Diffusion-Weighted Magnetic Resonance Imaging Detects Significant Prostate Cancer with High Probability

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Purpose: We prospectively assessed the diagnostic accuracy of diffusion-weighted magnetic resonance imaging for detecting significant prostate cancer.

Materials and Methods: We performed a prospective study of 111 consecutive men with prostate and/or bladder cancer who underwent 3 Tesla diffusion-weighted magnetic resonance imaging of the pelvis without an endorectal coil before radical prostatectomy (78) or cystoprostatectomy (33). Three independent readers blinded to clinical and pathological data assigned a prostate cancer suspicion grade based on qualitative imaging analysis. Final pathology results of prostates with and without cancer served as the reference standard. Primary outcomes were the sensitivity and specificity of diffusion-weighted magnetic resonance imaging for detecting significant prostate cancer with significance defined as a largest diameter of the index lesion of 1 cm or greater, extraprostatic extension, or Gleason score 7 or greater on final pathology assessment. Secondary outcomes were interreader agreement assessed by the Fleiss κ coefficient and image reading time.

Results: Of the 111 patients 93 had prostate cancer, which was significant in 80 and insignificant in 13, and 18 had no prostate cancer on final pathology results. The sensitivity and specificity of diffusion-weighted magnetic resonance imaging for detecting significant PCa was 89% to 91% and 77% to 81%, respectively, for the 3 readers. Interreader agreement was good (Fleiss κ 0.65 to 0.74). Median reading time was between 13 and 18 minutes.

Conclusions: Diffusion-weighted magnetic resonance imaging (3 Tesla) is a noninvasive technique that allows for the detection of significant prostate cancer with high probability without contrast medium or an endorectal coil, and with good interreader agreement and a short reading time. This technique should be further evaluated as a tool to stratify patients with prostate cancer for individualized treatment options.

Key Words: prostate; prostatic neoplasms; diagnosis, differential; magnetic resonance imaging; observer variation

Abbreviations and Acronyms

ADC = apparent diffusion coefficient
DCE = dynamic contrast-enhanced
DW = diffusion-weighted
GS = Gleason score
MR = magnetic resonance
MRI = MR imaging
PCa = prostate cancer
PSA = prostate specific antigen
RC = radical cystoprostatectomy
RP = radical prostatectomy

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Study received Kanton Bern regional ethics committee approval.

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Widespread serum PSA testing and transrectal ultrasound guided systematic prostate biopsy have resulted in a dramatic increase in PCa detection with most newly diagnosed tumors at low risk for progression.[1,2] Insignificant PCa is usually defined as any cancer with a volume of less than 0.5 cc, no extraprostatic extension and GS 7 in the RP specimen at

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final pathology evaluation.[3,4] Patients with insignificant PCa may benefit from expectant treatment, including active surveillance.[5,6]

Digital rectal examination and serum PSA have overall low specificity for detecting PCa and they do not accurately predict aggressive disease.[7] Systematic biopsy may show sampling error and the risk of under grading aggressive disease.[8]

Thus, it would be of the utmost importance to have a reliable, noninvasive diagnostic tool to discriminate tumors that require treatment from most tumors, which can be managed expectantly.[9] Recent publications suggest that functional MRI techniques, including DW-MRI, could represent such a tool due to their noninvasive nature and ability to detect the primary tumor in the prostate as well as pelvic lymph node and distant metastases when combined with anatomical MRI.[10–13]

The recent ESUR (European Society of Urogenital Radiology) guidelines on prostate MRI recommend that a structured scoring system such as PI-RADS (Prostate Imaging Reporting and Data System) be used for tumor detection and staging with multiparametric MRI, including T2-weighted imaging plus at least 2 functional MR techniques (DW-MRI, DCE-MRI and/or MR spectroscopy).[14] We hypothesized that a simpler scale based on qualitative image analysis of only 3 Tesla DW-MRI combined with T2-weighted sequences might allow for accurate detection of significant PCa without an endorectal coil. This approach would have the advantages of avoiding contrast medium, decreasing imaging time (including image analysis) and decreasing costs, thus, enabling large-scale dissemination of this technique with potential applicability in various scenarios of PCa diagnosis and management.

We prospectively investigated the diagnostic accuracy of DW-MRI at 3 Tesla using qualitative findings for detecting significant PCa. We also assessed interreader agreement.

PATIENTS AND METHODS

Patients

This prospective single center study was part of a larger prospective investigation of pelvic lymph node staging in patients with prostate and/or bladder cancer, as registered at ClinicalTrials.gov (NCT00622973) and previously published.[15,16] The study protocol was approved by the Kanton Bern regional ethics committee and performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from patients before study inclusion.

A total of 120 consecutive male patients with histologically proven PCa and/or muscle invasive bladder cancer who underwent open RP and/or RC with extended pelvic lymph node dissection were eligible for study. Nine men were excluded secondarily due to poor MRI quality, leaving 111 available for final analysis, including 78 and 33 treated with RP and RC, respectively. Including patients with PCa and/or bladder cancer with their RP or RC specimens as the reference standard allowed us to investigate DW-MRI in prostates with and without PCa.

Evaluation

Radiological. All patients underwent pelvic MRI on a 3 Tesla Trio scanner (Siemens Healthcare, Erlangen, Germany) using a combination of anterior body array matrix coil and posterior spine coil with an identical MR protocol a median of 9.5 days (range 1 to 50) before RP or RC. MRI included a coronal 3D T2-weighted sequence with 1 mm isotropic voxels, an axial high resolution T2-weighted sequence over the prostate and seminal vesicles, and an axial DW-MRI sequence with 3 b-values (0, 500 and 1,000 s/mm^2, respectively). To decrease bowel motion artifact 1 mg GlucaGen® was administered intravenously. Total acquisition time was 17 minutes. The supplementary Appendix (http://jurology.com/) lists other parameters.

All MR images were archived in a picture archiving and communication system (PACS R11.4.1, 2009, Philips, Best, The Netherlands). Three readers with 3, 5 and 8 years of experience each with body MRI, and less than 1, 1 and 2 years of experience each with prostate MRI performed independent readings of the 111 cases. The readers were aware that patients were scheduled for RP or RC but they were blinded to clinical and biopsy data, including cancer type.

DW images and ADC maps were used to qualitatively evaluate the prostate with T2-weighted high resolution axial, 1 mm coronal and 2 mm sagittal reconstructed images available for comparison as required. A 3-grade scoring system based on visual analysis of high b-value (1,000 s/mm^2) images and corresponding ADC maps was used to assign PCa suspicion grades. Readings were considered positive when we noted a single hyperintense lesion on high b-value DW-MRI that corresponded to a lesion on the ADC maps that was hypointense compared to surrounding prostatic tissue (see figure). This was defined as the index lesion. Readings were considered uncertain when no single focal lesion was detected on the high b-value image or the ADC map without correlation between the 2 images and without an obvious single index lesion. Readings were considered negative when no focal lesion was detected on high b-value images and the ADC map. Prostates with uncertain and negative readings were considered to show no PCa. For positive readings no distinction was made on qualitative image analysis between possibly significant vs insignificant disease.

Pathological. All RP and RC specimens were processed at the Institute of Pathology, University of Bern and evaluated by 2 experienced uropathologists blinded to clinical and radiological data.

Prostates were processed as previously described.[17] They were inked and fixed overnight in 4% neutral buffered formalin. The prostate apex and base were sliced parasagittally and embedded as perpendicular margins. The prostate itself was sliced serially in 3 to 4 mm sections perpendicular to the longitudinal axis and totally