Multiparametric MR Imaging in Prostate Cancer Diagnosis: make it easy

Poster No.: C-1811
Congress: ECR 2015
Type: Educational Exhibit
Authors: G. Popa, C. Scheau, A. preda, I. G. Lupescu; Bucharest/RO
Keywords: Pelvis, Oncology, MR, MR-Diffusion/Perfusion, Diagnostic procedure, Cancer, Neoplasia
DOI: 10.1594/ecr2015/C-1811

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Learning objectives

- To describe the basic MRI semiology of prostate cancer indicating the advantages and limitations of each sequence used and to elaborate an optimal MRI protocol.

- To explain how to use the Prostate Imaging and Reporting Archiving Data System (PI-RADS).

Background

- Prostate cancer is one of the most common malignancies in men, generally with a slow growth rate and early detection is essential for a complete treatment [1].

- The diagnosis is mainly based on digital rectal examination (DRE), serum prostate specific antigen (PSA) and trans-rectal ultrasound (TRUS) guided systematic random prostate biopsy, but cancer located outside the routine biopsy zone may be missed [1-3]. Currently, an accurate detection and localization of prostate cancer can be done easily using multip-parametric MRI (mp-MRI) examination which is able to provide anatomical and functional information about prostate tissue [3, 4]. Multip-parametric MRI (mp-MRI) examination includes a combination of high-resolution T2-wi and at least two functional MRI techniques, such as dynamic contrast-enhanced (DCE) MRI, diffusion-weighted imaging (DWI) or proton spectroscopy imaging (MRSI) [2, 5].

- Based on our experience, in this presentation we will refer to these acquisitions: T2-wi, DCE MRI and DWI / ADC map.

Anatomy of the Prostate

- The anatomy of the prostate gland was based on the zonal compartment system developed by McNeal: periurethral tissue and transitional, central and peripheral zones [1, 6]. According to this system, prostate is divided into two compartments, the central gland composed of a transitional zone and periurethral tissue, and the peripheral gland composed of peripheral zone and central zone [1] (Fig. 1 on page 7).

- The peripheral zone accounts over 70% of the glandular tissue [1, 7]. It is located posterior and lateral to the urethra and its ducts open into prostatic urethra distal to verumontanum [1, 7, 8]. About 70% of prostate cancers arise in the peripheral zone [1, 7, 8].
- **The central zone** accounts about 25% of the glandular tissue that surrounds the ejaculatory ducts and its ducts arise into the prostatic urethra close to the ejaculatory duct orifices [7, 8]. Carcinomas and other diseases are rarely present at this level [8].

- **The transitional zone** constitutes for 5% to 10% of the glandular prostate and its ducts arise into the postrolateral part of the prostatic urethra [1, 8]. Cellular proliferation in the transitional zone causes benign prostatic hyperplasia (BPH) [1, 8]. About 20% of prostate cancers are localized in the transitional zone [1].

- **Periurethral zone** consists of small ducts and acini which are not completely developed; it is located along the proximal urethral segment inside the preprostatic sphincter [8].

- **The anterior fibromuscular stroma** consists of nonglandular tissue; it covers the entire anterior surface of the prostate gland [8].

**Conventional MRI**

- T2-weighted MR imaging is optimal to characterize the anatomy of the prostate [1]. On T2-wi, the peripheral zone has high signal intensity, in contrast to the low signal intensity of the central and transitional zones, in young male subjects [1, 9] (Fig. 2 on page 8). With increasing age, the central gland is mainly composed of transition zone, due to BPH, which leads to the formation of adenomatous nodules [3, 5]. BPH appears as a well-defined and inhomogeneous area with intermediate signal intensity on T2-wi [3, 9].

The anterior fibromuscular stroma also appears as an area with low signal intensity on T2-wi [1].

- T2-w images are useful to detect prostate cancer in the peripheral zones, which appears as an area of low signal intensity [1, 3, 5].

- Sometimes, a focal area of low signal intensity located in the peripheral zone may represent a benign abnormalities such as chronic prostatitis, atrophy, scars, post-radiation therapy fibrosis and changes after hormone deprivation therapy [1, 3]. Usually a benign lesion appears as an area of low-signal-intensity with a wedge shape and a diffuse distribution without mass [3, 10].

- Another limitation of this method is represented by cancer detection in the transitional and central zones, because cancer and normal tissues have low signal intensity on T2-w images [1].

