MRI Characterization of Renal Lesions

Ivan Pedrosa M.D.
Chief of MRI
Associate Professor of Radiology and Advanced Imaging Research Center
University of Texas Southwestern Medical Center
Dallas, TX

The serendipitous discovery of renal cell carcinoma (RCC) is increasing with the proliferation of cross-sectional imaging studies (1). This discovery can lead to management quandaries as the natural history and growth rates of small incidentally detected renal masses are variable (2). Active surveillance approaches have been suggested to avoid unnecessary surgical and ablation procedures, especially in the elderly and infirm. Furthermore, the different histopathologic subtypes in RCC differ in their prognosis and biologic behavior (3, 4), as well as in their response to available therapies (5, 6). For example, patients with clear cell histology (ccRCC) may respond to immunotherapy with interferon as well as to treatment with tyrosine kinase inhibitors such as sunitinib, pazopanib, and sorafenib (6, 7). Cytoreductive nephrectomy is primarily indicated in ccRCC patients presenting with stage IV disease. However, these therapies are ineffective in papillary carcinoma although alternative therapy with temsirolimus has recently shown promising results (6). Thus, accurate preoperative diagnosis is important for the selection of the best treatment option both in patients with localized disease and those with metastatic disease.

MR imaging is a useful tool for the characterization of renal masses. In this talk, we will review an MRI imaging protocol for evaluation of renal masses using standard T1- and T2-weighted images (8). The advantages of 3D spoiled-gradient echo T1-weighted images over 2D approaches will be emphasized. Novel MRI techniques for assessment of renal masses, including non-contrast techniques like diffusion-weighted imaging (9, 10) and arterial spin labeling will be discussed (11). The MR imaging findings that allow for accurate characterization of malignant renal neoplasms and their distinction from non-neoplastic lesions and benign neoplasms will be presented.

Non-neoplastic lesions (e.g. complex cysts, hemorrhagic cysts) and benign neoplasms (e.g. angiomyolipoma, oncocytoma) can mimic renal cancer and their preoperative distinction is often challenging. We will discuss the MR imaging findings that are associated to these entities and that may facilitate their diagnosis, as well as review the use of MRI to select potential candidates for percutaneous biopsy to avoid an unnecessary surgical resection.

The correlation between the MRI appearance of renal masses, or MRI phenotype, and their histologic characterization will be discussed. The use of these MRI features may also be helpful to identify patients with masses more suitable for active surveillance. For

example, masses with homogeneous low signal intensity on T2-weighted images are less likely to grow when followed over time (12). In some other cases, the MRI phenotype may predict an aggressive behavior. For example, the infiltrative MRI phenotype in pRCC is a prognostic feature associated with higher likelihood of developing metastatic disease, independent of tumor type, grade, and stage (13). Large size, intratumoral necrosis, retroperitoneal vascular collaterals, and renal vein thrombosis on MRI predict more aggressive histology (i.e. high Fuhrman grade) in ccRCC (14). The sensitivity and specificity of a classification system based on MR phenotypes for diagnosing ccRCC and pRCC is 92% and 83%, and 80% and 94%, respectively. Detection of intratumoral lipids in a heterogeneous renal mass by chemical shift MRI is moderately sensitive (50%-82%) although highly specific (90%-97%) for characterizing ccRCC versus other histologic subtypes of RCC (14-16). Although this feature can also be seen in AMLs containing minimal fat, these lesions tend to exhibit homogeneous low signal intensity on T2-weighted images (17).

The most common subtypes of kidney cancer (clear cell, papillary, and chromophobe) demonstrate different patterns of enhancement when assessed with dynamic contrast enhanced MRI. These subtypes can be distinguished based upon the corticomedullary phase percentage enhancement. The use of a threshold value of 84% enhancement in the corticomedullary phase allows differentiation of clear cell and papillary renal cell carcinoma with sensitivity of 93% and specificity of 96% (18).

After confirming the presence of a renal tumor, accurate staging is important prior to developing a surgical or percutaneous ablation plan. Assessment of advance local disease, venous involvement, as well as lymph node and distant metastases is crucial in patient management. During this talk, we will review the staging of renal masses with MRI. The potential advantages of MRI over other imaging modalities and pitfalls in interpretation of the MR examinations will be reviewed.

