Calyceal diverticula complicated by urolithiasis: Imaging appearance and radiological intervention

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Authors:  G. J. McNeill, H. Stunell, N. Campbell, R. Grainger, W. C. Torregianni; Dublin/IE
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Learning objectives

1. To describe and illustrate the typical imaging features of stone bearing calyceal divericulae across the spectrum of imaging modalities
2. To describe and illustrate the radiological procedures available for the treatment of symptomatic calyceal diverticula.

Background

Introduction

The term calyceal diverticulum or pyelocalyceal diverticulum refers to a urine-containing cystic cavity within the renal parenchyma. It is lined by transitional epithelium and surrounded by muscularis mucosae, communicating with the collecting system via a narrow isthmus or infundibulum [1].

It may be diagnosed as an incidental finding or may be symptomatic due to recurrent urinary tract infection (UTI) or stone formation within the diverticulum. Both of these are precipitated by urinary stasis within the diverticulum. Other common presenting features include ipsilateral flank pain and haematuria [2, 3, 4, 5].

The incidence is 2.1 - 4.5 per 1000 intravenous urogram (IVU) examinations [1]. Whilst the incidence of calyceal diverticuli is low, the incidence of stone formation within them is relatively high and occurs in up to 50% of cases [2, 6]. They occur with equal frequency in male and female patients and there is no predilection for left or right. They are bilateral in only 3% of cases [7].

Two types of calyceal diverticula have been described [1, 7]. Type I calyceal diverticula are the more common subtype and communicate with a minor calyx. These are more commonly located at the upper pole of the kidney [3]. Type II calyceal diverticula communicate with a major calyx or the renal pelvis itself and are much less common. These tend to be larger, are more commonly symptomatic and are often located at the mid-pole of the kidney.

The increasing use of cross sectional imaging, in particular computed tomography (CT) urography, has resulted in the increased detection of calyceal diverticula. The majority
of calyceal diverticula can however be diagnosed by ultrasound. IVU and retrograde studies can be required to confirm diagnosis. In some cases, the divericulum may be misdiagnosed as complex cyst or even a neoplasm. This is particularly so when the diverticulum contains calculi or large amounts of debris.

**Imaging findings OR Procedure details**

**Plain Radiography** on page 6

Plain abdominal radiographs may demonstrate the characteristic appearance of radiopaque milk of calcium which appears as a half moon or meniscus-shaped calcification which changes position in erect or lateral decubitus positions to be seen to lie dependently within the diverticulum [3, 5, 8]. Milk of calcium is a fine colloidal suspension of precipitated calcium crystals of varying size (primarily calcium carbonate crystals) [8, 9]. When present within the urinary tract, it is most commonly encountered in association with calyceal diverticula and is strongly associated with low grade inflammation and inadequate drainage of the diverticulum [8].

The presence of calculi lateral to a line drawn through the minor calyces is also suggestive of a diverticulum, however this is an inconsistent finding in a 3-dimensional structure. In addition, the presence of multiple small calculi clustered together is a typical finding (figure 1).

**Ultrasound** on page 6

Ultrasound is generally accepted as having several advantages over plain radiographs and IVUs in the diagnosis of calyceal diverticula [3, 8]. Up to 50% of calyceal diverticula contain calculi or milk of calcium. The identification of a cystic renal lesion in close proximity to the renal sinus with curvilinear, plaque-like calcification along its posterior wall should alert the sonographer to the potential presence of a stone-containing calyceal diverticulum (figure 2). Multiple small stones within a diverticulum become layered along its posterior wall when the patient is supine [3, 8, 10].

A calyceal diverticulum may often be misinterpreted as a complex cystic lesion on ultrasound if the sonographer is unfamiliar with their appearances. Therefore it is advocated that when echogenic material or posterior wall calcification is identified within a renal cystic lesion, the patient should be scanned in both the supine and prone position to determine whether mobile calculi are present within a calyceal diverticulum [8, 10].
The presence of mobile echogenic content strongly suggests the diagnosis of a calyceal diverticulum since complex renal cysts contain calcification in other non-mobile forms e.g. septal or mural calcification [11].

