Multimodality imaging of gallbladder adenomyomatosis

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Learning objectives

To describe and illustrate the imaging findings of gallbladder adenomyomatosis on ultrasound, computed tomography (CT) and magnetic resonance imaging (MRI), including MR cholangiopancreatography (MRCP).

Background

Adenomyomatosis of the gallbladder is a relatively common benign proliferative disease, found in up to 8.7% of cholecystectomy specimens (1). It is a benign cholecystosis, consisting of mucosal hyperplasia, thickening of the muscular wall and presence of small intramural diverticula (Rokitansky-Aschoff sinuses). Histologically the gallbladder wall is composed of four layers: mucosa, lamina propria, muscularis propria and serosa. The wall thickening found in adenomyomatosis relates to hyperplasia of the mucosa and muscularis layers. There is deposition of cholesterol crystals in the bile accumulated in the small Rokitansky-Aschoff sinuses, which is responsible for some of the typical imaging findings of adenomyomatosis.

Adenomyomatosis can be classified into three morphologic types, according to its diffuse, segmental or focal distribution (2). Diffuse adenomyomatosis manifests as diffuse wall thickening with luminal narrowing. In the segmental form there is circumferential thickening in the midportion of the gallbladder, with a characteristic hourglass morphology. Focal adenomyomatosis is the most common and it usually affects the gallbladder fundus, producing a crescentic or nodular wall thickening.

Although it is usually found in patients in their 50s, it affects patients with a wide age range. There are even some case reports of paediatric adenomyomatosis (3). It is most commonly found as an incidental finding in patients investigated for other conditions, as it is mostly asymptomatic. There is a frequent association with gallbladder stones, in 90% of cases (4).

On imaging studies it can sometimes be confused with cholecystitis if diffuse or gallbladder carcinoma in its focal or segmental form. Therefore, radiologists must be familiar with the characteristic imaging findings of adenomyomatosis in order to make an adequate differential diagnosis.

Imaging findings OR Procedure details
1. ULTRASOUND

Ultrasound is the primary imaging modality in the diagnosis of adenomyomatosis. There is usually a non-specific focal or diffuse thickening of the gallbladder wall. The distinctive feature of this condition is the presence of multiple hyperechogenic millimetric foci within the wall with characteristic "comet tail" reverberation artifacts, which are highly specific for adenomyomatosis (3). These relate to the presence of small cholesterol crystals within the bile accumulated in Rokitansky-Aschoff sinuses. Biliary sludge and intraluminal calculi can be found as associated findings.

Adenomyomatosis can present sonographically in the three distribution patterns mentioned previously:

- Diffuse adenomyomatosis presents as diffuse wall thickening with scattered hyperechogenic reverberating foci, sometimes with luminal narrowing (Fig 1).
- Segmental adenomyomatosis has the characteristic hourglass appearance with circumferential thickening in the midportion of the gallbladder with segmental luminal narrowing.
- Fundal adenomyomatosis, the most common pattern, can sometimes be mistaken for a gallbladder hypoechogenic mass. However, with careful analysis the characteristic hyperechogenic reverberating foci can be found in most cases, leading to the correct diagnosis (Fig 2). In this regard the use of higher frequency probes might be useful when the gallbladder fundus is located close the abdominal wall.

Main ultrasonographic differential diagnosis consists of cholecystitis and gallbladder neoplasm.

CHOLECYSTITIS

Diffuse wall thickening with stratification and without hyperechoic reverberating foci

Sometimes pericholecystic fluid

Pain with probe pressure on the gallbladder (Murphy sign equivalent)

Clinically presenting with right upper quadrant pain, fever and leucocytosis

GALLBLADDER NEOPLASM

Mass-like hypoechogenic lesion replacing the gallbladder (most common presentation)

Focal or diffuse irregular thickening of the gallbladder wall
Polypoid mass within the gallbladder lumen
Doppler intralesional signal may be found
Loss of normal wall layering
Absence of hyperechoic reverberating foci
Clinically presenting with right upper quadrant pain, anorexia and weight loss
More than 85% of cases occur in the 6\textsuperscript{th} decade or later (5)

2. COMPUTED TOMOGRAPHY

CT usually shows the gallbladder wall thickening but in most cases cannot demonstrate the small Rokitansky-Aschoff sinuses within the wall (Fig 3 and 4). There are however some characteristic morphologies which are suspicious for adenomyomatosis and should prompt the correlation with ultrasound for confirmation of this diagnosis: the presence of nodular thickening in the fundal region (adenomyomatosis \textit{fundica}) and the presence of circumferential thickening in the body with luminal narrowing, configuring the typical hourglass morphology (Fig 5).

If Rokitansky-Aschoff sinuses are large enough to be visualized the diagnosis is more straight-forward (Fig 6).

The main differential diagnosis on CT imaging is gallbladder neoplasm, as cholecystitis presents with a different clinical scenario and is usually evaluated primarily by ultrasound.

GALLBLADDER NEOPLASM

Hypodense or isodense mass in the gallbladder fossa, replacing the gallbladder (the most frequent presentation)
Irregular focal/ diffuse wall thickening
Asymmetrical thickening is more suspicious for neoplasm
Might present with liver and lymph nodes metastasis

3. MAGNETIC RESONANCE IMAGING
MRI also demonstrates gallbladder wall thickening and, unlike CT, exquisitely delineates the small Rokitansky-Aschoff sinuses as small intramural lesions hypointense on T1 and hyperintense on T2, producing the typical "pearl necklace" (2) or "string of beads" sign (4), which is the hallmark of adenomyomatosis in MRI (Fig 7-9). This sign is highly specific in distinguishing adenomyomatosis from gallbladder carcinoma, with a reported specificity of 92% (4).

