Practical Approach to Adrenal Imaging

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KEYWORDS

• Adrenal • Adenoma • Pheochromocytoma • Adrenocortical carcinoma • Computed tomography • Magnetic resonance

KEY POINTS

- Noncontrast attenuation less than 10 Hounsfield units is most compatible with a lipid-rich adenoma.
- CT enhancement washout technique is the most sensitive and specific technique for evaluation of adrenal masses exhibiting an attenuation higher than 10 Hounsefield units on noncontrast CT.
- MR imaging is helpful in the setting of a heterogeneous mass or when there is contraindication of iodinated contrast medium (allergy or renal insufficiency).
- Adrenal adenoma is the most common adrenal mass containing intracytoplasmic lipid. Rarely, metastases can contain intracytoplasmic lipid, thus can mimic adenoma on MR imaging.
- Diffuse bilateral gland thickening with preserved adreniform configuration in patients with hypercortisolism is consistent with adrenal hyperplasia.

INTRODUCTION

The adrenal gland can be affected by a variety of pathologies, the majority of which are benign. Adrenal lesions tend to be encountered incidentally when performing imaging for other purposes. Diagnosis of adrenal masses can be challenging, but the imaging characteristics of morphologic and physiologic features can be used to appropriately guide the identification and management of adrenal lesions. This review describes an array of pathologic adrenal conditions discovered through imaging and illustrates their imaging characteristics with the implications for management.

IMAGING TECHNIQUES

Computed Tomography

Computed tomography (CT) is the imaging method most often used to detect and characterize adrenal masses. When an adrenal mass is found incidentally on imaging, a dedicated CT protocol is usually performed to further evaluate the mass. This is particularly true for patients with a history of malignancy. The adrenal mass protocol includes densitometry of the mass on noncontrast CT. Measuring the unenhanced attenuation value of an adrenal mass is crucial for accurate diagnosis of lipid-rich adenoma. An unenhanced attenuation value of less than 10 Hounsfield units (HU) is characteristic. If the mass fits this criterion, no further imaging is required.[1]

Adrenal masses with attenuation values of greater than 10 HU often have a unique contrast enhancement and washout pattern. Adenomas behave differently from other masses, enhancing rapidly after contrast administration and then rapidly washing out. Although most malignant lesions also enhance rapidly, they show a slower

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washout pattern owing to leaky capillaries.[2] The absolute percentage of enhancement washout is calculated by measuring the unenhanced value, the enhanced attenuation at 60 seconds, and enhancement 15 minutes after contrast injection and applying them in the following formula:

$$\frac{\text{Enhanced attenuation value} - \text{delayed attenuation value}}{\text{Enhanced attenuation value} - \text{unenhanced attenuation value}} \times 100$$

Absolute washout measurement requires an unenhanced HU measurement, which is not usually acquired in daily practice. Relative washout can be obtained as an alternative formula when noncontrast phase is not available. Relative enhancement washout is calculated as:

$$\frac{\text{Enhanced attenuation value} - \text{delayed attenuation value}}{\text{Enhanced attenuation value}} \times 100$$

Absolute washout threshold values of greater than or equal to 60% and relative washout threshold values of greater than or equal to 40% have been reported to be highly sensitive (88%–96%) and highly specific (96%–100%) for diagnosing adrenal adenomas (**Fig. 1**).[1,3,4]

Dual-energy computed tomography

Recent technologic advances in dual-energy CT permit nearly simultaneous acquisition of the targeted region at 2 different tube voltages (usually 80 and 140 kVp) during a single breath-hold acquisition. Using a 3-material decomposition algorithm, virtual unenhanced CT images can be reconstructed from contrast-enhanced CT images.[5,6]

Because adrenal lesions display different attenuations at different voltage settings, they are suited for characterization by dual-energy CT.[7] The use of virtual unenhanced images may permit characterization of some adrenal lesions as adenomas, which would be characterized as indeterminate if enhanced images were the only images available.[8]

Lower attenuation of an adrenal lesion at 80 kVp than at 140 kVp has been shown to be a highly specific sign of adrenal adenoma, the diagnostic equivalent of the presence of intracytoplasmic lipid. However, because some adenomas and adrenal metastases show higher attenuation at 80 kVp, the sensitivity of this test is low. Gupta and

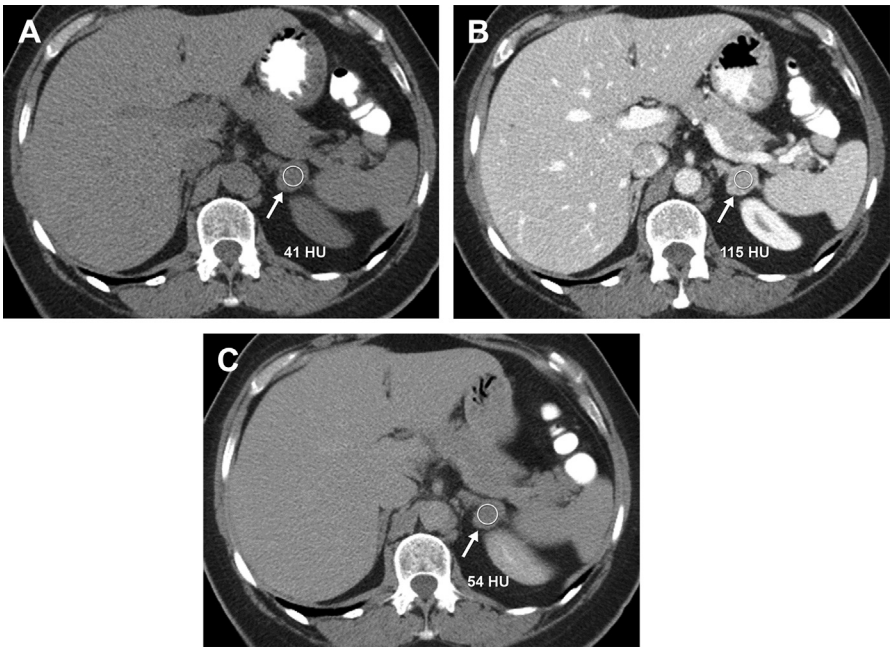

Fig. 1. Lipid-poor adrenal adenoma on computed tomography (CT). Axial nonenhanced CT (*A*), contrast-enhanced CT in venous phase (*B*), and delayed 15 minutes (*C*), demonstrate a well-circumscribed oval mass (*arrows*) involving the left adrenal gland with an attenuation value of 41, 115, and 54 Hounsfield units (HU) on noncontrast, venous, and delayed phase imaging, respectively, yielding an absolute enhancement washout of 82%, characteristic of a lipid-poor adenoma.