Multiparametric Prostate MRI Techniques

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Overview

• Overview of Pulse Sequences
• Technical Considerations
• T2-Weighted Imaging
• Diffusion-Weighted Imaging
• Dynamic Contrast-Enhanced Imaging
• No News Is Good News?
Disclosure

Ad hoc consultant for Promaxo, Inc

Guerbet ad-hoc advisory panel
Prostate Imaging Reporting and Data Systems v2.1: “PI-RADS”
>20 publications prove PI-RADS v2 the Standard for Prostate MRI

- ACR website or *European Urology*
- Technique
- Normal appearance
- Assessment and reporting
- Staging
Prostate Imaging Reporting & Data System (PI-RADS)

To improve early diagnosis and treatment of prostate cancer, ACR, AdMeTech Foundation and ESUR formed a joint effort to develop standards for the Prostate Imaging Reporting and Data System (PI-RADS).

The goal is to expedite the transfer of high-quality MRI from laboratories to patients to help improve early diagnosis of clinically significant prostate cancer and reduce unnecessary biopsies and treatment for benign and subclinical diseases.

License Information

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Contact us: rads@acr.org

PI-RADS v2.1 Module

What's new?

Click here to download a presentation comparing changes from 2.0 to 2.1 [Download]

- PI-RADS 2019 v2.1 (full text document)
- PI-RADS v2.1 Lexicon
- PI-RADS Atlas (Login required)
- PI-RADS v2.1 Report Template - Available as a .TXT or .PDF file
PI-RADS v2.1 is Designed for Assessing Primary Significant Cancer
PI-RADS Does Not Address Some Issues
Pulse Sequences
mpMRI is Multiparametric

T2-Weighted
(Anatomy)

Diffusion-Weighted
(Qualitative)

Dynamic Contrast-Enhanced

Optional Spectroscopic
**mpMRI Components**

- **Diffusion-weighted imaging + apparent diffusion coefficient map:** most specific
- **Dynamic contrast-enhanced perfusion imaging:** most sensitive

**T2-weighted images:**
- transition zone characterization & staging
**Parameters**

<table>
<thead>
<tr>
<th>Pulse sequence</th>
<th>T2</th>
<th>DWI</th>
<th>DCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR/TE</td>
<td>“Stock” TSE/FSE</td>
<td>&gt;3000/&lt;90 ms</td>
<td>&lt;100 / &lt;5 ms</td>
</tr>
<tr>
<td>Slice thickness</td>
<td>3 mm</td>
<td>≤ 4 mm</td>
<td>3 mm</td>
</tr>
<tr>
<td>FOV</td>
<td>12-20 cm</td>
<td>16-22 cm</td>
<td>“gland + SV’s”</td>
</tr>
<tr>
<td>In-plane</td>
<td>≤0.7 x ≤0.4 mm</td>
<td>≤2.5 x 2.5 mm</td>
<td>≤2 x 2 mm</td>
</tr>
<tr>
<td>Specifics</td>
<td>2 or 3 plane</td>
<td>Low b 50-100 s/mm²</td>
<td>≤15 s/phase</td>
</tr>
<tr>
<td></td>
<td>Axial match DWI/DCE</td>
<td>ADC Max b 1000 s/mm²</td>
<td>≥2 min total</td>
</tr>
<tr>
<td></td>
<td>Axial straight/oblique</td>
<td>Min high b 1400 s/mm²</td>
<td>2-3 ml/s</td>
</tr>
</tbody>
</table>

0.1 mmol/kg
MRI Spectroscopy

- Technically very demanding
- Adds least to AUC for cancer characterization
- Poorest spatial resolution
- But – most specific
Technical Considerations
Quality Standards Defined for Minimum Acceptable Quality

- Endorectal coil may be necessary
  - Poor gradient performance
  - Resolution of capsule
- Voxel size, coverage
- DWI, DCE parameters
- Artifacts, e.g. hemorrhage
T2-Weighted Imaging
T2-Weighted Imaging

Staging

Transition Zone

Acquire axial + (sagittal and/or coronal)
T2 hypointensity can arise from cancer, inflammation, hemorrhage, or prior treatment.

- **T1:** hyperintense PZ
- **No endorectal coil**

- **Corresponding T2WI hypointensity.**
- **Endorectal coil =** better contrast to background
T2 hypointensity can arise from cancer, inflammation, hemorrhage, or prior treatment.

Peripheral gland is diffusely hypointense, with defects from HDR brachytherapy. Pre-treatment imaging shows normal peripheral signal except for suspicious areas.
3D T2-Weighted Images have better through-plane resolution, but worse motion artifact.

