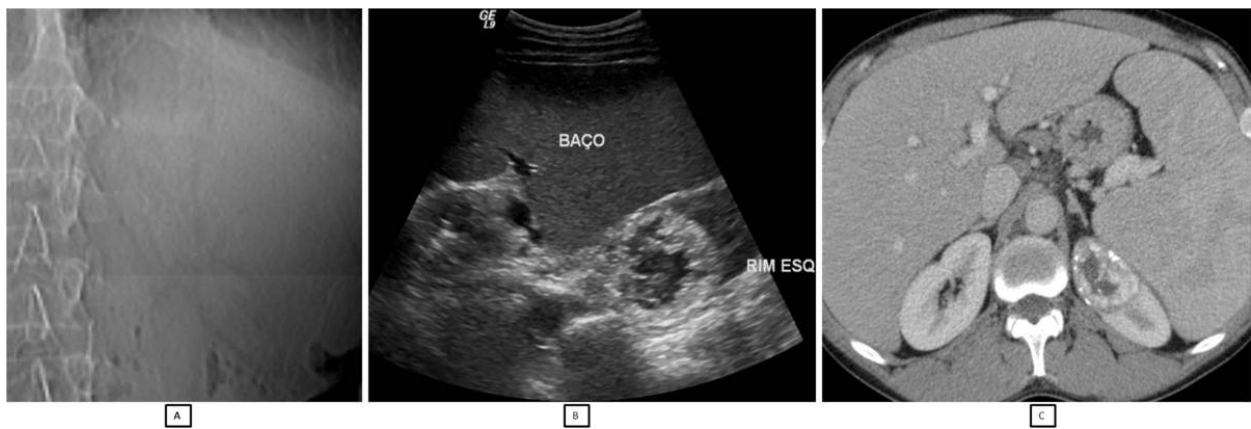


Fig. 10: Renal cell carcinoma (A) Plain radiograph shows a spotty calcification in the left upper quadrant of the abdomen. (B) Ultrasound shows in the left upper pole of the right kidney a nodular formation with multiple and millimetric hyperechoic areas. (C) Contrast material-enhanced CT scan demonstrates a mass containing multiple punctuate calcifications in the upper pole of the left kidney.