**IVU and retrograde**

Calyceal diverticula will become apparent at the time of IVU study on page 7 owing to their inherent connection with the collecting system. Delayed imaging on page 8 is thought to demonstrate the diverticulum to best effect as it fills retrogradely from its connection to the renal pelvis or calyx (Figure 3 & 4). Contrast should be seen to surround the stone and this completes the diagnostic picture. It has been our experience however that calyceal diverticula are poorly visualised on IVU, and retrograde pyelography has been necessary in a number of cases to definitively demonstrate the diverticulum and delineate the infundibulum (Figure 5).

Whilst the calyceal diverticulum may opacify at the time of IVU, the small communicating neck or infundibulum of the diverticulum is rarely visualised. The presence of a narrow and poorly draining neck is however expected and contributes to the process of stone formation. The failure to demonstrate the neck does not detract from the diagnosis.

**Retrograde pyelography** on page 10 is recognised as having a higher success rate in demonstrating the infundibulum and its communication with the renal collecting system [2] as it allows greater distension of the collecting system than can be attained with IVU (Figure 5).

**Computed Tomography**

Multislice CT with its ability to perform multiphase contrast-enhanced scans has led to increased diagnostic accuracy in the diagnosis of calyceal diverticulum. Multiplanar reformats can elegantly delineate the anatomy and the relationship of the diverticulum with the collecting system.

CT can be performed with either 5 or 10mm collimation at 5 to 10mm intervals through the renal parenchyma. Unenhanced, post-contrast and delayed phase imaging should be performed in all patients (figures 6 & 7).

**Non-contrast scans** on page 11 demonstrate heterogenous round lesions, containing high attenuation material of calcific density lying inferiorly within the cystic structure and fluid of water density. Following the administration of intravenous contrast on page 11t
an increase of approximately 20 hounsfield units occurs in the fluid in the upper part of
the cyst. Delayed imaging demonstrated opacification of the entire lesion with a similar
density to that of the collecting system, confirming the presence of a calyceal diverticulum.

Delayed imaging is of paramount importance as it demonstrates layering of contrast
medium within an apparent cystic mass containing luminal densities which is considered

As highlighted by Gayer et al [12], following intravenous contrast administration, there
is slight increase in density of the cystic lesion which may be mistakenly perceived
as "enhancement" of a cystic renal malignancy rather than early opacification of a
calyceal diverticulum if delayed imaging is not routinely performed. The key to the
correct identification of such lesions as calyceal diverticula lies in the recognition that the
apparent "enhancement" represents delayed filling of a calyceal diverticulum from the
collecting system rather than vascular supply to a cystic mass.

Magnetic resonance imaging on page 12

Whilst the role of conventional radiographic techniques such as contrast-enhanced CT
and retrograde pyelography in the diagnosis of calyceal diverticula is well established,
magnetic resonance imaging (MRI) may offer an alternative without ionising radiation.
Similar to reconstructed CT images, multiplanar MRI can delineate calyceal diverticulae
and their infundibulum.

The role of Interventional Radiology in Management

A number of treatment modalities exist for the management of calyceal diverticular
stones. These include extracorporeal shock wave lithotripsy (ESWL), endoscopic,
laparoscopic, open surgical as well as percutaneous procedures [7, 12]. PCNL has a
higher stone-free rate of 83% compared to 17% with ESWL and is an effective means
of treating calyceal diverticular stones regardless of large stone size or location of the
diverticulum [13].

Percutaneous treatment of symptomatic calyceal diverticular stones involves access
to the collecting system, stone removal, dilatation of the diverticular infundibulum,
fulguration of the diverticular cystic cavity and insertion of a nephrostomy tube [7].
The calyceal diverticulum is accessed using ultrasound, contrast is introduced into
the diverticulum to allow delineation of both the diverticulum as well as its connecting
infundibulum to the adjacent calyx (Figure 9) on page 13. A hydrophilic guidewire as
well as a steerable 4 or 5 French catheter is then introduced through a sheath allowing
access of the calyceal system of the kidney. A guide wire is passed into the bladder and
serial dilatation of both the tract into diverticulum as well as the infundibulum to a minimum of 24 French is performed (figure 10) on page 14. Following this a nephroscope is introduced into the diverticulum allowing stone extraction.

