Prostate Image Reporting and Data System (PI-RADS): Summary and overview of the related works

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Introduction

In recent years, multiparametric MRI (mpMRI) of the prostate has emerged a robust imaging approach for non-invasive characterization of prostate cancer (Hegde et al. 2013). mpMRI includes morphological (T2-weighted Imaging, or T2WI) and functional imaging (Diffusion Weighted Imaging (DWI), Dynamic Contrast Enhanced (DCE), and Magnetic Resonance Spectroscopic Imaging (MRSI) sequences). While the performance of the individual sequences is being investigated, and the acquisition techniques are being refined, integration of mpMRI into the clinical practice has been challenging due to the lack of consistent approaches for assessing mpMRI and reporting of the clinical findings. Prostate Imaging Reporting and Data System (PI-RADS) is a scoring system that aims to enable consistent interpretation, communication and reporting of prostate multiparametric MRI (mpMRI) findings (Barentsz et al. 2012; Dickinson et al. 2011). PI-RADS is currently under development by an international group of prostate imaging experts. Recently, European Society of Urogenital Radiology (ESUR) adopted an initial version of this scoring system based on the consensus opinion and literature evidence (Dickinson et al. 2011).

The purpose of this document is to summarize the PI-RADS scoring recommendations of ESUR, and refer to the major studies validating and evaluating PI-RADS in the clinical setting, as well as other resources summarizing this scoring system. In the future, this document will be updated to include developments and modifications of PI-RADS.

PI-RADS Scoring System: ESUR 2012 recommendations

The following summary is prepared based on the ESUR recommendations presented in (Barentsz et al. 2012; Dickinson et al. 2011).

PI-RADS scoring system includes the following components:

1. Anatomical division of the prostate into 16 (at a minimum) or 27 (optimally) regions of interest, as illustrated in Fig.1.
2. Maximum diameter of the largest abnormal lesion should be measured.
3. Each lesions should be assigned a score for each of the MR parameters using a five-point scoring system defined as follows:

   1: Clinically significant disease is highly unlikely to be present
   2: Clinically significant cancer is unlikely to be present
   3: Clinically significant cancer is equivocal
   4: Clinically significant cancer is likely to be present
   5: Clinically significant cancer is highly likely to be present.

It is recognized that "*the criteria for assigning scores to lesions identified by each technique are not yetgenerally accepted*". Therefore, recommendations for scoring each of the mpMRI parameters have been proposed based on expert consensus and literature analysis, as summarized below. In addition to the scores assigned to individual MR parameters, each lesion is given an overall score to summarize its overall chance of

being a clinically significant cancer. Of note, PI-RADS does not provide the guidelines on assigning the overall lesion score.