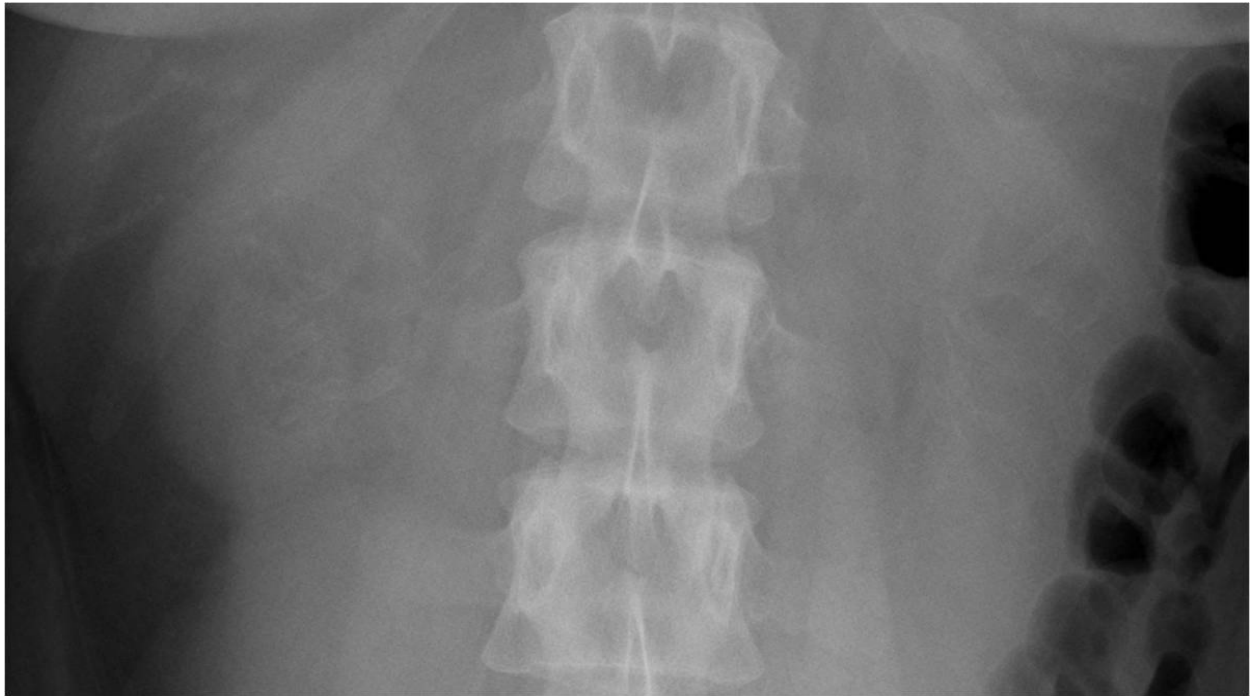


Fig. 11: Renal vascular calcification in diabetes mellitus. Plain radiograph shows extensive calcification of both main renal arteries and their peripheral branches.

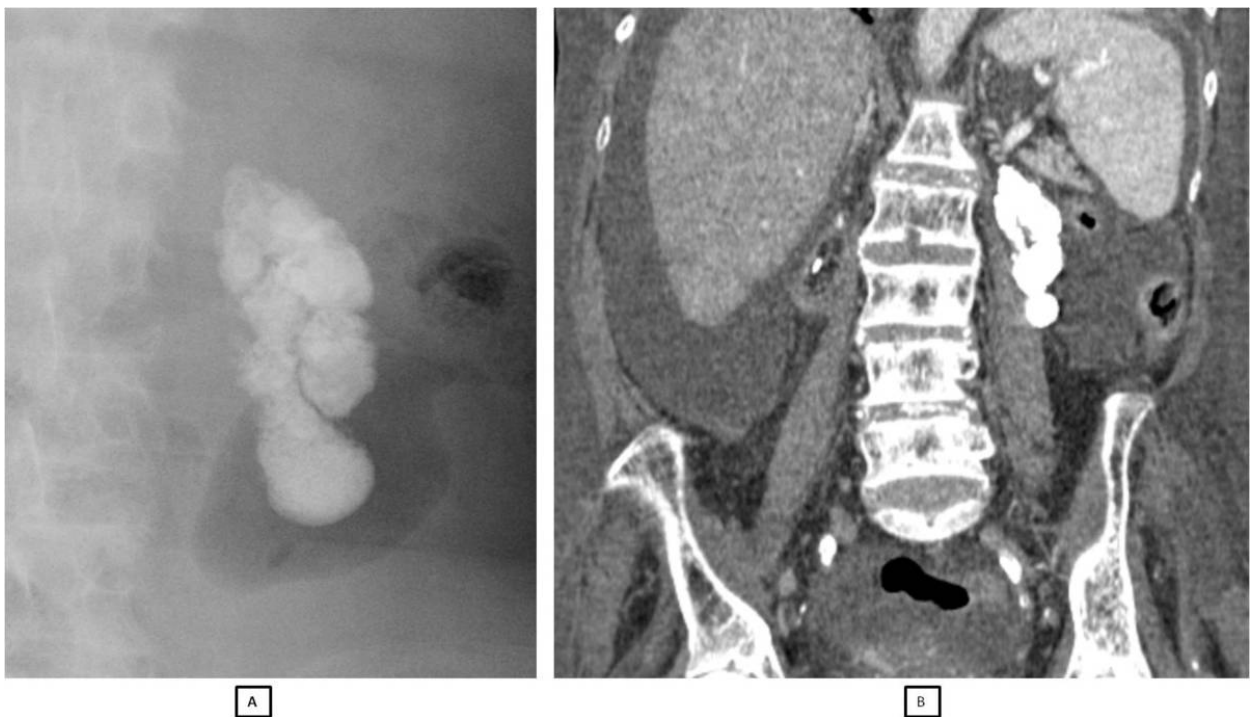


Fig. 12: Putty Kidney in a patient with renal tuberculosis. (A) Plain radiograph of the abdomen shows extensive calcification in the left kidney, which was nonfunctional, consistent with autonephrectomy from tuberculosis. (B) CT scan demonstrates the

extensive parenchymal and collecting system calcification as a result of tuberculosis infection.



Fig. 13: Xanthogranulomatous pyelonephritis. (A) Plain radiograph shows a large staghorn calculus in a dilated right renal pelvis. The calculus is not fragmented. (B) Contrast material-enhanced CT scan demonstrates an enlarged kidney that contains multiple rounded, hypoattenuating masses, typically arranged in a hydronephrotic pattern, representing dilated calices or inflammatory tissue. Note that the parenchymal collections exhibit marginal enhancement. This pattern resembles a bear's paw.