References:

1.   Jayson M, Sanders H. Increased incidence of serendipitously discovered renal cell carcinoma. Urology. 1998;51(2):203-5.
2.   Volpe A, Panzarella T, Rendon RA, Haider MA, Kondylis FI, Jewett MA. The natural history of incidentally detected small renal masses. Cancer. 2004;100(4):738-45.
3.   Amin MB, Tamboli P, Javidan J, et al. Prognostic impact of histologic subtyping of adult renal epithelial neoplasms: an experience of 405 cases. Am J Surg Pathol. 2002;26(3):281-91.
4.   Bostwick DG, Murphy GP. Diagnosis and prognosis of renal cell carcinoma: highlights from an international consensus workshop. Semin Urol Oncol. 1998;16(1):46-52.
5.   Lam JS, Shvarts O, Leppert JT, Figlin RA, Belldegrun AS. Renal cell carcinoma 2005: new frontiers in staging, prognostication and targeted molecular therapy. The Journal of urology. 2005;173(6):1853-62.

6.   Schrader AJ, Olbert PJ, Hegele A, Varga Z, Hofmann R. Metastatic non-clear cell renal cell carcinoma: current therapeutic options. BJU Int. 2008;101(11):1343-5.

7.   Upton MP, Parker RA, Youmans A, McDermott DF, Atkins MB. Histologic predictors of renal cell carcinoma response to interleukin-2-based therapy. J Immunother. 2005;28(5):488-95.

8.   Zhang JB, Pedrosa I, Rofsky NM. MR techniques for renal imaging. Radiologic Clinics of North America. 2003;41(5):877-+.

9.   Taouli B, Thakur RK, Mannelli L, et al. Renal lesions: characterization with diffusion-weighted imaging versus contrast-enhanced MR imaging. Radiology. 2009;251(2):398-407.

10.   Zhang J, Tehrani YM, Wang L, Ishill NM, Schwartz LH, Hricak H. Renal masses: characterization with diffusion-weighted MR imaging--a preliminary experience. Radiology. 2008;247(2):458-64.

11.   Robson PM, Madhuranthakam AJ, Dai W, Pedrosa I, Rofsky NM, Alsop DC. Strategies for reducing respiratory motion artifacts in renal perfusion imaging with arterial spin labeling. Magn Reson Med. 2009;61(6):1374-87.

12.   Dodelzon K, Mussi TC, Babb JS, Taneja SS, Rosenkrantz AB. Prediction of growth rate of solid renal masses: utility of MR imaging features--preliminary experience. Radiology. 2012;262(3):884-93.

13.   Rosenkrantz AB, Sekhar A, Genega EM, et al. Prognostic implications of the magnetic resonance imaging appearance in papillary renal cell carcinoma. European Radiology. 2013;23(2):579-87.

14.   Pedrosa I, Chou MT, Ngo L, et al. MR classification of renal masses with pathologic correlation. European Radiology. 2008;18(2):365-75.

15.   Outwater EK, Bhatia M, Siegelman ES, Burke MA, Mitchell DG. Lipid in renal clear cell carcinoma: detection on opposed-phase gradient-echo MR images. Radiology. 1997;205(1):103-7.

16.   Yoshimitsu K, Honda H, Kuroiwa T, et al. MR detection of cytoplasmic fat in clear cell renal cell carcinoma utilizing chemical shift gradient-echo imaging. J Magn Reson Imaging. 1999;9(4):579-85.

17.   Hindman N, Ngo L, Genega EM, et al. Angiomyolipoma with minimal fat: can it be differentiated from clear cell renal cell carcinoma by using standard MR techniques? Radiology. 2012;265(2):468-77.

18.   Sun MRM, Ngo L, Genega EM, et al. Renal Cell Carcinoma: Dynamic Contrast-enhanced MR Imaging for Differentiation of Tumor Subtypes-Correlation with Pathologic Findings. Radiology. 2009;250(3):793-802.