

Cutting Edge in MR Imaging in Genitourinary Imaging

SY06-1

Small renal masses: How can we differentiate them with MRI

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Most of solid renal masses are malignant tumors, such as renal cell carcinoma (RCC). However, in small sized renal mass, malignant potential of mass is relatively low, approximately 20%. MRI has been used to differentiate and evaluate small renal masses. Angiomyolipoma (AML) is a representative benign renal tumor, and typically has gross fat, so can be easily diagnosed on CT and MRI. However, in the case of AML with minimal fat, it is difficult to differentiate it from RCC. MRI is a useful method for differentiating these renal tumors. The clear cell RCC on MRI is high signal intensity (SI) on T2WI and high T2 SI ratio (ratio of tumor to renal cortex on T2WI), typically. However, tumors that showed low signal intensity in T2WI or low T2 SI ratio (ratio of tumor to renal cortex on T2WI) include unusual clear cell RCC and papillary RCC (pRCC), AML with minimal fat. In these cases, the SI index ($[SI_{in} - SI_{opp}]/[SI_{opp}] \times 100$) may be helpful in differentiating pRCC from AML with minimal fat. In the study, pRCC has a lower SI index rather than AML with minimal fat, but, there are contradictory results in other study. In addition, there are also studies using ADC or area under contrast enhanced MRI curve as a method of differentiating AML and RCC. However, more research is needed to make an accurate diagnosis.

Keywords : Small renal mass, MRI, Kidney

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SY06-2

Multiparametric approach for uterinecervical cancer and endometrial cancer

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Of the variable malignancies in female reproductive organs, uterine endometrial cancer is the most prevalent disease in the developed countries. On the other hands, uterine cervical cancer is the second most common in the world and it is more prevalent in the developing countries. Although these tumors can be pathologically diagnoses by using gynecologic procedures, radiologic evaluation is important to determine the therapeutic plan.

Of the imaging methods, the role of magnetic resonance imaging (MRI) has been widely investigated in the field of gynecologic oncology. For endometrial cancer, MRI is the most valuable imaging for local staging. T2-weighted imaging (T2WI) is the fundamental MRI sequence because it provides anatomical detail with high soft tissue contrast. Dynamic contrast enhanced imaging (DCEI) is a valuable MRI technique in endometrial cancer due to its ability to differentiate tumor from normal hyperplastic endometrium. Furthermore, diffusion-weighted imaging (DWI) has been actively investigated for local staging of endometrial cancer. According to the guideline of International Federation of Gynecology and Obstetrics (FIGO), MRI is not mandatory for staging of cervical cancer. However, several studies have demonstrated the superiority of MRI in detection and localization of cervical cancer. Multiparametric MRI approaches including DCEI and DWI strengthen the utility of MRI in accurate detection and staging of cervical and endometrial cancers.

Recently, several studies reported the promising role of DCEI or DWI in predicting patients' prognosis by using the quantitative parameters at variable time points around treatment. The MRI parameters were associated with the degree of therapeutic response during concurrent chemoradiotherapy. Furthermore, some reports demonstrated the relationship between MRI parameters and known prognostic factors before or after surgery of cervical and endometrial cancer.

In conclusion, multiparametric MRI is the most valuable imaging technique for localization of uterine cervical and endometrial cancer. Furthermore, several parameters derived from multiparametric MRI have potential in predicting patients' prognosis after treatment of the gynecologic malignancies.

Keywords : Multiparametric MRI, Endometrial cancer, Cervical cancer

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SY06-3

Pre-biopsy MRI for prostate cancer: pros and cons

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Currently, prostate MRI is performed for staging work-up in patients who are diagnosed as cancer by TRUS-guided biopsy. Accordingly, post-biopsy hemorrhage is frequently seen on MR images and is the most common mimicker for tumor. It may hamper exact localization and staging of prostate cancer. To reduce the hemorrhagic effect, MRI is performed at least 3 weeks after biopsy. However, hemorrhage may be frequently shown more than 3 weeks after biopsy.

Pre-biopsy MRI is increasingly performed usually in patients who have repeat negative biopsy results and persistently high PSA. Theoretically, MRI prior to biopsy can depict cancer because of no hemorrhage. This imaging can provide exact tumor localization. As such, this MRI information helps to reduce the number of biopsy cores in these clinical settings.

Pre-biopsy MRI provides information on cancer grading with PIRADS. This MRI grading of prostate cancer is useful to determine whether or not there is significant cancer or which cancer is significant or insignificant. MRI-TRUS fusion or MRI-guided biopsy is possible to perform due to cancer detection with pre-biopsy MRI.

However, there has been no study for evaluating cost-effectiveness of pre-biopsy MRI. Further investigation is required to set up the indication and optimal protocols. This presentation is to discuss pros and cons of pre-biopsy MRI.

Keywords : Prostate, Cancer, MRI

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SY06-4

Gadolinium contrast agents and adverse effect: Too much attention or Too little

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Gadolinium-based contrast agents have been used for magnetic resonance imaging (MRI) examinations since the late 1980s with an excellent overall cumulative safety record. Initially favored for use in patients with renal impairment because of lack of significant nephrotoxic effect at clinical doses, in 2006, multiple reports convincingly linked the rare but serious disease nephrogenic systemic fibrosis to the administration of gadolinium based contrast agents in patients with severe renal failure. This in turn led to new policies on administration of these agents, resulting in changes in practice patterns that have virtually resulted in the elimination of the disease after the year 2009. In this lecture, we are going to summarize the factors that led to the emergence of nephrogenic systemic fibrosis, including the risk associated with different types of contrast agents based on their stability, and the changes in practice patterns and usage of gadolinium-based contrast agents in recent years that have been mainly driven by the discovery and association with nephrogenic systemic fibrosis. We will conclude with a brief overview of new emerging safety concerns that could further impact the use of this class of contrast agents and impact practice patterns in the future.

