



MRI for Prostate Cancer

- MR imaging can be used for prostate cancer detection and is commonly recommended if cancer is suspected despite negative transrectal US and biopsy findings
- Optimal MR images are acquired with the combined use of an endorectal coil and a pelvic phase-array coil
- MR imaging is most effective for the detection of tumors in the peripheral zone
- MR imaging can detect extracapsular extension of tumors and seminal vesicle invasion
- Diffusion weighted MR imaging, MR spectroscopy, and dynamic MR imaging increase the sensitivity and specificity of prostate cancer detection
- Future MR applications include detection of lymph node metastases using a nanoparticle contrast agent

Prostate cancer accounts for twenty-five percent of all male cancers in the United States and it is estimated that there will be over 220,000 new cases in 2008 and almost 30,000 deaths from this disease. Because of the use of prostate specific antigen (PSA) testing, 91% of the new cases are detected when the disease is at a local or regional stage, when the 5-year survival rate is above 95%. However, the management of prostate cancer is challenging because the disease has variable clinical and pathologic behavior and there are a number of treatment options to choose from.

Most prostate cancers are diagnosed with the aid of transrectal ultrasound and ultrasound-guided biopsy. However, up to 40% of prostate cancers are isoechoic with the surrounding tissue, limiting their detection, and the finding of a hypoechoic area within the peripheral zone is not specific. Therefore, biopsy samples are obtained under ultrasound guidance from multiple sites within the prostate. Sampling errors are common and a single biopsy session has a sensitivity of 70-80% for the detection of cancer.

The role of CT in detection and staging of prostate cancer is limited because of poor soft tissue contrast. CT is only recommended when the patient's PSA level is >20 ng/ml, Gleason score >7, and/or clinical tumor stage is T3 or higher for the purpose of nodal staging. The criterion for positive nodal disease on CT is based on node size (>1 cm diameter) and nodal enlargement due to metastases occurs relatively late in the progression of prostate cancer.

The Role of MR Imaging

MR imaging is recommended for prostate cancer detection only in those cases where cancer is suspected despite negative transrectal ultrasound and biopsy.

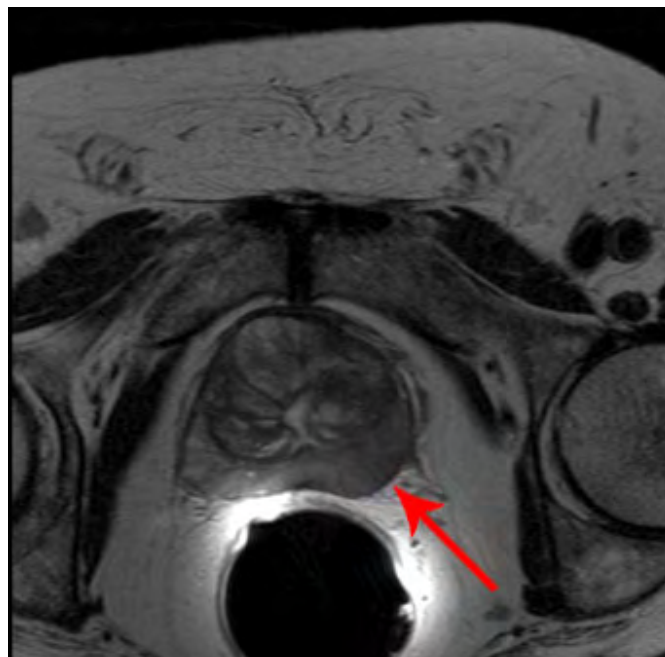


Figure 1. Axial thin section T2 weighted MRI shows low signal along the left peripheral zone (arrow). There is no evidence of extracapsular spread. Findings consistent with prostate cancer with no extracapsular extension.

Optimal MR imaging requires the use of an endorectal coil in conjunction with a phased array pelvic coil to obtain sub-millimeter resolution images, which are necessary for local staging. In T2-weighted images, tumors appear as low signal intensity areas (Figure 1), which are seen more readily in the peripheral zone because it normally has higher signal intensity than the transitional and central zones. The sensitivity of this method is estimated to be 85.3% with a positive

predictive value of 92.6% for tumors >1 cm but only 26.2% and 75.9% for tumors <1 cm. It is expected, but not yet proven, that imaging with a 3 Tesla scanner will allow better detection of cancers due to better image resolution.