Fig. 14: Ureteral Stone. Plain radiograph shows a ureteral stone on the medial portion of the left ureter. Sometimes these calculi may be difficult to detect when overlying bony structures, such as the sacrum, as shown in this radiograph.

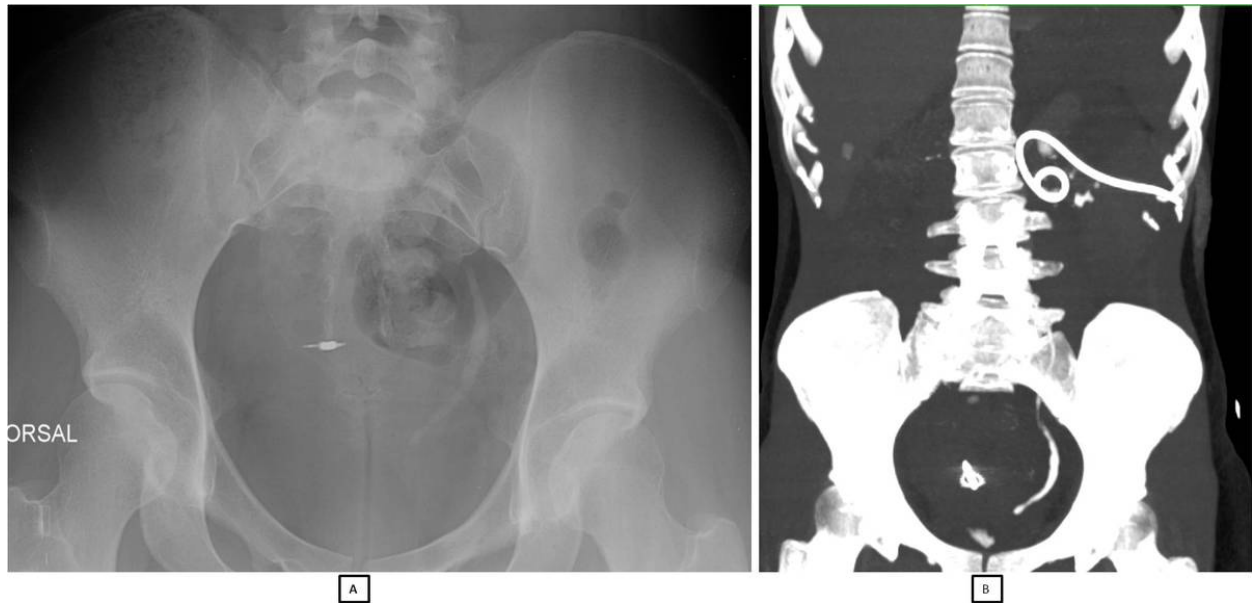


Fig. 15: Ureteral Stones. (A) Plain radiograph and (B) CT scan apparently show a giant ureteral stone in left distal ureter. Later, after surgical approach, it was verified that the patient had multiple small calculi instead.

