The Diagnostic Performance of Multiparametric Magnetic Resonance Imaging to Detect Significant Prostate Cancer

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Abbreviations and Acronyms

DRE = digital rectal examination
mp = multiparametric
MRI = magnetic resonance imaging
NPV = negative predictive value
PC = prostate cancer
PI-RADS = Prostate Imaging Reporting and Data System
PPV = positive predictive value
PSA = prostate specific antigen
ROI = region of interest
RP = radical prostatectomy
T2WI = T2-weighted imaging
TRUS = transrectal ultrasound
TTMB = transperineal template mapping biopsy

Purpose: We assess the accuracy of multiparametric magnetic resonance imaging for significant prostate cancer detection before diagnostic biopsy in men with an abnormal prostate specific antigen/digital rectal examination.

Materials and Methods: A total of 388 men underwent multiparametric magnetic resonance imaging, including T2-weighted, diffusion weighted and dynamic contrast enhanced imaging before biopsy. Two radiologists used PI-RADS to allocate a score of 1 to 5 for suspicion of significant prostate cancer (Gleason 7 with more than 5% grade 4). PI-RADS 3 to 5 was considered positive. Transperineal template guided mapping biopsy of 18 regions (median 30 cores) was performed with additional manually directed cores from magnetic resonance imaging positive regions. The anatomical location, size and grade of individual cancer areas in the biopsy regions (18) as the primary outcome and in prostatectomy specimens (117) as the secondary outcome were correlated to the magnetic resonance imaging positive regions.

Results: Of the 388 men who were enrolled in the study 344 were analyzed. Multiparametric magnetic resonance imaging was positive in 77.0% of patients, 62.5% had prostate cancer and 41.6% had significant prostate cancer. The detection of significant prostate cancer by multiparametric magnetic resonance imaging had a sensitivity of 96%, specificity of 36%, negative predictive value of 92% and positive predictive value of 52%. Adding PI-RADS to the multivariate model, including prostate specific antigen, digital rectal examination, prostate volume and age, improved the AUC from 0.776 to 0.879 ($p < 0.001$). Anatomical concordance analysis showed a low mismatch between the magnetic resonance imaging positive regions and biopsy positive regions (4 [2.9%]), and the significant prostate cancer area in the radical prostatectomy specimen (3 [3.3%]).

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Conclusions: In men with an abnormal prostate specific antigen/digital rectal examination, multiparametric magnetic resonance imaging detected significant prostate cancer with an excellent negative predictive value and moderate positive predictive value. The use of multiparametric magnetic resonance imaging to diagnose significant prostate cancer may result in a substantial number of unnecessary biopsies while missing a minimum of significant prostate cancers.

Key Words: prostatic neoplasms, magnetic resonance imaging, early detection of cancer, biopsy, prostate-specific antigen

The early detection and management of prostate cancer are among the most challenging and controversial issues in medicine. Currently the standard of care for men with increased prostate specific antigen or an abnormal DRE is a 12-core template systematic TRUS guided biopsy.[1,2] The limitations of this biopsy strategy are a relatively low yield of tumors,[3] failure to detect significant PC,[4] inaccurate tumor risk stratification[5] and the over detection of insignificant PC.[6]

Multiparametric magnetic resonance imaging provides the best anatomical and functional imaging of the prostate compared to other imaging methods.[7] The positive predictive value of significant PC detection with mpMRI is 20% to 68%, which is considerably higher than that of random systematic TRUS guided biopsy.[8–11] The reported sensitivity of mpMRI for significant PC is 76% to 96%.[8–11] However, most studies are limited by their retrospective design, lack of standardized mpMRI scanning and reporting protocols, the use of targeted biopsies, 12-core TRUS guided biopsies or radical prostatectomy alone as the reference standard, each of which has limitations due to detection, ascertainment and selection biases. In addition, most studies failed to report a lesion specific correlation between regions of interest on mpMRI and histopathology.[8]

To overcome these limitations the ideal study design to determine diagnostic accuracy would consist of standardized double reported mpMRI followed by grid directed TTMB and validation against whole mount sectioned radical prostatectomy specimens as the reference standard in those undergoing RP. Since performing RP in all study participants, including those with no cancer or insignificant cancer on biopsy, would be unethical, TTMB is considered the best available reference standard.[12,13] In this prospective cross-sectional study we determine the overall and lesion specific accuracy of mpMRI for significant PC detection before diagnostic biopsy in men with abnormal PSA or DRE, using TTMB as the reference.

MATERIALS AND METHODS

Study Population Characteristics

Between April 2012 and March 2014 a total of 388 men were enrolled in this prospective cohort. Selection criteria included men older than 40 years, scheduled to undergo biopsy for abnormal PSA or DRE, with a life expectancy greater than 10 years and no previous prostate MRI or biopsy. Institutional review board approval was granted (SVH12/007) and informed consent was obtained from all patients before MRI and biopsy. Data were reported according to the START (Standards of Reporting for MRI-targeted biopsy studies) criteria.[14] Figure 1 presents a flow diagram of patient selection.

Study Protocol

The study and MRI protocol are described in detail by Thompson et al.[15] In summary, all mpMRI was performed at 2 centers (1.5 Tesla magnet, b-value 0 to 800 seconds per mm^2 at center 1 and 3 Tesla magnet, b-value 0 to 1,500 seconds per mm^2 at center 2) using a standard MRI protocol.[16] According to the study protocol 2 radiologists double reported independently and were blinded to each other. General agreement (each scoring PI-RADS 1 or 2, or 3 to 5) between the 2 radiologists was 75% and quadratic weighted κ was 0.63.[15] The standardized 5-point PI-RADS was used.[16] Using objective criteria ROIs were assigned a score of 1 to 5 for each parameter (T2WI, dynamic contrast enhanced imaging and diffusion weighted imaging) and then an overall impression ROI score (based on individual parameter scores). MRI derived ROIs were indicated on a topographic map with 18 MRI regions corresponding to biopsy template locations (fig. 2).

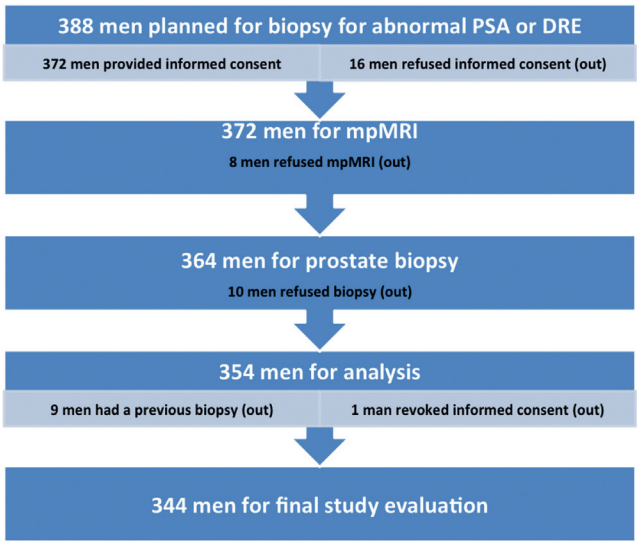

Figure 1. Flow chart selection patient study population