Images for this section:

**Fig. 1:** Magnified view of opacity in the right upper quadrant shows it to be made up of multiple small calculi, raising the suspicion of a stone bearing calyceal diverticulum.
Fig. 2: Longitudinal ultrasound of the right kidney with the patient supine demonstrates a cystic lesion at its upper pole with hyperechoic material lying dependently within it (arrow). The material demonstrates moderate posterior acoustic shadowing. Gravitational change was evident on scanning in the prone position (not shown).
Fig. 3: Twenty minute (figure 3) and post-micturition (figure 4) radiographs from an IVU study demonstrate contrast opacifying a lower pole calyceal diverticulum containing numerous calculi (arrow). Further opacification of the diverticulum is evident on the later film (arrow), highlighting the need for delayed images. Note that the infundibulum cannot be seen on either radiograph.
Fig. 4: Twenty minute (figure 3) and post-micturition (figure 4) radiographs from an IVU study demonstrate contrast opacifying a lower pole calyceal diverticulum containing numerous calculi (arrow). Further opacification of the diverticulum is evident on the later
film (arrow), highlighting the need for delayed images. Note that the infundibulum cannot be seen on either radiograph.
Fig. 5: Oblique radiograph from a retrograde pyelogram study elegantly depicts the short, narrow infundibulum of a calyceal diverticulum arising from a mid-pole calyx (arrow).

Fig. 6: Non-contrast CT of the kidneys (figure 6) and following intravenous contrast (figure 7). Non contrast CT demonstrates a cystic lesion at the upper pole of the left kidney with apparent mural calcification posteriorly (arrow). This may be mistaken for a complicated or indeterminate renal cystic lesion. However, following administration of intravenous contrast the low attenuation fluid within the cystic cavity when compared with the normally enhancing renal parenchyma confirms the presence of an upper pole calyceal diverticulum (arrow). Delayed imaging demonstrated layering of contrast material in the cavity of the diverticulum, confirming its connection to the collecting system (not shown).
Fig. 7: Non-contrast CT of the kidneys (figure 6) and following intravenous contrast (figure 7)). Non contrast CT demonstrates a cystic lesion at the upper pole of the left kidney with apparent mural calcification posteriorly (arrow). This may be mistaken for a complicated or indeterminate renal cystic lesion. However, following administration of intravenous contrast the low attenuation fluid within the cystic cavity when compared with the normally enhancing renal parenchyma confirms the presence of an upper pole calyceal diverticulum (arrow). Delayed imaging demonstrated layering of contrast material in the cavity of the diverticulum, confirming its connection to the collecting system (not shown).
Fig. 8: Transverse images from MR Urogram identifying a lower pole calyceal diverticulum on the left side. Multiple areas of low signal are identified within it, corresponding to calculi (arrow).
**Fig. 9:** Percutaneous tracking of stone-bearing calyceal diverticulum prior to nephrolithotomy. The calyceal diverticulum is accessed under ultrasound guidance. Contrast outlines the neck of the diverticulum (figure 9) and a guidewire and catheter is passed to the renal pelvis (figure 10). A wire is then passed to the bladder and then the tract is serially dilated.
**Fig. 10:** Percutaneous tracking of stone-bearing calyceal diverticulum prior to nephrolithotomy. The calyceal diverticulum is accessed under ultrasound guidance. Contrast outlines the neck of the diverticulum (figure 9) and a guidewire and catheter is passed to the renal pelvis (figure 10). A wire is then passed to the bladder and then the tract is serially dilated.
Conclusion

Calyceal diverticula containing calculi remain an uncommon urological condition, although when present are frequently symptomatic. It is important for both the uroradiologist as well as the general radiologist to be familiar with their appearances thus avoiding diagnostic uncertainty and unnecessary investigation for suspected complex renal cysts. A combination of imaging modalities may be necessary to reach a definitive diagnosis in difficult cases, although in most cases the diagnosis can be made by ultrasound. We have described and illustrated the imaging appearances of calyceal diverticula across the spectrum of imaging modalities.

Personal Information

Graeme McNeill

Department of Radiology
Adelaide and Meath Hospital incorporating the National Children's Hospital
Tallaght
Dublin 24

+353 (0)1 414 3700

pjmcneill@gmail.com

References