MR imaging also permits the detection of extracapsular extension of tumors and involvement of the seminal vesicles (Figure 2). Extracapsular extension can be detected when there is asymmetry or envelopment of the neurovascular bundle, an irregular or spiculated margin, an angulated margin of the prostate gland, capsular retraction, a tumor-capsule interface >1 cm, or a breach of the capsule with evidence of tumor extension. Seminal vesicle involvement can be detected from the observation of disruption of the normal architecture of the seminal vesicle, low intensity regions within the seminal vesicle or ejaculatory ducts, obliteration of the angle between the prostate gland and seminal vesicle, or demonstration of direct tumor extension into and around the seminal vesicle.

Diffusion weighted imaging can increase the sensitivity of prostate tumor detection. Diffusion weighted imaging is a rapid MR imaging method that is sensitive to the random Brownian motion of water. The normal prostate gland has an extensive branching configuration that allows water to move more freely than it can through prostate cancers, where intercellular spaces are more restricted. Diffusion weighted images show high signal regions and images that map the apparent diffusion coefficient (ADC) show tumors as darker regions. In a small series, the sensitivity of tumor detection by an experienced reader increased from 50% to 73.2% and the positive predictive value from 65.7% to 74.8% when ADC maps were examined as well as T2 images.

Future uses of MRI

Another promising technique for the detection and evaluation of prostate tumors is MR spectroscopic imaging. Depending on their chemical composition, hydrogen nuclei respond to slightly different radiofrequencies, making it possible to identify a spectrum of responses from different chemical substances. In the prostate, the amount of citrate is relatively high, whereas tumors generally have high levels of choline. Measuring the ratio of these two entities in small regions of interest increases the sensitivity of detection, especially for less experienced readers. MR spectroscopic data is dependent on the Gleason scale, indicating that MR spectroscopic imaging makes it possible to assess tumor aggressiveness. However, this method is not routinely used because it is subject to motion artifacts and it is time consuming.

Dynamic contrast-enhanced MR imaging is another promising method for the diagnosis of prostate cancer. Like other tumors, prostate cancers induce angiogenesis and the development of vascular abnormalities. This results in more rapid uptake of contrast agent into the tumor as well as more rapid wash-out. However, the analysis of dynamic contrast



Figure 2. Sagittal T2 weighted MR image of the prostate with a prostate coil shows low signal mass involving the base of the seminal vesicles (arrow) consistent with invasion of the seminal vesicles.

images is not yet standardized and it is not yet clear whether relatively simple methods or complex mathematical models are best.

Finally, there is the promise of improved detection of lymph node metastases with the aid of a novel form of contrast agent, lymphotropic superparamagnetic nanoparticles. This method requires MR imaging on two consecutive days. On day 1, a baseline image is obtained in which the lymph nodes can be observed as regions of signal intensity relative to the surrounding tissue. After the first MR image has been acquired, the patient is injected with a bolus of the nanoparticle contrast agent. Macrophages avidly take up these nanoparticles and transport them to the lymph nodes. Twenty-four hours later, a second MR image is acquired. All normal lymph nodes appear darkened due to accumulation of the nanoparticle contrast agent, whereas metastatic tissue has high intensity. In the initial clinical trial of 80 men with prostate cancer, this agent had a positive predictive value of 95% and a negative predictive value of 97.8% for the detection of nodal metastases, significantly better than either CT or MR imaging and estimates of nodal size. In order to guide the surgeon in removing potentially malignant nodes and sparing normal ones, it is possible to create three-dimensional images that show the position of the nodes relative to anatomical landmarks (Figure 3), highlighting those that appear to harbor metastases. However, the FDA has not yet approved this agent and it remains as an investigational device.