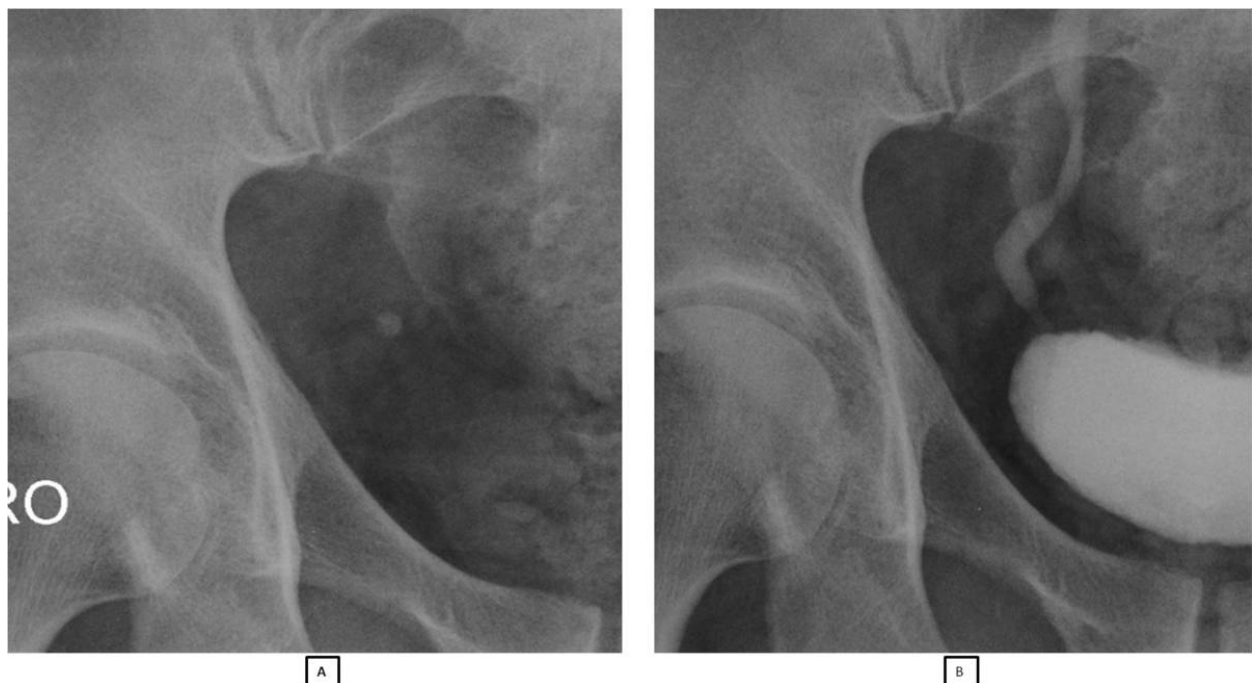


Fig. 16: Ureteral Stone. (A) Plain radiograph shows a round opacity (ureteral calculus) in the right side of the pelvis that could easily be mistaken for a phlebolith. (B) Urogram demonstrates that it is localized inside the ureter confirming the diagnosis.

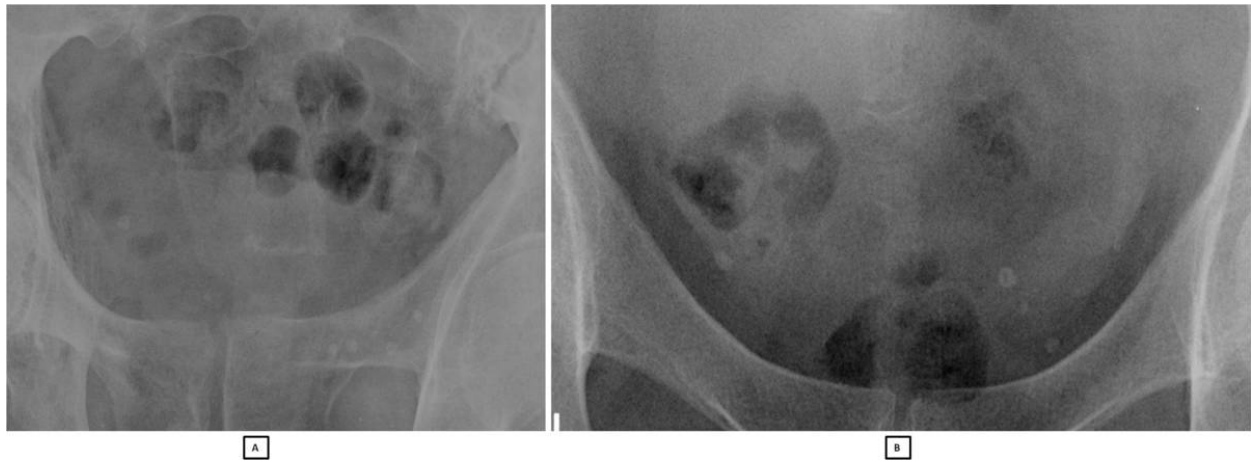


Fig. 17: Phleboliths. (A) (B) Plain radiographs show, in the pelvis, several areas of high opacity with a central radiolucency suggestive of phleboliths. This diagnosis was later confirmed by CT scan.

