Characterization of adrenal lesions on CT and MRI: all that a radiologist must know

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Learning objectives

Illustrate the radiological characteristics of a wide range of common diseases and frequently affecting the adrenal glands, using different imaging techniques, mainly CT and MRI.

Define key findings that may help characterize these lesions.

Emphasize pitfalls, diagnostic difficulties and differential diagnoses of the entities.

Propose a diagnostic algorithm in order to optimally manage the discovery of an adrenal
Background

The adrenal incidentalomas are common and diverse in nature. Imaging tools especially CT and MRI, allow a good characterization of most of these lesions, with very few cases where invasive diagnostic procedures are required for a definitive diagnosis.

Adrenal incidentalomas are largely dominated by adenomas. Imaging findings include benign tumors (adenoma, myelolipoma, cysts, hemangioma); malignant tumors (adrenal carcinoma, metastasis); adrenal hemorrhage and infections.

The radiologist' role is to identify the benign or malignant character of the adrenal lesion. Atypical adenomas are considered malignant. In CT, the diagnostic tree includes spontaneous densities and washout characteristics at 10 minutes. MRI is used as a second line to find the fat content.
Imaging findings OR Procedure details

1- Specific Imaging Features

1.1. Myelolipoma (fig 1, 2, 3)

A myelolipoma is a benign tumor composed of bone marrow elements. Myelolipomas do not produce hormones, and most are detected as incidental findings. Occasionally, large tumors or those undergoing tumor necrosis or spontaneous hemorrhage may cause flank pain.

Although most are adrenal in location, extraadrenal myelolipomas have been reported. Because of the large amount of mature fat, most myelolipomas are easily recognized on CT.

Calcifications are seen in up to 20% of the cases.

Occasionally myelolipomas have no recognizable fat, which precludes the diagnosis on imaging studies.

**On MR imaging**, myelolipomas are recognizable thanks to the proportion of fat and of bone marrow elements in the tumor.

Fat has high signal intensity on both T1- and T2-weighted sequences.

The bone marrow elements have a low signal intensity on T1-weighted images and moderate signal intensity on T2-weighted images.

Treatment: is almost conservative, because the diagnosis can usually be made with confidence using CT or MR imaging.

In some cases, distinguishing a large myelolipoma from a retroperitoneal sarcoma may not be possible, and biopsy or surgery may be needed for definitive diagnosis.

1.2. Cyst (fig 4,5,6,7,8,9)

Adrenal cysts are uncommon lesions, and few reports about their CT appearance can be found in the literature.

Adrenal cysts show a 3:1 female predilection.

Four types of cysts are recognized on the basis of pathologic classification: endothelial, epithelial, parasitic(hydatid), and posttraumatic pseudocysts.
CT finding: nonenhancing mass with or without wall calcification.

A small adrenal cyst with near-water attenuation and a thin (#3 mm) wall is likely to be benign.

The sonographic appearance of an adrenal pseudocyst can be complex, with multiple internal septations. CT is usually more useful to define the lesion and assess contrast enhancement.

1.3. Hemorrhage (fig 10, 11, 12)

Adrenal hemorrhage can be bilateral or unilateral.

When adrenal hemorrhage is bilateral, the cause is usually associated with anticoagulation therapy or a blood dyscrasia; less commonly, it is associated with the stress of surgery, sepsis, or hypotension; and rarely, it is caused by trauma.

Unilateral adrenal hemorrhage is usually caused by blunt abdominal trauma, adrenal vein thrombosis. It may occur into a preexisting neoplasm, necessitating surgical exploration if follow-up imaging does not show a nearly normal adrenal gland.

Acute or subacute adrenal hemorrhage typically has an unenhanced attenuation value of 50-90 H. Follow-up studies show diminution in size of the adrenal mass with a gradual decrease in the attenuation value.

The high attenuation value of a recent adrenal hemorrhage is usually readily apparent on unenhanced CT, but is indistinguishable from a solid adrenal neoplasm on contrast-enhanced CT.

Detection of an adrenal mass on contrast-enhanced CT after trauma is usually assumed to result from a hematoma, but an unrelated adrenal neoplasm can be excluded only by unenhanced CT or serial follow-up CT.

MR imaging, hemorrhage have a high signal intensity, which reflects the presence of methemoglobin, on T1-weighted images.

2- Nonspecific Imaging Features

2.1. Granulomatous Disease (fig 13, 14, 15)

Tuberculosis, histoplasmosis, and other granulomatous diseases are usually bilateral but often asymmetric.

CT findings are nonspecific and can include soft-tissue masses, cystic changes, calcifications, or a combination of these findings.
Although these adrenal lesions, which rarely occur unilaterally, are uncommon, they should be considered in the differential diagnosis of incidental bilateral adrenal masses in the absence of a primary neoplasm or coagulation abnormality.

Biopsy is needed to confirm the diagnosis and identify the responsible organism.

2.2. Hemangioma (fig 16, 17)

An adrenal hemangioma is a rare benign tumor. Hemangiosarcomas occur but are even less common.

Hemangiomas are composed of closely adjacent vascular channels lined with a single layer of endothelium.