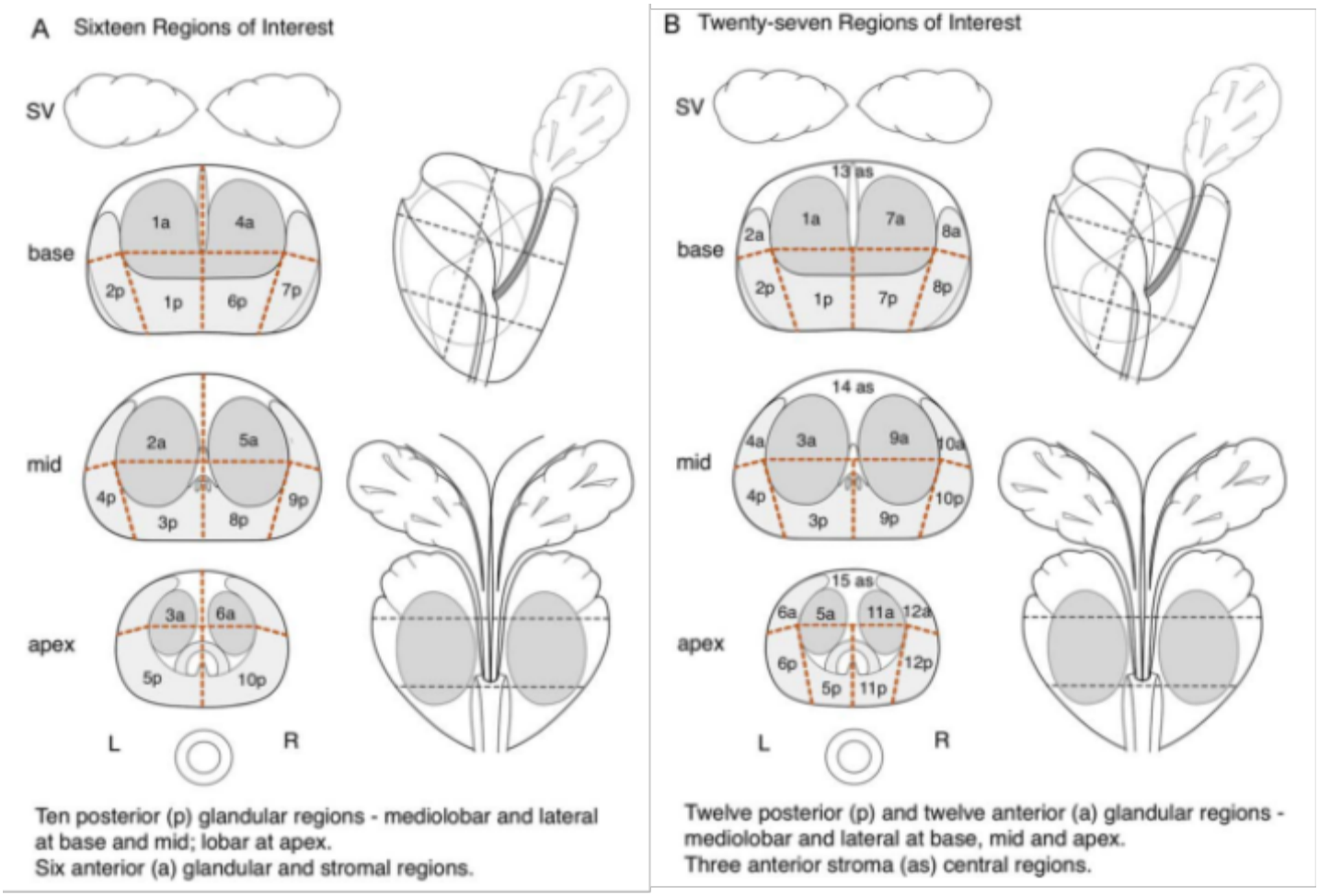

Fig.1: (A) Sixteen regions/sectors standardised magnetic resonance imaging (MRI) prostate reporting scheme. Posteriorly (p), average axial sections at prostate base and midgland are subdivided into four regions (midlobar and lateral) and at the prostate apex into two regions. Anteriorly (a), prostate base, midgland, and apex are divided into two regions. The anterior region starts 17mm from the prostatic posterior surface (biopsy core length). A 10- core extended biopsy scheme would be expected to sample the 10 posterior sectors. (B) Twenty-seven regions/sectors standardised MRI prostate reporting scheme. Posteriorly (p), average axial sections at prostate base, midgland, and apex are subdivided into four regions (midlobar and lateral). Anteriorly, the prostate is divided into four anterior regions (a) (midlobar and lateral) and three anterior stroma regions (as). The anterior region starts 17mmfromthe prostatic posterior surface (biopsy core length). A 12-core extended biopsy scheme would be expected to sample the 12 posterior sectors. From (Dickinson et al. 2011).

- *T2WI for the peripheral zone (PZ)*

  1: Uniform high signal intensity (SI)

  2: Linear, wedge shaped, or geographic areas of lower SI, usually not well demarcated

  3: Intermediate appearances not in categories 1/2 or 4/5

  4: Discrete, homogeneous low signal focus/mass confined to the prostate

  5: Discrete, homogeneous low signal intensity focus with extra-capsular extension/invasive behaviour or mass effect on the capsule (bulging), or broad (>1.5 cm) contact with the surface.