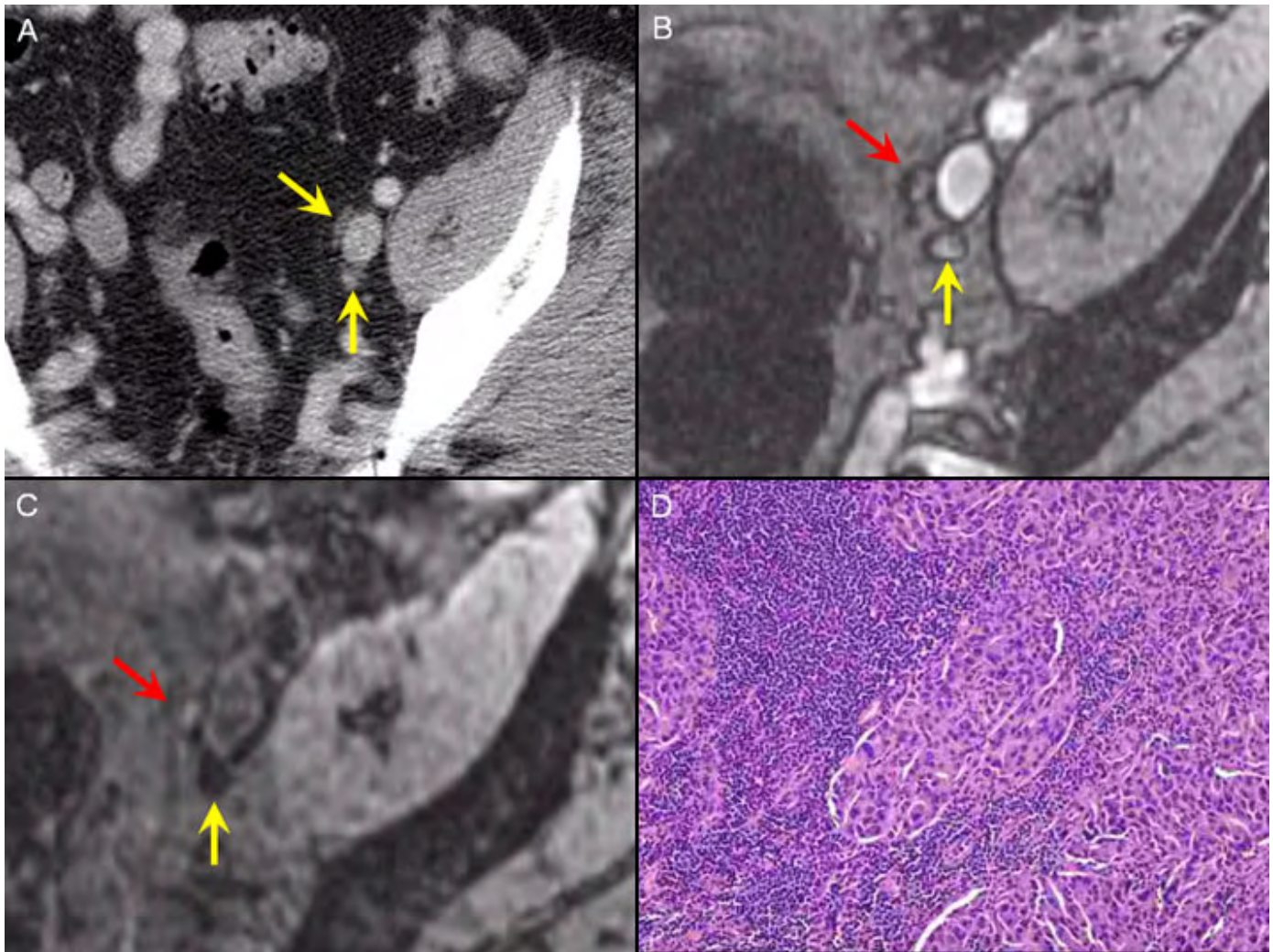


Figure 3 - Malignant lymph node in a patient with prostate cancer. **(A)** Axial contrast enhanced CT image shows two small external iliac lymph nodes (arrows) which do not meet size criterion for enlargement. **(B)** Conventional MRI at the level of the two nodes (arrows) with identical signal intensity. **(C)** MRI following nanoparticle showing decrease in signal in the normal (yellow arrow) but high signal in the metastatic node (red arrow). **(D)** Histopathology of the malignant lymph node showing sheaths of carcinoma cells.

Scheduling

MR imaging examinations are performed on the main MGH campus, Mass General West Imaging - Waltham, and Mass General Imaging - Chelsea. They may be scheduled online through Radiology Order Entry (ROE) (<http://mghroe>) or by calling 617-724-9729 (4-XRAY).

Further Information

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We would like to thank Mukesh Harisinghani, M.D., and Shahin Tabatabaei, M.D., Urology Unit, Massachusetts General Hospital for their assistance and advice for this issue.

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