Imaging of the Adrenal Gland Lesions

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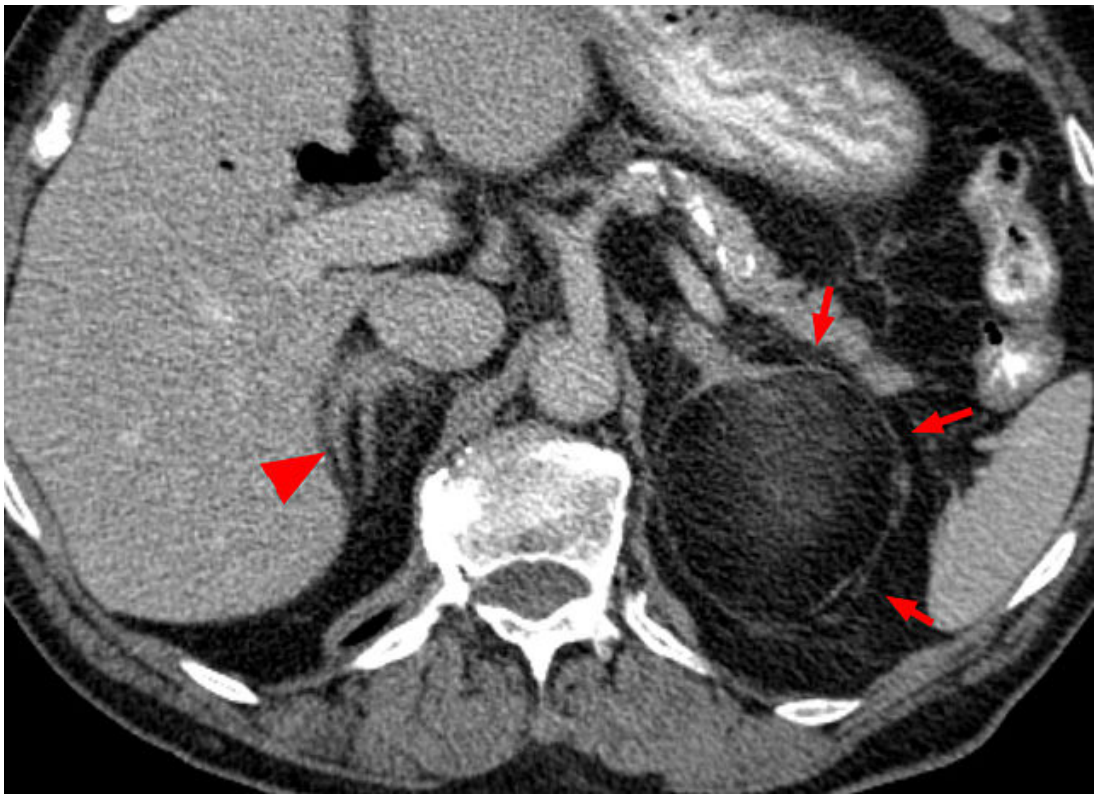
Several benign or malignant lesions can affect the adrenal glands. These abnormalities include benign adenomas, other benign tumors, malignant tumors, hemorrhage, metastasis, and adrenal gland hyperplasia. The finding of an adrenal gland lesion might be incidental in many cases, i.e., an incidental adrenal adenoma on an abdominal computed tomography scan ordered for an unrelated issue. The diagnosis of a mass as an 'adrenal incidentaloma' has become increasingly problematic leading to a shift in terminology by radiologists. Thus, modern-day adrenal masses are only classified as benign, malignant or indeterminate depending on various features. Most adrenal lesions are benign adenomas. However, malignancy must be ruled out via various imaging modalities such as CT scan, PET scan, and MRI.



Background on Imaging of the Adrenal Gland Lesions

The main imaging modalities used in the evaluation of the adrenal glands are:

- non-enhanced computed tomography
- contrast-enhanced computed tomography
- non-enhanced magnetic resonance imaging

- gadolinium-enhanced magnetic resonance imaging

Each modality has its own advantages and disadvantages:

1. The usual approach is to start with a non-enhanced computed tomography scan of the abdomen.
2. Following is an intravenous contrast-enhanced computed tomography scan.
3. If the symptoms and radiographic findings suggest a lesion that is better visualized by magnetic resonance imaging, then this is going to be the next step in the diagnostic workup of the patient.