3D: blurry, better small detail

2D: fine detail obscured

12 months later
Extracapsular Extension

Obvious, NVB involved

Recto-prostatic angle

Capsule contact

Spiculation

Slide courtesy Bryan Foster, OHSU

28mm

21mm
Diffusion-Weighted Imaging
DWI Connotes Cellularity

• Low Grade: Gleason 3+3 (ISUP category 1)
• High Grade: Gleason 4+3 (ISUP category 3)
Technique Clarifications in PI-RADS v2.1

• B-values → diffusion weighting
• Low SNR at higher b-values= ↑NEX
• B=0 is OK for ADC, b ≥ 100 preferred
  • Including b=0 → higher ADC
  • Minimum 0-100, maximum 800-1000 s/mm²
• Acquire or calculate b ≥ 1400 s/mm² series
  • Separately acquired from ADC values
• Report ADC – Average? Minimum?
High b-value DWI Is Crucial
Dynamic Contrast-Enhanced Imaging
DCE Technique

• PK map is helpful for ROI choice and for follow-up
  • Simple early subtraction map is sufficient for detection
  • Calculated parameters multifactorial
• Temporal resolution ideally ≤10 seconds, ≤15 OK
  • 3D – Consider view-sharing, e.g. TWIST/DISCO
• Must do spectroscopy first
Dynamic Contrast Timing Is Also Crucial

Pharmaco-kinetic maps automatically find the early enhancement time point.

- Precontrast
- Early Enhancement
- 8 sec. later
- Subtraction

$K_{\text{trans}}$ map
Conventional DWI → thicker slice, OK ADC

DWI: acceptable

- Constrained FOV → excessive noise

- Resolve prostate margin
- Dark bladder lumen
- ADC features
- DCE conspicuous

DCE: ↑matrix=↑noise
3T same vendor: different coil

Better DWI, less noise

Improved contrast

T2 nearly identical
So, What’s Happened In The Past Four Years?
And maybe something for focal ablation?
“Bi-Parametric Prostate MRI”

• T2- & diffusion-weighted only
• Potentially <15 minutes
  • Requires adequate DWI and calculated high b-value
• Potential pitfalls
  • More category 3
  • Hip replacement
  • Inexperienced readers

PI-RADS Committee Position on MRI Without Contrast Medium in Biopsy Naive Men with Suspected Prostate Cancer: A Narrative Review

Ivo G. Schoots, MD, PhD, Jelle O. Barentsz, MD, PhD, Leonardo K. Bittencourt, MD, PhD, Masoom A. Haider, MD, Katarzyna J. Macura, MD, Daniel J.A. Margolis, MD, Caroline M. Moore, MD, Aytekin Oto, MD, Valeria Panebianco, MD, Mohammad M. Siddiqui, MD, Clare Tempany, MD, Baris Turkbey, MD, Geert M. Villeirs, MD, Jeffrey C. Weinreb, MD, Anwar R. Padhani, MD
<table>
<thead>
<tr>
<th>PI-Qual Score</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>1</td>
<td>All mpMRI sequences are below the minimum standard of diagnostic quality. It is NOT possible to rule in or rule out all significant lesions.</td>
</tr>
<tr>
<td>2</td>
<td>Only one mpMRI sequence is of acceptable diagnostic quality.</td>
</tr>
<tr>
<td>3</td>
<td>At least two mpMRI sequences taken together are of diagnostic quality. It is possible to rule in all significant lesions; It is NOT possible to rule out all significant lesions.</td>
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<tr>
<td>4</td>
<td>Two or more mpMRI sequences are independently of diagnostic quality. It is possible to rule in all significant lesions. It is possible to rule out all significant lesions elsewhere.</td>
</tr>
<tr>
<td>5</td>
<td>All mpMRI sequences are of optimal diagnostic quality.</td>
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Future of Prostate MRI

- Artificial Intelligence (of course!)
- Quantitative MRI
  - Susceptibility Mapping
  - Texture Analysis and Deep Learning
- MRI-guided Therapies
- Integrated Management
  - Treatment Planning
  - Outcome Assessment
Advanced Diffusion

- Intravoxel incoherent motion, diffusion kurtosis
- Use of multiple b-values/echoes to model cellularity
  - Restriction-spectrum imaging
  - Luminal water imaging (also T2)
  - VERDICT
- Improved performance vs. ADC alone
- RSI FDA approved – not quantitative
- U Chicago, VERDICT research only
Take-Home Points

• PI-RADS v2.1 defines technical recommendations in addition to performance, assessment & reporting
• An endorectal coil may be necessary for surgical planning or for sufficient SNR for DWI
• Exact parameters depend on platform – optimize to diagnostic image quality
Thank you.

Questions?

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