Keywords : Gadolinium, Adverse effect, Nephrogenic systemic fibrosis

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SY06-5

Hyperpolarized MR - Application in genitourinary imaging

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Hyperpolarized Carbon-13 (^{13}C) MRI has become an established technique enabling real-time in vivo observations of metabolism and perfusion using injected ^{13}C substrates. Using dynamic nuclear polarization (DNP) and rapid dissolution, polarization of ^{13}C substrates can be significantly enhanced and thus the signal sensitivity of ^{13}C can be increased by 10,000-fold or more compared with that of the thermal equilibrium state. When combined with the rapid acquisition of ^{13}C MRSI/MRI, the distribution of substrate and its metabolic products can be imaged.

One of the most widely used substrates for hyperpolarization is [$1\text{-}^{13}\text{C}$] pyruvate, which is converted to several downstream metabolites such as lactate, alanine, and bicarbonate. Measurement of the metabolic activities such as conversion rate constants and the ratio of substrates to downstream metabolites is commonly used as a marker for diagnosis or observation of treatment response for cancer in the brain, prostate, and liver. In particular, for prostate cancer, owing to its high rate of conversion from pyruvate to lactate, elevated hyperpolarized [$1\text{-}^{13}\text{C}$] lactate can be observed in cancer relative to surrounding benign tissues.

Metabolically inactive agents such as hyperpolarized ^{13}C urea can be used for angiography and perfusion imaging. In renal perfusion imaging, kidney blood flow can be quantified by using ^{13}C urea. Urea functions as a key osmolyte in the urinary concentrating mechanism of the inner medulla. The urea transporter UT-A1 is upregulated by antidiuretic hormone. In previous studies in rat kidney, more rapid inner medullary enhancement was observed in antidiuretic state compared with diuretic state by hyperpolarized ^{13}C urea imaging.

Keywords : Hyperpolarized ^{13}C MRI, Pyruvate, Prostate Cancer, Urea, Kidney

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SY06-6

Recent Development of Diffusion MRI

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Recent development of diffusion MRI in basic science

During past 10 years, there has been great number of developments in the area of contrast mechanisms in biological tissues. The most significant finding / agreement is that decrease of diffusion coefficient in the pathological tissues is mainly caused by restricted diffusion, rather than changes in diffusion coefficient itself. Simply stated, the reason of decreased ADC in the tumors is due to existence of small tumor cells, and ADC changes in the ischemic brain diseases is caused by changes in the cell shapes called beading. While the simple models can be explained well by these theoretical framework, actual tumor tissues in the clinical setups is much more complex, and advancement in the basic sciences has not transferred to the clinical practices yet. Following is some attempt to address some of clinical issues using recent knowledge. One group of techniques is based on the data taken with multiple b-values. Another group is based on two point data, with low and high b-value pair.

Non-gaussian diffusion

Without restricted diffusion, MRI signal strength decays linearly (in logarithmic scale) with b-value. However, in biological tissues, the relation between the b-value and the signal strength is no linear. This behavior is sometimes called "non-gaussian", because the PDF (probability density function) of simple diffusion has the form of gaussian distribution. By analyzing data taken with multiple b-values, it is possible to extract more information than just ADC (apparent diffusion coefficient).

One of the approaches that tries to extract more than just ADC is the technique called DKI. It started as a q-space based approach that estimates kurtosis of the PDF, but recently it is calculated by curve-fitting of the signal decay curve to polynomial. Interpretation of the result is somewhat ambiguous, but said to be related to "diffusional heterogeneity" (1).

Another approach is to consider that many different components exist within each voxel, each having different ADC values. It is not possible to actually measure the distribution of ADC values within each voxel, but when combined with appropriate modeling, it is possible to relate the distribution with the MRI signal decay. The distribution functions used for this model include truncated gaussian distribution and the gamma distribution (2, 3). The main advantage of this approach is that interpretation of the result is relatively straight forward, since ADC of each component can be related to cell size, amount of free water, or perfusion etc.

Scatter plot analysis

For 2 point (low and high b-values) diffusion data, the information contained within the data can be summarized to the signal intensity with low b-value, and the ADC. In other words, the essential information is the T2 and ADC of each voxel. This information can be visualized as a scatter plot with two axes, low-b and high-b image intensities. While this approach is informative, it is not suitable for everyday diagnostic process. For that purpose, a kind of subtraction technique was proposed called WDS (weighted diffusion subtraction) (4).

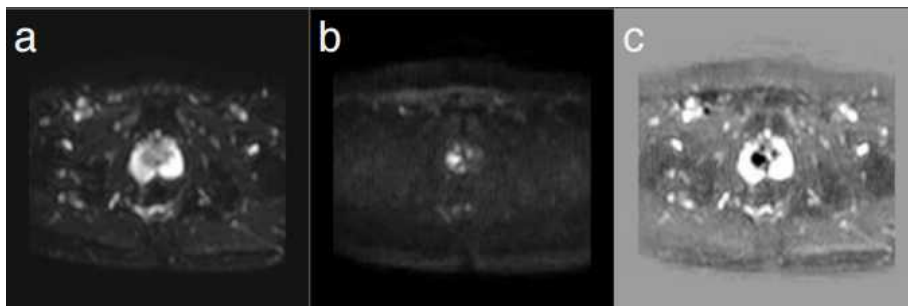


Fig 1.

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Legend : Weighted diffusion subtraction (WDS). (a) Low-b image, (b) high-b image, (c) WDS.

Keywords : Diffusion, Non-Gaussian, DKI, Statistical model