It does not produce adrenal hormones, and most are large when found as an incidental finding.

On CT, hemangiomas are seen as large well-defined masses. They have a soft-tissue density on unenhanced images and exhibit inhomogeneous enhancement. Most hemangiomas are calcified, either from phleboliths in the tumor or from previous hemorrhage.

The MR findings: a hypointense appearance relative to the liver on T1-weighted sequences. Central hyperintensity may be seen because of hemorrhage.

On T2-weighted images, they are hyperintense.

Peripheral enhancement that persists on delayed images is characteristic.

They are usually removed because of the risk of hemorrhage and inability to exclude malignancy.

2.3. Adenoma (fig 18, 19)

An adenoma is the most common adrenal tumor.

Adenomas are reported to occur in from 1.4% to 8.7% of postmortem examinations, depending on the criteria used. The incidence is even higher among patients with hypertension or diabetes mellitus.

Adenomas large enough to be recognized on survey abdominal CT examinations are found in approximately 1% of patients, but may be increasingly detected as CT technology improves.

Nonhyperfunctioning adenomas elaborate adrenal cortical hormones the same as other functioning adrenal cortical tissue.
Thus, these lesions are seen to take up adrenal cortical labeling radionuclides.

On CT, adenomas may have the same density as normal adrenal tissue. Because most adenomas contain large amounts of intracytoplasmic lipid, many have a low density, often near that of water, on unenhanced examinations.

Calcification is rare.

Adenomas enhance after the IV administration of iodinated contrast medium. Although the degree of enhancement does not significantly differ from that of other adrenal tumors, adenomas show more rapid washout of contrast medium than adrenal metastases.

The MR signal characteristics of adenomas are also similar to those of normal adrenal tissue.

Although the signal intensity of an adenoma tends to be low on T2-weighted sequences, this finding is not useful for differentiating adenomas from metastases because the range of signal intensity of adenomas overlaps 20-30% with metastases.

2.4. Abcess (fig 20, 21, 22, 23)

They are typically encountered in the newborn as a complication of neonatal adrenal hemorrhage.
They are exceptional in adults and are secondary to hematogenous spread or infection of adrenal hematoma.

Diagnosis is suggested by an abnormal mass projected in the anatomical location of the adrenal gland, usually associated with a septic condition.

Ultrasound scan, CT scan and MRI are all helpful in describing the lesion.

Early images can be misleading as the abscess can mimic a renal or adrenal tumor, but imaging follow-up will demonstrate a rapid growth and liquefaction of the mass.

Percutaneous aspiration may be useful in establishing an accurate diagnosis and is essential for a conservative approach.

2.5. Lymphoma (fig 24, 25, 26)

Primary lymphoma of the adrenal glands is rare, but secondary involvement when other retroperitoneal lymphoma is present is seen more commonly among patients with non-Hodgkin's lymphoma than Hodgkin's disease.

Involvement is often bilateral and other retroperitoneal disease is usually present.

CT appearance: discrete masses (tumefactive) or of more diffuse involvement of the gland in which the shape of the gland may be maintained.
There may be extensive retroperitoneal tumor that engulfs the adrenal glands, making them difficult to identify.

The enhancement after the administration of intravascular contrast medium is less than that of the aorta or inferior vena cava.

On MR imaging, the signal intensity is lower than that of the liver on T1-weighted images. Lymphoma is typically heterogeneously hyperintense on T2-weighted sequences.

2.6. Metastases (fig 27)

The adrenal glands are a common site of metastatic disease, found in approximately 27% of the postmortem examinations of patients with malignant neoplasms of epithelial origin.

The most common neoplasms with adrenal metastases are carcinomas of the lung and breast and melanoma.

They can be unilateral or bilateral, small or large.

The CT and MR imaging features are nonspecific.

Small metastases are often homogeneous on contrast-enhanced CT or MR imaging, whereas large metastases often have local regions that appear heterogenous as a result of necrosis, hemorrhage, or both.

Calcification is rare in adrenal metastases.

Other: carcinoma, pheochromocytoma, neuroblastoma, ganglioneuroma….

3- Algorithm (fig 28)

ESSENTIALS

Almost all incidental adrenal lesions (IALs) in patients without a known primary cancer are benign.

Characterization of IALs in patients with cancer is essential to predict prognosis of the primary disease, to assess staging, and to direct therapy.

Almost all IALs can be characterized by using imaging alone, although some lesions will require percutaneous biopsy for definitive characterization.

Characterization depends on lesion morphology, perfusion differences between benign and malignant masses, the intracellular lipid concentration of the mass, and the metabolic activity of the mass.
CT contrast medium washout tests offer the highest test sensitivity and specificity for IAL characterization.
Right adrenal mass. The measurement of spontaneous density found a double component, a dominant negative density -60 (UH) and the other tissular (45 UH).

Fig. 1: fig

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Myelolipoma

Ultrasound: hyper echoic mass of the right adrenal lodge.

Fig. 2: fig

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Axial CT scan without contrast medium: right adrenal mass with a large fatty component (spontaneous density -67 UH).

