Characterization of small renal lesions: Problem solving with MRI

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With the widespread use of cross-sectional imaging, many renal masses are incidentally found. These need to be accurately characterized as either lesions potentially requiring surgery such as renal cell carcinoma or as nonsurgical lesions including cyst, angiomyolipoma, abscess, hematoma, lymphoma, or metastasis.

MRI and CT can both accurately characterize renal masses and frequently, both exams are complimentary to each other. Advantages of CT include a short imaging time, familiarity to referring clinicians, the ability to detect calcium and to quantify enhancement. The advantages of MRI include better intrinsic soft tissue contrast, primary multiplanar capability, lack of radiation exposure, and safer contrast material.

MRI is especially useful in those patients who require follow-up imaging studies and who would otherwise be exposed to additional radiation and iodinated contrast material during follow-up CT exams. This includes patients with indeterminate cystic masses, with a history of renal cell carcinoma, and with a genetic predisposition (Von Hippel-Lindau) to develop renal cell carcinoma.

The concepts of evaluating a renal mass with MR imaging are the same as those used in CT. An enhancing mass indicates a vascular mass, which is indicative of a neoplasm. A combination of T1-weighted images with and without fat saturation and T2-weighted images should be obtained prior to gadolinium administration. This is followed by fat suppressed T1-weighted images after gadolinium. Diffusion weighted imaging may also

be performed and there is early evidence that this may be helpful in characterizing renal masses. The capability of acquiring images and any plane helps demonstrate the relationship of a mass to its surrounding tissues, which aids the urologist at the time of surgery.

Enhancement of a renal mass may qualitatively be demonstrated by comparing images prior to and after gadolinium. By keeping these imaging parameters constant, it is often possible to appreciate enhancement of a renal mass. However, this may not be feasible when the mass is hypovascular or demonstrates hyperintense signal on precontrast T1-weighted images, usually secondary to hemorrhage. It is then necessary to utilize a subtraction algorithm to assess lesion enhancement.

Renal cysts demonstrate uniform hyperintense signal on T2-weighted sequences and may have variable signal intensity on T1-weighted sequences secondary to their contents. After gadolinium administration, enhancement is not observed and subtraction images will demonstrate uniform hypointense signal.

Renal cell carcinoma demonstrates variable signal intensity on T1-weighted and T2-weighted images. Therefore, the diagnosis of renal cell carcinoma rests on defining an enhancing renal mass that does not contain macroscopic fat. 3D fat suppressed T1-weighted GRE sequences performed before and after contrast material enables optimum demonstration of a neoplasm and its relationship to the surrounding kidney. After gadolinium administration, imaging can be performed during a corticomedullary phase which can give us qualitative information about the function of the kidneys and also produces an MR angiogram. This acquisition is also useful in identifying hypervascular tumors as well as pseudotumors including hypertrophied columns of Bertin. A second

acquisition occurs during the nephrographic phase of enhancement. This part of the examination is useful in identifying any enhancement of a renal mass. In addition, the renal venous anatomy and the possibility of venous invasion can be evaluated. If necessary, a final acquisition may be obtained during the excretory phase to help define the relationship of the neoplasm to the collecting system. After an enhancing renal mass is identified, it is necessary to stage the neoplasm. MRI can accurately demonstrate enlarged lymph nodes and vascular invasion.

Angiomyolipoma (renal hamartoma), a benign tumor, is composed of varying amounts of fat, smooth muscle, and blood vessels. They are uncommon lesions with a prevalence of 0.3% - 3% and occur more commonly in women than men. Angiomyolipomas occur in 2 different clinical scenarios. More commonly, they are sporadic (80%), however, they may be associated with tuberous sclerosis (20%) in which they tend to be multiple and bilateral. Patients are usually asymptomatic and angiomyolipomas are usually incidentally discovered when the patient is imaged for another reason. However, when large, angiomyolipomas may exert mass effect on the adjacent organs and cause symptoms. In addition, patients with large angiomyolipomas may present with acute flank pain caused by spontaneous hemorrhage. This may be life threatening and require emergent laparotomy.

Angiomyolipoma is the only renal tumor that may be characterized on the basis of its tissue composition and signal characteristics. The relative amounts of fat, smooth muscle and vessels within the tumor will establish its MR imaging appearance. The diagnosis of angiomyolipoma rests on demonstrating the presence of macroscopic fat within the lesion. When an angiomyolipoma is predominately composed of fatty tissue, it will

demonstrate hyperintense signal on the T1-weighted images. However, other renal masses including hemorrhagic cysts may also show similar signal characteristics. It is therefore imperative to compare the T1-weighted images obtained with frequency-selective fat-suppression to those obtained without fat-suppression, to establish the presence or absence of macroscopic fat. The use of frequency-selective fat-suppression is essential, as hemorrhage and other tissues with a short T1 will lose signal on inversion recovery pulse sequences and may be erroneously diagnosed as containing fat. Some angiomyolipomas contain only a tiny amount of macroscopic fat and therefore, a concerted effort should be made to identify even small amounts of fat. In rare instances these lesions may not contain any fat. In such cases, the diagnosis of angiomyolipoma cannot be made and the lesion is indistinguishable from a renal cell carcinoma.

Angiomyolipoma may also be diagnosed with the use of chemical shift imaging techniques. This technique provides images when fat and water signal are in phase (additive) or out of phase (destructive). This produces the characteristic India ink artifact on the T1-weighted out of phase images, manifested as a low signal intensity rim at any soft tissue (water) and fat interface. Both hemorrhagic cysts and angiomyolipomas are hyperintense on T1-weighted in phase images and may be indistinguishable from each other. However, they are readily differentiated on the T1-weighted out of phase images. For angiomyolipomas, the India ink artifact appears at the interface of the tumor (fat) with the kidney (water). For hemorrhagic cysts, the India ink artifact occurs at the interface of the cyst (fluid) and the perirenal fat (fat), not at the interface of the cyst and the kidney.

Caution should be used in diagnosing a renal mass as an angiomyolipoma if it loses signal on out of phase imaging, as clear cell carcinoma of the kidney may show identical findings. However, clear cell carcinoma does not contain bulk fat, and will not lose signal on a frequency-selective fat suppressed T1-weighted images.

Suggested Readings

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