The second goal of adrenal gland imaging is to **differentiate between benign and malignant lesions**. Certain radiographic features—such as the presence of lipid, intralesional fat, water or blood—might indicate a benign lesion. A very high-lipid content lesion that is well-circumscribed, for example, is most likely an adrenal lipid-rich adenoma.

Computed Tomography in Adrenal Gland Abnormalities

Multidetector computed tomography

Multidetector computed tomography (**MDCT**) is the imaging modality of choice as **the first step** in the imaging diagnostic workup of an adrenal gland lesion. MDCT produces excellent images that can help in **understanding** the nature of the pathology, **differentiate** benign from malignant lesions, and **identify** the anatomical relationship of the lesion to adjacent structures.

Non-enhanced MDCT

Non-enhanced MDCT is excellent in visualizing fat, hemorrhage, and necrosis. The next step is to perform a contrast-enhanced MDCT to get more information about the perfusion pattern of the adrenal lesion.

Contrast-enhanced MDCT

The adrenal gland is very well perfused. Therefore, the venous phase enhancement patterns of adrenal adenomas and non-adenomas are very similar. To improve the ability of contrast-enhanced MDCT in the differentiation between adenomas and non-adenomas, one should obtain a delayed image series at 10–15 minutes. The **absolute percentage washout and relative percentage washout are two important parameters** that can be obtained from this image series. These two parameters are used to **increase one’s certainty** that the lesion is indeed a benign adrenal adenoma.

Multiphase CT using an initial contrast-enhanced scan followed by a delayed scan at 10-15 minutes is performed and relative percentage washout (RPW) is calculated.

Histogram

Histogram analysis is also used to calculate the negative-attenuation pixels within the region of interest, i.e., the lesion. Adenomas usually have more than 10 % negative attenuation pixels on unenhanced images.

Magnetic Resonance Imaging in Adrenal Gland Abnormalities

Magnetic resonance imaging (**MRI**) is an excellent tool in the **visualization of soft-tissue abnormalities and lesions including adrenal gland lesions**. Lipid visualization with MRI is excellent.

MRI images of adrenal adenomas and myelolipomas show a dark lesion that is hypo-intense. On the other hand, malignant adrenal lesions do not show any signal loss on out-of-phase images.

Benign Adrenal Lesions

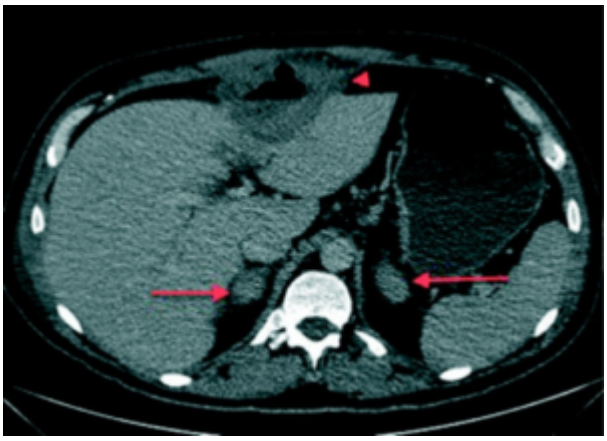


Image: “Axial view of CT adrenals revealing hemorrhagic adrenal glands (arrows) and drained abscess (arrowhead)” by Gowda, D. et al. License: CC BY 3.0

The most common benign adrenal lesions are:

- Adrenal adenomas
- Myelolipomas
- Cysts
- Pseudocysts
- Schwannomas
- Hemangiomas
- Ganglioneuromas
- Infections

$$RPW = \frac{(\text{Enhanced HU} - \text{Delayed HU})}{\text{Enhanced HU}} \times 100$$

- Adrenal gland hemorrhage.

The imaging features of each lesion and the imaging modality of choice for the confirmation of the diagnosis are discussed below.

Adrenal Gland Adenoma

These lesions are usually **asymptomatic** and are **identified by chance**, hence the name incidentalomas. In some patients, the adrenal gland adenoma can be functional and can produce aldosterone, cortisone or androgens. The lesions are usually small in size (less than 3 cm in diameter), have well-defined borders and are ovoid in shape.

MDCT

MDCT scans of an adrenal gland adenoma show a lesion with hypo-attenuation due to the **presence of fat**. In a small number of patients, the adenoma might be poor in lipid and can resemble a malignant lesion.