- *T2WI for the transition zone (TZ)*

  1: Heterogeneous TZ adenoma with well-defined margins: “organised chaos”

  2: Areas of more homogeneous low SI, however well marginated, originating from the TZ/BPH

3: Intermediate appearances not in categories 1/2 or 4/5

4: Areas of more homogeneous low SI, ill defined: “erased charcoal sign”

5: Same as 4, but involving the anterior fibromuscular stroma or the anterior horn of the PZ, usually lenticular or water-drop shaped.

- *Diffusion weighted imaging (DWI)*

  1: No reduction in ADC compared with normal glandular tissue. No increase in SI on any high b-value image (≥b800)

  2: Diffuse, hyper SI on ≥b800 image with low ADC; no focal features, however, linear, triangular or geographical features are allowed

  3: Intermediate appearances not in categories 1/2 or 4/5

  4: Focal area(s) of reduced ADC but iso-intense SI on high b-value images (≥b800)

  5: Focal area/mass of hyper SI on the high b-value images (≥b800) with reduced ADC

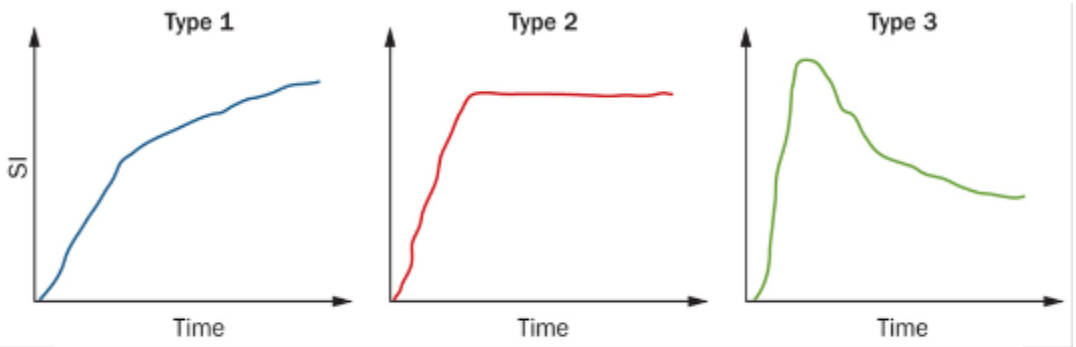

Fig.2: Curve types representing enhancement patterns on DCE–MRI. Type 1 represents progressive enhancement, type 2 rapid enhancement with plateauing, and type 3 represents rapid enhancement followed by a rapid wash out of the contrast material. Abbreviations: DCE–MRI, dynamic contrast-enhanced MRI; SI, signal intensity. From (Johnson et al. 2014).

- *Dynamic contrast enhanced (DCE)-MRI*

  1: Type 1 enhancement curve (see Fig.2, adapted from (Johnson et al. 2014))

  2: Type 2 enhancement curve

  3: Type 3 enhancement curve

  +1 For focal enhancing lesion with curve type 2–3

  +1 For asymmetric lesion or lesion at an unusual place with curve type 2–3

- *Qualitative magnetic resonance spectroscopic imaging (MRSI)*

  1: Citrate peak height exceeds choline peak height >2 times

  2: Citrate peak height exceeds choline peak height times >1, <2 times

  3: Choline peak height equals citrate peak height

  4: Choline peak height exceeds citrate peak height >1, <2 times

  5: Choline peak height exceeds citrate peak height >2 times

  In qualitative analysis, the relative peak heights of citrate and choline are visually compared (pattern analysis), rather than quantified. The criteria apply for 1.5T for at least three adjacent voxels.

