Imaging Algorithms for Adrenal Lesion Characterization

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The information below regarding the use of imaging to characterize adrenal masses, will benefit practicing radiologists in both the academic and private practice settings. The decision as to how to manage an incidentally detected adrenal mass is one we face every day, and in order to recommend the most appropriate imaging test for characterization, we need to be familiar with the various imaging techniques used for characterization of adrenal masses, as well as their advantages and limitations.

Adrenal masses are often incidentally discovered on routine contrast-enhanced CT studies. Our role as radiologists is to characterize these masses as benign or malignant, usually by performing another imaging test. Less commonly, patients present with signs of adrenal hyperfunction, and our role is to localize the source. If it is adrenal, we need to distinguish mass from hyperplasia, and characterize the mass as benign or malignant.

There is no single imaging test, either invasive or non-invasive, that can be used to characterize all types of adrenal pathology. Decades ago, MR imaging was thought to be the best imaging technique for characterization adrenal mass when all pheochromocytomas were thought to be "light-bulb bright" on T2-weighted imaging, and when opposed-phase/in-phase imaging was the most widely used technique for lipid detection within adrenal adenomas. Since then, several other imaging techniques have gained popularity and surpassed MRI for characterization of adrenal masses. These tests include unenhanced and enhanced CT for the characterization of lipid-rich and lipid-poor adrenal adenomas respectively, and FDG-PET for distinguishing benign from malignant adrenal masses. Despite all these developments, MRI remains a very effective method for characterizing adrenal masses, especially adenomas, and has the major advantage of lack of ionizing radiation and the need for intravenous contrast to characterize adrenal adenomas.

Our encounter, as radiologists, is mostly with the incidentally detected adrenal mass. Most of these are benign non-functioning adenomas and only a small proportion are non-adenomas that can be benign or malignant. The rate of malignancy in an incidentally detected adrenal mass, particularly metastasis, varies according to the study series and the presence and type of primary malignancy. In some series, the incidence of malignancy has been reported to be as high as 30%.

Adrenal masses are characterized on imaging by their lipid content, enhancement-washout characteristics, and metabolic features.

Adrenal adenomas are characterized primarily by their lipid content because 70% have abundant intracellular lipid. Both MR and CT lipid-sensitive techniques are extremely effective for characterization. Using a cut-off value of less than 10 Hounsfield Units (HU) on enhanced CT, lipid containing adrenal adenomas can be characterized with a sensitivity of 71% and a specificity of 98%. Using opposed phase

(OP) and in-phase (IP) MR imaging with cut-off signal intensity index (SII) value of 16.5-20%, the reported sensitivities range from 87% to 92%, and the specificity is 100%. The main advantages of MRI over CT is that it is more sensitive for the detection of small amounts of lipids and therefore, can better characterize lipid-poor adenomas that have unenhanced CT values of 10-30 HU with a sensitivity of 89% and specificity of 100%. Thus, unenhanced MRI using OP/IP technique for the detection of lipid can be used to characterize most adrenal adenomas measuring 1 cm or more without exposing the patient to ionizing radiation or intravenous contrast. Lesions smaller than 1 cm can be difficult to characterize on CT and MRI, due to their small size and partial volume averaging effects. For uniform adrenal masses measuring more than 30HU on unenhanced CT, enhanced CT with washout measurements is preferred to MRI as MRI has not been shown to be sensitive for the detection of minuscule amounts of lipid. The functional status of adrenal adenomas cannot be determined by imaging and biochemical tests are needed for this purpose.

Lipid distribution in adrenal adenomas is mostly homogeneous but can be heterogeneous in 14% of adenomas. Lipid can also be seen in adrenal cortical carcinomas. To ensure that a lesion with heterogeneous lipid is an adenoma and not carcinoma, follow-up imaging, PET-CT, or sometimes tissue sampling, should be considered. Lipid can also be seen in adrenal metastases from primary tumors that contain lipid, such as clear cell renal cell carcinoma and hepatocellular carcinoma. Therefore, in the presence of such primary tumors, a lipid containing adrenal mass can be difficult to characterize with certainty as an adrenal adenoma. Comparison with old studies, follow-up imaging, PET-CT, or tissue sampling can be used to better characterize such lesions. Degenerated adrenal adenomas and the rare collision tumor can be difficult to confidently characterize on imaging and may require tissue sampling for characterization.

Contrast enhancement and washout characteristics are better evaluated with CT than MRI but should only be used as the second-line imaging test if the lesion cannot be confidently characterized based on its lipid content.

Metabolic characteristics of adrenal masses can be used to characterize masses functioning masses such as pheochromocytoma. Biochemical testing and nuclear medicine tests, such as octereotide scan, are used for this purpose. A few recent papers have emerged using MR spectroscopy for assessment of the metabolic profile of adrenal masses, but the results are preliminary and need to be confirmed in larger studies.

We suggest that a homogeneous, non-functioning, adrenal mass measuring 1 cm or more that is incidentally detected on a routine enhanced CT study, especially in patients without history of malignancy, be characterized with MRI rather than CT, as most of these adenomas can be characterized with MRI based on their lipid content. Enhanced CT should be reserved for those masses that cannot be characterized with MRI. Heterogeneous masses can be difficult to reliably characterize with MRI or CT especially if prior imaging is not available, and biopsy or resection may be necessary for reliable characterization.