MDCT scans with a delayed image series usually show an absolute percentage washout of more than 60 % and a relative percentage washout of more than 40 %. This is very characteristic of adenomas and can be used to differentiate them from other adrenal gland lesions.

Histogram

A **histogram** analysis is also useful in differentiating adenomas from non-adenomas based on the presence of more than 10 % of negative attenuation pixels in the former.

Adrenal Gland Myelolipoma

MDCT

Myelolipomas are also **found incidentally**. The fat content of myelolipomas is much higher compared to adenomas, therefore their negative attenuation on **MDCT is much stronger**.

Contrast-enhanced CT scans

Contrast-enhanced CT scans of an adrenal myelolipoma show strong enhancement due to the presence of a highly vascularized myeloid component. MRI shows a significant signal loss on frequency-selected fat-saturated T2-weighted images.

Image: “Myelolipom rechts CT axial” by Hellerhoff. License: CC BY-SA 3.0

Adrenal Gland Cysts

Adrenal gland cysts are **rare**. They are also **found incidentally** and are usually **asymptomatic**. The cyst can be epithelial in etiology, caused by a parasitic infection “a hydatid cyst,” a pseudocyst, a hemangioma or a lymphangioma.

MDCT and MRI

MDCT scans show a well-defined non-enhancing lesion that is filled with water. **MRI** shows a hypointense lesion on T1-weighted images and a very hyperintense lesion on T2-weighted images. Hemorrhage within the cyst presents with variable heterogenicity on T1- and T2-weighted images.

Adrenal Gland Pseudocysts

Sometimes, a cystic lesion **develops within the adrenal gland that is surrounded by a fibrous wall without an epithelial or endothelial lining**. The etiology of adrenal gland pseudocysts is unknown. The most common risk factors of an adrenal gland pseudocyst are a previous adrenal gland hemorrhage or adrenal gland infection. **MRI** shows a septate cystic lesion with blood components.

Adrenal Gland Hemangioma

Adrenal gland hemangiomas are usually **asymptomatic and nonfunctional**. They are more common in people aged between 50–70 years of age and are more usual in men. Peripheral cavitation is seen in most biopsies, whereas central hemorrhage, necrosis, calcification, and fibrosis are the typical histopathological findings. Radiographic evaluation of such lesions can only raise suspicion but is not confirmatory, therefore the diagnosis **can be confirmed only post-operatively and with histopathological examination**.

MDCT

Contrast-enhanced MDCT shows a heterogenous centripetal lesion. Non-enhanced CT scans typically reveal a hypo-attenuating lesion that can range in size from few cubic centimeters up to 25 cm^3. Central lesion calcifications are more common with larger lesions.

MRI

T1-weighted MRI shows a heterogeneous lesion with peripheral hypo-intensity and possibly central hyperintensity. T2-weighted MRI images show a very hyperintense lesion. Hemangiomas show post-contrast enhancement after contrast administration on CT and MRI.

Adrenal Gland Schwannoma

These are **benign tumors of the nerve sheath that arise from Schwann cells**. They arise from the Schwann cells from the phrenic, vagus nerves or sympathetic trunk innervating the adrenal glands.

MDCT and MRI

MDCT shows a well-circumscribed homogenous mass. MRI T1-weighted images show a homogenous hypointense lesion, whereas T2-weighted images show a heterogenous hyperintense lesion. **Contrast-enhancement does not provide useful information in confirming the diagnosis**.

Adrenal Gland Ganglioneuroma

These **benign tumors** can grow large in size but are usually **asymptomatic**. They can be easily visualized on **MDCT** and are usually in close relation to the major blood vessels.

Image: “Hepatic cytolysis revealing adrenal ganglioneuroma” by Baïzri, H. et al. License: CC BY 2.0

Adrenal Gland Infections

The most common organisms known to cause an infectious focus within the adrenal gland lead to **histoplasmosis, tuberculosis and blastomycosis**. These infections can result in adrenal gland insufficiency.

The most common finding on imaging studies is non-specific bilateral gland enlargement. **MDCT confirms** bilateral adrenal gland enlargement but also shows multiple areas of necrosis and very small dot-like calcifications. The clinical picture combined with these radiographic features is usually sufficient to confirm the diagnosis.