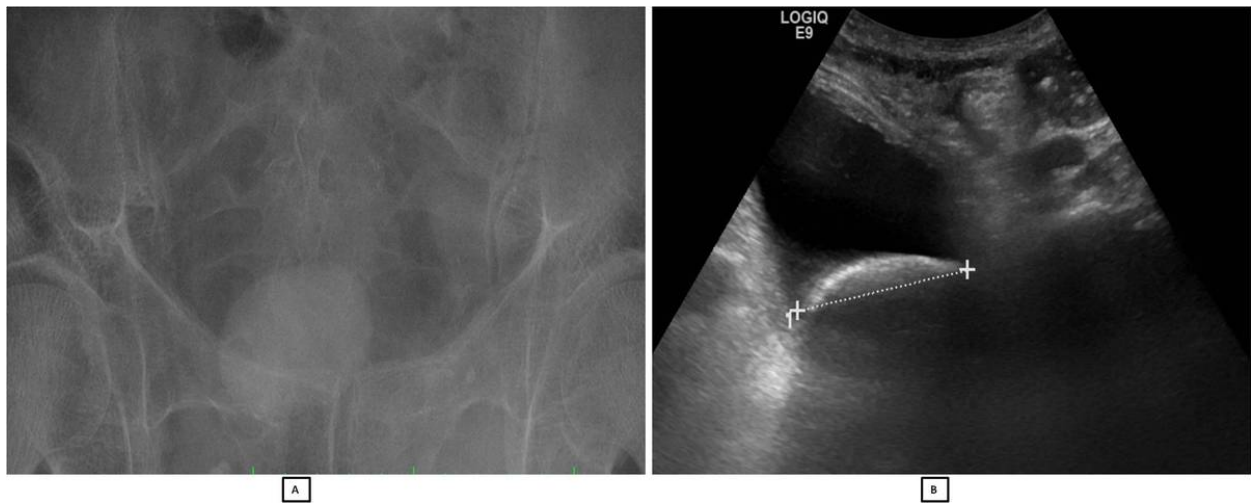


Fig. 18: Large bladder calculus. Plain radiograph (A) and Ultrasound (B) show a large calculus in the bladder.

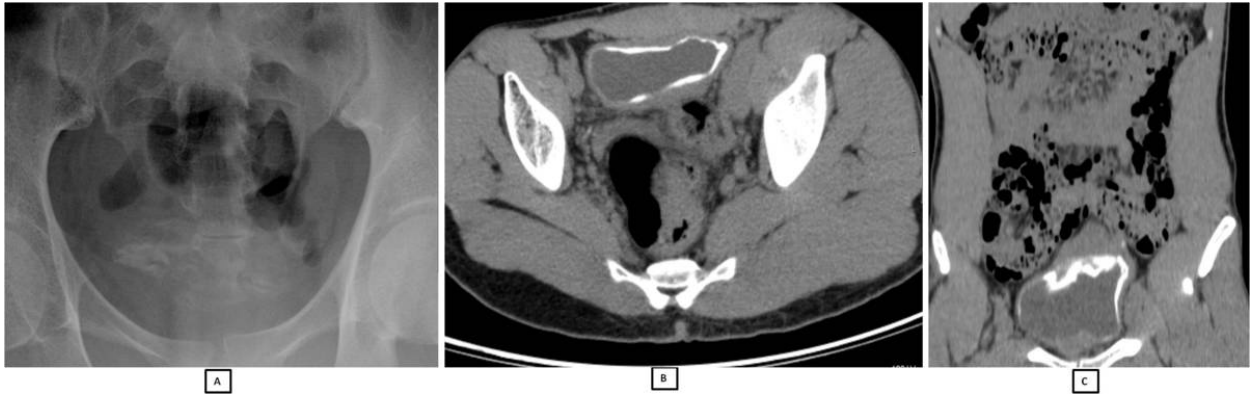


Fig. 19: Schistosomiasis. Plain radiograph (A) shows a heterogeneous calcification in the pelvic region. CT scans (B) (C) show a rim of calcification within the bladder wall as a sequel of a previous infection.



Fig. 20: Plain radiograph shows calcification of the prostate gland.



Fig. 21: Plain radiograph shows calcification of the seminal vesicles.

Conclusion

Urinary tract calcifications are very common. Usually they present with specific imaging characteristics on conventional radiology that suggest certain diagnoses. Nevertheless, correct interpretation of these findings is not an easy task and the use of other imaging modalities should be considered whenever necessary.

It is our role, as radiologists, to be aware of these findings in order to allow an adequate management of the patient.

Personal information

References

1. Dyer R.B. et al; Abnormal Calcifications in the Urinary Tract; Radiographics, 1998.
2. Dyer R.B. et al; Classical Signs in Uroradiology; Radiographics, October 2004.
3. Kawashima A. et al; CT of Renal Inflammatory Disease; Radiographics 1997.
4. Van Arsdalen, K.N.; Pathogenesis of Renal Calculi; Urologic Radiology, 1984.