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Seminar article

State-of-the-art imaging of prostate cancer

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Abstract

Prostate cancer is the most common cancer in men. Modern medical imaging is intimately involved in the diagnosis and management of prostate cancer. Ultrasound is primarily used to guide prostate biopsy to establish the diagnosis of prostate carcinoma. Prostate magnetic resonance imaging uses a multiparametric approach, including anatomic and functional imaging sequences. Multiparametric magnetic resonance imaging can be used for detection and localization of prostate cancer and to evaluate for disease recurrence. Computed tomography and scintigraphic imaging are primarily used to detect regional lymph node spread and distant metastases. Recent advancements in ultrasound, multiparametric magnetic resonance imaging, and scintigraphic imaging have the potential to change the way prostate cancer is diagnosed and managed. This article addresses the major imaging modalities involved in the evaluation of prostate cancer and updates the reader on the state of the art for each modality. Published by Elsevier Inc.

Keywords: Prostatic neoplasms; Radiology; Ultrasonography; Magnetic resonance imaging; Radionuclide imaging; Positron emission tomography

Introduction

Prostate cancer is the most common cancer in men. In 2014, approximately 233,000 men were diagnosed with prostate cancer and roughly 29,480 died from the disease [1]. Optimal management of prostate cancer requires accurate, safe, and timely diagnosis and staging. Modern medical imaging is intimately involved in the diagnosis and management of prostate cancer. Ultrasound (US) is primarily used to guide prostate biopsy to establish the diagnosis of prostate carcinoma. Multiparametric magnetic resonance imaging (mp-MRI) can aid in diagnosis and provide staging information. Computed tomography (CT) and scintigraphic imaging are used to detect metastases. This article addresses the major imaging modalities involved in the evaluation of prostate cancer and updates the reader on the state of the art for each modality.

Ultrasound

Transrectal ultrasonography (TRUS) is primarily used for biopsy guidance in patients with either a positive-result digital rectal examination or elevated prostate-specific antigen (PSA). The classic appearance of prostate cancer on TRUS is a hypoechoic lesion in the peripheral zone of the prostate gland with increased vascularity on color Doppler US (Fig. 1). Unfortunately, this classic pattern has a low specificity and sensitivity for the detection of prostate cancer for several reasons. First, only approximately 50% of hypoechoic lesions seen in the prostate gland on gray-scale US represent prostate cancer [2]. Many benign lesions such as hyperplasia, prostatitis, benign glandular ectasia, fibrosis, and cysts also present as a hypoechoic lesion in the prostate gland (Fig. 2). Second, up to 30% of prostate cancers are isoechoic on gray-scale US and not detectable. Third, benign conditions, such as infection and inflammation, may have increased vascularity on color Doppler US. And lastly, a high percentage of prostate cancers do not have increased vascularity on color Doppler US. Taken together, up to 60% of prostate cancers

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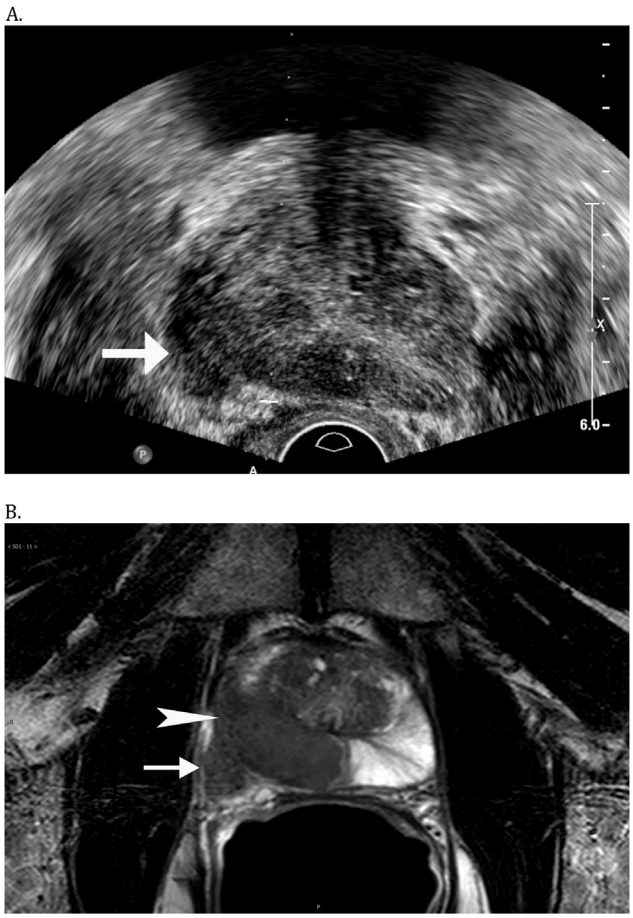

Fig. 1. A 74-year-old man with elevated PSA and positive digital rectal examination. (A) Gray-scale TRUS image showing a lobulated hypoechoic lesion in the posterolateral right peripheral zone (arrow). (B) Corresponding axial T2W image showing focal low T2W signal in the right peripheral zone compatible with prostate carcinoma (arrowhead). Extracapsular extension is evident (arrow). Images courtesy of Baris Turkbey, MD.

cannot be detected on gray-scale and color Doppler ultrasonography [3].