These findings are especially prominent on MR cholangiopancreatography (MRCP), allowing a confident diagnosis of adenomyomatosis. Also, MRCP has been reported to visualize sinuses of smaller size (>3mm) compared with MRI and arterial phase CT (>5mm) (2).

Intraluminal calculi, if present, are visualized as small signal voids inside Rokitansky-Aschoff sinuses.

The non-visualization of Rokitansky-Aschoff sinuses on MRI, in the presence of gallbladder wall thickening, should raise the suspicion for gallbladder carcinoma. These however might not be visualized when they are of very small size (<3mm) or in the presence of impacted stones. There are also a few cases reporting the coexistence of adenomyomatosis and gallbladder carcinoma (2). However in the majority of these cases carcinoma was very small and confined to the mucosal layer, being diagnosed only microscopically.

The main differential diagnosis of adenomyomatosis in MRI, as already described, is gallbladder carcinoma.

GALLBLADDER CARCINOMA

Irregular mass replacing the gallbladder (most frequent presentation)

Might present as wall thickening or polypoid lesion

Wall thickening > 1cm or asymmetric highly suggestive of carcinoma (4)

Absence of the small hyperintense images in the wall

Liver metastases or adenopathy can be present

Images for this section:
**Fig. 1:** Ultrasound findings of diffuse adenomyomatosis in two different patients. Longitudinal ultrasound images show the characteristic small hyperechogenic foci with comet-tail reverberation artifacts in the anterior gallbladder wall.

**Fig. 2:** Ultrasound findings of focal adenomyomatosis in two different patients. On both longitudinal ultrasound images a localized thickening of the gallbladder wall in the fundal region can be seen, with the small hyperechogenic reverberating foci characteristic of this condition. Image on the right also shows the frequent association of adenomyomatosis and gallstones (between callipers).
**Fig. 3:** MDCT findings of focal adenomyomatosis. Axial oblique and sagital oblique MPR reconstructions demonstrate a nodular thickening of the gallbladder fundus. The small Rokitansky-Aschoff sinuses are not easily visualized. The fundal localization and regular thickening can suggest the diagnosis of adenomyomatosis, but correlation with ultrasound is necessary for confirmation.

**Fig. 4:** MDCT findings of segmental adenomyomatosis. Axial CT images and sagital oblique MPR reconstruction show a localized thickening near the fundal region, with luminal narrowing. There is an associated endoluminal gallstone. As in figure 3 the small Rokitansky-Aschoff sinuses are not visualized.
**Fig. 5:** MDCT findings of segmental adenomyomatosis. Axial oblique images show circumferential wall thickening in the midportion of the gallbladder with luminal narrowing. This is the typical morphology of segmental adenomyomatosis with the characteristic hourglass appearance. Small hypodense images can be seen in the thickened wall (arrow) suggesting the diagnosis.

**Fig. 6:** MDCT findings of focal adenomyomatosis. Axial CT images show a focal nodular thickening of the gallbladder fundus. Small hypodense images in the thickened wall (arrow) are clearly visualized, corresponding to Rokitansky-Aschoff sinuses sufficiently large to be visualized with CT, facilitating the diagnosis of focal adenomyomatosis of the gallbladder fundus.
Fig. 7: MRI findings of adenomyomatosis on T1 and T2 weighted sequences. T1 axial image shows a nodular hypointense nodular thickening at the gallbladder fundus, while T2 axial image depicts small hyperintense images in the thickened wall (arrow) confirming the diagnosis of focal adenomyomatosis of the gallbladder fundus.

Fig. 8: MRI findings of adenomyomatosis on T2 weighted sequences and MRCP, same patient as in figure 7. Axial and coronal T2 images show a localized thickening of the gallbladder fundus, with the characteristic small hyperintense images in the thickened wall (arrow), with the typical "pearl necklace" or "string of beads" sign. These findings are more prominent on MRCP images which outline the gallbladder luminal contents and the small Rokitansky-Aschoff sinuses filled with bile.
**Fig. 9:** MRI findings of fundal adenomyomatosis. Axial T2 and MRCP images show a localized wall thickening of the gallbladder fundus with multiple small hyperintense images in the thickened wall (arrow), configuring the "pearl necklace" or "string of beads" sign, the hallmark of adenomyomatosis on MRI.
Conclusion

Gallbladder adenomyomatosis has characteristic imaging findings, especially on ultrasound and MRI, which if recognized can allow the radiologist to make a confident diagnosis of this condition.

The recognition of the typical ultrasonographic findings of adenomyomatosis can allow the radiologist to reach the diagnosis with a simple procedure, avoiding further investigations with more complicated and expensive studies.

In cases that are not as straight-forward, MRI would be the most appropriate imaging technique. If the small Rokitansky-Aschoff sinuses are visualized in the thickened wall, producing the characteristic "pearl necklace" or "string of beads" sign, the diagnosis of adenomyomatosis can be made with a high degree of specificity.

In most cases CT cannot demonstrate the small Rokitansky-Aschoff sinuses and is therefore less specific than ultrasound and MRI.

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