Malignant Adrenal Lesions

The most common malignant adrenal lesions are:

- Metastases
- Adrenocortical carcinoma
- Pheochromocytoma
- Lymphoma
- Neuroblastoma

Adrenocortical Carcinoma

These are **rare tumors** that can be **functional or non-functional**. Functional adrenocortical carcinomas are more common in females, whereas non-functional carcinomas are more commonly seen in men.

CT

On **CT**, adrenocortical carcinoma appears as a large, solid, irregularly shaped lesion with necrosis, calcifications and hemorrhage. They have a heterogeneous density and can show evidence of vascular invasion of the major adjacent blood vessels.

Pheochromocytoma

These are **rare tumors arising from the chromaffin cells of the adrenal medulla**. They release catecholamines and are symptomatic. **The most commonly seen symptoms of pheochromocytoma are:**

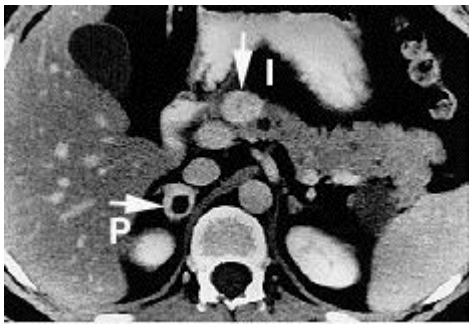


Image: “Pheochromocytoma” by Unknown.
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- Episodic hypertension
- Headache
- Anxiety
- Palpitations
- Tachycardia

CT and MRI

CT and MRI images of pheochromocytoma are **very characteristic and diagnostic**. Extremely strong contrast enhancement is a key feature on both modalities. Contrast-enhanced T2-weighted images show a marked hyperintense lesion that is known as a light bulb sign.
Intralesional hemorrhage, necrosis, and calcification is variable and should not be relied

upon to differentiate the lesion from other lesions. Additionally, the washout parameters previously described for adenomas are not useful with pheochromocytomas due to the high variability.

Adrenal Gland Lymphoma

Diffuse non-Hodgkin disease might involve the adrenal glands. **MDCT and MRI show evidence of bilateral soft tissue masses** that mildly enhance after contrast administration. The imaging findings are not specific. They are mainly tumors of older men and present with additional features of weight loss, abdominal pain and adrenal insufficiency.

Adrenal Gland Neuroblastoma

Adrenal gland neuroblastomas are the **second most common pediatric abdominal mass** after Wilms tumor. These are tumors arising from embryonal neural crest cells thus are found in the adrenal medulla. They can be found anywhere along the sympathetic chain. They are usually **asymptomatic** but can cause a non-specific paraneoplastic syndrome of flushing, tachycardia, and hypertension.

CT

CT shows a lobulated mass that can be homogenous or heterogeneous. Heterogenicity is increased when there is hemorrhage, necrosis or calcifications. Calcifications are present in up to 85 % of the patients.

MRI

T1-weighted MRI images show a heterogenous hypointense lesion whereas T2-weighted images show a hyperintense lesion. The lesion shows good enhancement after contrast administration on T2-weighted images.

Metastases to the Adrenal Gland

This is the second most common mass after adrenal adenoma, making up 50% of all adrenal masses. They are bilateral in 10-50% of the cases. The common tumors that metastasize to the adrenal gland are lung, breast, melanomas, rectal and thyroid tumors although almost any cancer can metastasize to the adrenal glands. The lesions are usually multiple, have irregular borders, show necrosis and hemorrhage. They vary is size and shape but are almost always larger than 4-6cm. **MRI** images show prolonged heterogeneous enhancement after contrast administration.

CT

Metastatic lesions typically show a slow washout rate, i.e., an absolute percentage washout below 60 % and a relative percentage washout below 40 % on delayed imaging with contrast-enhanced CT.

CT-guided percutaneous biopsy is the best tool to confirm the diagnosis and identify the nature of the malignant cells, which can be useful in narrowing down the most likely primary cancer.

References

Guerrisi A., Marin D., Baski M., Guerrisi P., Capozza F., and Catalano C. “Adrenal Lesions: Spectrum of Imaging Findings with Emphasis on Multi-Detector Computed Tomography and Magnetic Resonance Imaging.” *Journal of Clinical Imaging Science*. 2013;3:61. doi:10.4103/2156-7514.124088. Available at: http://www.clinicalimagingscience.org/article.asp?issn=2156-7514;year=2013;volume=3;issue=1;spage=61;epage=61;aulast=Guerrisi

Notes