The inability to detect most prostate cancers with standard-gray-scale and color Doppler US has led to a true positive-result TRUS-guided biopsy rate of approximately 25% to 30%. Several new US techniques, including elastography, contrast-enhanced US (CEUS), and mp-MRI TRUS fusion biopsy, may improve the true positive-result biopsy rate in prostate cancer.

Elastography is a US technique that measures the stiffness of tissues. It has been shown that prostate cancer is often stiffer than normal prostate tissue [4]. It follows that elastography can, in theory, distinguish prostate cancer from normal prostatic tissue. There are 2 types of US elastography: static or strain elastography (SE) and shear-wave or transient elastography (SWE). SE is a US technique that qualitatively measures the relative stiffness of tissues within a given field of view (FOV); an absolute stiffness measurement cannot be obtained with this method. SE requires mechanical compression, most often accomplished by compression of the rectal wall by the TRUS transducer. As the measurement of SE is a relative one, a FOV that includes the entire prostate gland is necessary to detect prostate cancer. Measurements are displayed as a gray-scale or color-coded map. Studies have shown that SE has a positive predictive value of 57% to 87% and an negative predictive value (NPV) of 72% to 87% for the detection of prostate cancer [5]. Results have been mixed regarding improving biopsy guidance. SE has decreased sensitivity for the detection of prostate cancer in the transitional zone and anterior prostate compared with the posterior prostate [6].

SWE provides a quantitative measurement of the stiffness of a given tissue. The measurements are displayed as a color-coded map and quantitative measurements can be obtained. SWE has several advantages over SE. First, it is an absolute quantitative measurement, rather than a relative qualitative measurement. This is advantageous as it allows for the possibility of a cutoff value to be determined. Also, the entire prostate does not have to be in the FOV during scanning as the values determined are absolute, not relative. Second, mechanical compression is not required with SWE, improving reproducibility. In preliminary studies, SWE has

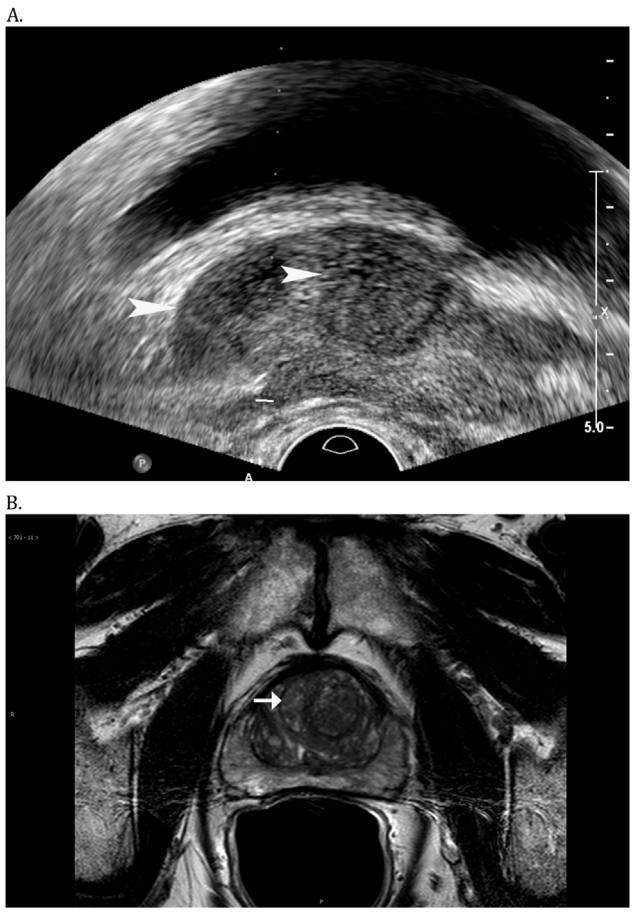

Fig. 2. A 64-year-old man with elevated PSA. (A) Gray-scale TRUS image showing multiple rounded hypoechoic lesions in the transitional zone (arrowheads). (B) Corresponding axial T2W image showing multiple well-defined nodules within an enlarged transitional zone compatible with benign prostatic hyperplasia (arrow). Images courtesy of Baris Turkbey, MD. (Color version of figure is available online.)