Fig. 3: fig

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**HYDATID CYST**

Sonographic appearance:
anechoic multi-partitioned lesion.

**Fig. 4:** fig

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CT: hypodense homogeneous formation thin walled: adrenal hydatid cyst confirmed by serology and surgery.

Fig. 5: fig

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Pyogenic Abscess Or Adrenal Anthrax

MRI coronal T1-weighted injected: right adrenal cystic mass with hypointense center with peripheral enhancement.

Fig. 22: fig

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CT scan after two months of antibiotics:

Axial injected CT: net regression of right adrenal mass.

Fig. 23: fig

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Fig. 18: Adenoma

CT appearance

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Fig. 19: fig

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Fig. 24: Hypodense tissular bilateral adrenal mass, well limited and homogeneous, which should suggest: metastasis, tuberculosis, lymphoma, pheochromocytoma (10% of cases bilateral).
MRI: axial T2-weighted and coronal T1-weighted after injection of contrast medium; bilateral adrenal masses with discrete hypersignal T2 compared to the liver which enhances intensely after gadolinium injection due to an isolated adrenal lymphoma histologically proven.

Fig. 25: fig

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**Primitive Adrenal Lymphoma**

Bilateral well limited and homogeneous tissular adrenal mass, related to a primitive adrenal lymphoma.

**Fig. 26:** fig

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Metastasis

Axial injected CT: heterogeneous left adrenal mass with area of necrosis.
Metastasis of lung adenocarcinoma.

Fig. 27: fig

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Pyogenic Abscess Or Adrenal Anthrax

Axial CT with injection of contrast medium: right adrenal mass with central hypodensity and peripheral enhancement and thickening of the surrounding fat.

Fig. 20: fig

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CT appearance:
Spontaneously hyperdense appearance of the lesion.
Absence of enhancement after injection of contrast medium.
This aspect in a context of liver failure in a newborn should suggest adrenal liquefied hematoma.

Fig. 10: fig

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Fig. 11: fig

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Hemangiomas

CT without injection

CT later after injection

CT after early injection

Retroperitoneal heterogeneous mass displacing laterally and anteriorly the spleen and splenic vessels, and enhancing centripetally after IV injection of contrast medium. Spontaneously hypodense central areas corresponding to zones of fibrosis rather than necrosis as take contrast on sections realized later after injection of PDC.

Fig. 17: fig

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Fig. 16: fig

Abdominal ultrasound performed as part of a supervisory of breast neoplasia treated, in remission, in a woman of 55 years. Hyperechogenic retroperitoneal heterogeneous mass displacing at the bottom the left kidney.
CT scan at 18 months after treatment:

Bilateral adrenal atrophy with a discreet spontaneous hyperdensity in the right adrenal in favor of beginning calcification.

**Fig. 15:** fig

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CT Control after 6 months of treatment:

A significant regression mainly of left adrenal lesion

Fig. 14: fig

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Cystic Lymphangioma

Incidental finding in a woman aged 45, a large left adrenal mass. **CT without injection of contrast medium**: liquid formation of the left adrenal lodge. It is a surgically proven cystic lymphangioma.

Fig. 6: fig

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Simple Adrenal Cyst

Ultrasound: Transonore cystic formation, well defined with moderately thickened wall in the right adrenal.

Fig. 7: fig

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Hemorrhagic Adrenal Cyst

39 year old patient who presented with pain in the right flank.
Left adrenal cystic formation well limited by a thick wall and with hyperechoic heterogeneous content.
Hemorrhagic cyst, confirmed surgically.

Fig. 8: fig

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Cystic Neonatal Hematoma

A 4 months old baby has been admitted because of hepatic impairment.

**Ultrasound appearance:** Polylobed well defined liquid mass of the right adrenal lodge.

Fig. 9: fig

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Adrenal Tuberculosis

Both adrenals are heterogeneous with a spherical pseudotumoral appearance with low contrast enhancement.

The research of BK in sputum is positive, a biopsy was performed at the left adrenal lesion confirmed the diagnosis of adrenal tuberculosis.

Fig. 13: fig

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**Pyogenic Abscess Or Adrenal Anthrax**

**MRI:** axial T2-weighted: a heterogeneous hyperintense mass of the right adrenal lodge.

**Fig. 21:** fig

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Post Traumatic Hematoma

Peri-vesicular effusion and in the Morrison’s space associated with fat infiltration of the right para renal space with a limited spontaneously hyperdense zone the right adrenal lodge diffusing in hepato renal.

Fig. 12: fig

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Fig. 28: Algorithm

© Incidental Adrenal Lesions: Principles, Techniques, doi: 10.1148/radiol.2493070976 December 2008 Radiology, 249, 756-775. and Algorithms for Imaging Characterization Giles W. L. Boland, MD, Michael A. Blake, MD, Peter F. Hahn, MD, PhD and William W. Mayo-Smith, MD,
Conclusion

A wide spectrum of diseases can affect the adrenal gland (benign or malignant tumor, infections ...)

CT and MRI have contributed to the recognition and in the characterization of most disease processes affecting the adrenal glands.

A systematic approach with a diagnostic algorithm allows a proper management of these adrenal lesions.
References

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