Imaging of the Male Pelvis

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Part I: MRI of Prostate Cancer*

Introduction

Prostate cancer continues to be the leading cancer among American men, with 184,500 new cases annually [1]. It has been estimated that 39,200 men died of prostate cancer in the U.S.A. in 1998. This makes prostate cancer the second cause of cancer-related death in men [2, 3]. Furthermore, the probability of developing prostate cancer from birth to death is 20% [3]. Treatment selection is dependent on patient age and health, cancer stage and grade, morbidity and mortality of treatment, as well as patient and physician preference. The mainstay for organ-confined disease is either radical surgery or curative radiotherapy [4, 5]. This is only considered an option in the absence of seminal vesicle infiltration (SVI), extension through the prostatic capsule (extracapsular extension, ECE) or metastatic disease. Therefore, the purpose of staging is the possible detection of extraprostatic disease. Clinical staging by digital rectal examination (DRE) and prostate specific antigen (PSA) remains as yet inaccurate. Imaging modalities such as transrectal ultrasound (TRUS) and magnetic resonance (MR) imaging can be used to increase staging accuracy. This review deals with the current possibilities and limitations of MR imaging in the staging of prostate cancer.

Clinical Staging Methods

Accurate staging of prostate cancer is important because treatment decisions are mainly based on the local extent of prostate cancer (ECE, SVI) and the presence of metastatic disease (lymphatic or hematogenous). DRE is not an accurate staging method, as there are no gross characteristics that are reliable to distinguish benign from malignant nodules [6]. Furthermore, the interobserver agreement among urologists for detection of prostate cancer by DRE is only fair [7]. Data accumulated from carefully examined prostatectomy specimens revealed that DRE underestimates the local extent of cancer in 40-60% of the cases [8, 9]. PSA is the most accurate marker to screen for prostate cancer, but has limited accuracy in staging because there is a substantial overlap in PSA concentrations and pathologic stages. Nevertheless, the combination of serum PSA concentration and other variables such as tumour grade, volume and clinical stage, significantly enhance the predictive value of serum PSA for the pathological stage [10, 11]. The probability of ECE, SVI and nodal involvement can be predicted by using the nomograms of Partin [10] that are based on clinical stage, Gleason score and serum prostate specific antigen (PSA).

MR Imaging

MR imaging of the prostate is still in an exploratory phase and is not yet advocated as a routine staging procedure. Prostate MR imaging should be performed in centers where at least 25-50 patients per year are examined and the results can be compared with histology, preferably whole mount specimen [12]. Currently, the major clinical indication for MR imaging is detection of ECE, SVI, nodal and bone marrow metastases, which are contraindications for radical prostatectomy [13]. Prostate cancer is usually visible as a low signal intensity lesion in a bright peripheral zone on a T2-weighted image (Fig. 1). The differential diagnosis of low signal intensity areas includes cancer, hemorrhage, prostatitis, effects of hormonal or radiation treatment, benign prostate hyperplasia (BPH), scar, calcifications, smooth muscle hyperplasia, and fibromuscular hyperplasia [14]. Hemorrhage, mostly a result from biopsy, can be differentiated from cancer by evaluation of T1-weighted images (Fig. 2). Hemorrhage is hyperintense on these images, whereas cancer has the same intensity compared to adjacent normal tissue. BPH, smooth muscle hyperplasia and fibromuscular hyperplasia are located mostly in the central zone (CZ) and transitional zone (TZ), whereas cancer is primarily located in the peripheral zone (PZ). Calcifications are common in all locations of the prostate; however, these may be differentiated from cancer based on their distinct oval form. Scars are rare. Detection of cancer in the CZ and TZ is generally not possible, as this area is commonly replaced by BPH, which has an identical signal.

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A review of existing literature revealed that an optimal imaging protocol includes turbo/fast spin echo, at least two imaging planes, high-resolution images, and the use of an endorectal phased array coil. Reading should (preferably) be performed in consensus, using experienced readers.

Staging

Several MR imaging criteria for ECE have been used. Table 1 presents commonly used criteria for ECE with its specificity and sensitivity. Most frequent used criteria are asymmetry of the neurovascular bundle, obliteration of the rectoprostatic angle, and bulging of the prostate capsule (Fig. 3). SVI is detected by an abnormal, asymmetric, low signal intensity within the lumen on T2-weighted images (Fig. 4) [15]. It should be noted that amyloid deposits, stones or blood could also cause low signal intensity of the seminal vesicles on T2-weighted images [14-17].

In staging, MR imaging should have a high specificity for periprostatic extension, to ensure that only few patients will be deprived of a potentially curative therapy [18]. Sensitivity for periprostatic extension is of minor importance, because even a low sensitivity is an improvement on clinical staging [18]. MR imaging is considered cost-effective if performed in a subgroup of patients with a prior-probability of ECE of at least 30%; that is, a PSA greater than 10 or a Gleason grade greater than 7 [19].

The initial accuracy in 1990 for the staging of prostate cancer with MR imaging was 69% [20]. Since then the most prominent change was the development of an endorectal coil (ERC), which resulted in faster imaging and improved spatial resolution. Accuracy for ECE with the ERC has a wide range, between 58-90% [21-24]. Several reasons for this wide range can be given. Firstly, due to the rapidly developing MR imaging technique, different studies used different imaging protocols. Secondly, due to inexperience with this new method, considerable interobserver variation may be present. A third important reason is that different studies use different criteria for ECE (Table 3) resulting in different accuracies. Although this variation remains, the use of an ERC is considered to be an improvement of the conventional MR examination [23-25]. Although major developments have changed the MR imaging technique, it is still not possible to detect microscopic ECE [20, 22, 26, 27]. The detection of SVI is generally not

Table 1. Criteria to predict extracapsular extension of prostate cancer

<table>
<thead>
<tr>
<th>Criteria for capsular penetration</th>
<th>Acc</th>
<th>Spec</th>
<th>Sens</th>
<th>PPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymmetry of neurovascular bundle</td>
<td>70%</td>
<td>95%</td>
<td>38%</td>
<td>–</td>
</tr>
<tr>
<td>Obliteration of rectoprostatic angle</td>
<td>71%</td>
<td>88%</td>
<td>50%</td>
<td>–</td>
</tr>
<tr>
<td>Bulge</td>
<td>72%</td>
<td>79%</td>
<td>46%</td>
<td>28%</td>
</tr>
<tr>
<td>Overall impression</td>
<td>71%</td>
<td>72%</td>
<td>68%</td>
<td>32%</td>
</tr>
<tr>
<td>Extracapsular tumor</td>
<td>73%</td>
<td>90%</td>
<td>15%</td>
<td>34%</td>
</tr>
</tbody>
</table>

Acc, accuracy; Spec, specificity; Sens, sensitivity; PPV, positive predictive value; –, no data available