Findings related to extra-prostatic involvement should also be scored on a five-point scale using the following criteria for individual findings:

- *Extra-capsular extension*

  Abutment: 1

Irregularity: 3
Neurovascular bundle thickening: 4
Bulge, loss of capsule: 4

- *Seminal vesicles*
  Expansion: 1
  Low T2 signal: 2
  Filling in of angle: 3
  Enhancement and impeded diffusion: 4
- *Distal sphincter*
  Adjacent tumor: 3
  Effacement of low signal sphincter muscle: 3
  Abnormal enhancement extending into sphincter: 4
- *Bladder neck*
  Adjacent tumor: 2
  Loss of low T2 signal in bladder muscle: 3
  Abnormal enhancement extending into bladder neck: 4

PI-RADS evaluation and continuing development

In the recent years, numerous studies have been conducted that incorporated PI-RADS into the assessment of prostate cancer. Portalez et al. (Portalez et al. 2012) applied PI-RADS scoring in a population of 129 patients with at least one negative TRUS biopsy. The localized lesions were subsequently biopsied using both random systematic and targeted MR/US fusion based approaches. ROC analysis showed that increments of five points in the sum PI-RADS score led to significant increase in proportion of positive biopsies. A significant difference was observed in the percent of the positive cores identified using targeted vs systematic biopsy approach. In a similar study, Junker et al. identified positive correlation between the sum PI-RADS score and both the incidence and malignancy of the tumor (Junker et al. 2013). PI-RADS sum score of 10 or above was associated with good detection rate of PCa. This study was based on a population of patients with previous negative TRUS biopsy (n=73).

Thompson et al. (Thompson et al. 2014) evaluated PI-RADS scoring in a population of 150 men with no prior mpMRI that were referred for biopsy due to rising PSA and suspicious findings of the digital rectal exam. Per-lesion score was defined as the mean of the individual parameter scores. Validation was done using the results of the transperineal biopsy by sampling 18 template location and also specific suspicious areas using MR/US fusion for guidance. 48/150 patients underwent radical prostatectomy. The study concluded that PI-RADS exhibited excellent NPV, and moderate PPV for significant PCa. Significant cancer at RP was defined based on a recent study as any of 1) Gleason 7-10 with greater than 5% grade 4 and 0.7 cc or greater, 2) Gleason 6 and 1.3 cc or greater, 3) pT stage 3a or greater and 4) nodal metastasis (pN1). The authors reported substantial agreement across readers, and no significant effect of the magnet strength on the results.

Roethke et al. investigated the performance of PI-RADS prospectively in a population of 64 consecutive patients that were referred for MR/US fusion biopsy due to suspicion of PCa (Roethke et al. 2014). The investigators observed that the sum PI-RADS score had higher areas under the ROC curve as compared to Likert score (with the individual lesions scored on a 5-point scale only), and reported “[...] 73%/92% and 85%/67% for PI-RADS scores of 9 and 10, respectively; 85%/56% and 60%/97% for Likert scores of 3 and 4, respectively”.

On the other hand, based on the report from Rosenkrantz et al. (Rosenkrantz et al. 2013), Likert scale performs as well as the PI-RADS scoring system, with Likert scoring exhibiting advantages in the transitional zone of the prostate.

(Schimmöller et al. 2013) et al. investigated inter-reader (n=3) agreement in applying PI-RADS scoring in a population of 63 patients with prior negative TRUS biopsy, concluding that agreement was good to moderate (Schimmöller et al. 2013). Hoeks et al. conducted a prospective multi-center study applying PI-RADS in a population of active surveillance cancer patients (n=64) (Hoeks et al. 2014). Lesions were assigned overall score using 5 point scale (as opposed to sum score used by Portalez et al. and Junker et al.), and were subsequently biopsied using MR-guided biopsy (transrectal approach). Overall lesion score of 1 or 2 had 100% negative predictive value for detecting cancer of Gleason 4 or 5 based on the results of MR-guided biopsy, while the score of 4 and above had sensitivity of 92% for detection of high Gleason cancer (Gleason 4 or 5).

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