- Because T1-w contrast in the prostate is very low, it is not possible to identified the different anatomic zones [1, 3]. T1-w images are mainly used to identify blood product, usually after biopsy, which leads to high signal intensity on T1-w images, respectively low signal intensity on T2-w images [1, 3, 11]. Therefore, the MRI examination should be avoided for 8 weeks after biopsy to reduce artifacts caused by hemorrhage [3, 12].
MR-dynamic contrast enhanced (DCE)

**Principles**

- This technique is based on tumor angiogenesis [1]. Genetic mutation caused by cancer leads to the production and release of angiogenic factors such as the vascular permeability factor or vascular endothelial growth factor in reaction to the presence of local hypoxia or lack of nutrients [1, 3, 13]. Therefore, the number of vessels increases in cancerous tissue, and these newly formed tumor vessels presents a higher permeability than do normal vessels because of weak integrity of the vessel wall [1, 13].

- Because the interstitial space is greater in cancerous tissue than in normal tissue, there is a significant difference of contrast material concentration between the plasma and the interstitial space [1].

- This characteristic environment explain the enhancement pattern of cancerous tissue with earlier and faster enhancement and earlier contrast agent washout compared with surrounding normal prostate tissue [1, 13-16].

- This technique requires a rapid acquisition methods, before, during, and after a fast bolus administration of low-molecular-weight gadolinium contrast media using an injection rate of 2-4 mL/s [13].

- IV-injected contrast media reaches to the tissue microvasculature and extravasate within seconds to the extravascular extracellular space, leading to a fast brightening of signal on T1-w images [13]. The signal measured in cancerous tissue on DCE-MRI represents a combination of perfusion and permeability due to alterations in vascular permeability, extracellular space, and blood flow [13] (Fig. 3 on page 9).

**Image Acquisition**

- DCE-MRI usually use 3D T1-w fast spoiled gradient-echo sequences to examine the prostate after the administration of a bolus of IV contrast agent [13]. The image sets are obtained repeatedly every 5 seconds for up to 5#10 minutes, the aim is to detect early enhancement of the cancerous tissue, but many centers use acquisition times up to 10 seconds with good results [13].

**Image analysis**
- The most common method of image analysis is the semi-quantitative, based on the supposition that early and intense enhancement and washout is a predictor of malignancy [13].

- It is necessary to quantify the signal intensity changes represented by time-intensity (gadolinium concentration) curves analyzing the following parameters, the first peak of enhancement, integral area under the curves, wash-in / wash-out gradient, maximum signal intensity, time-to-peak enhancement and start of enhancement [3, 13].

- In prostate cancer, there is early intense enhancement and fast washout of contrast agent [13, 15, 17].

- After initial uptake, three types of time-intensity curves can be seen, persistent increase (type 1), plateau (type 2) and decline after initial upslope (type 3) [13] (Fig. 4 on page 10).

- The most suspicious for prostate cancer is type 3 of time-intensity curve, especially if associated a focal asymmetric enhancing lesion [13].

- Kim et al. analyzed the role of Parametric Imaging of the Wash-In Rate and T2-wi in the detection of prostate cancer [1, 18]. The sensitivity and specificity for cancer detection in the peripheral zone were significantly greater on parametric imaging of the wash-in rate (96% and 97%) than on T2-wi (75% and 53%); in the transitional zone, the sensitivity for cancer detection was significantly greater on parametric imaging of the wash-in rate (96%) than on T2-wi (45%), but the specificity is greater on T2-wi (73%) than on parametric imaging of the wash-in rate (51%) [18].

**Diffusion-weighted Imaging (DWI)**

- DWI is a fast and simple MR imaging technique in the detection and characterization of prostate cancer based on the random movement of water molecules in cancerous tissue [3, 5]. Movement of water molecules is limited in cancerous tissue or fibrosis and the images will show diffusion restriction appearing in high signal intensity on the high b-value images, respectively low signal intensity on the apparent diffusion coefficient (ADC) maps [5].

- The prostate cancer appearance on ADC maps correlates well with tumor aggressiveness, increasing the specificity of magnetic resonance examination [5, 19].

- b values between 500 and 800 sec/mm² are typically used for prostate cancer, but b values of 1000 and 2000 sec/mm² may increase the detection of prostate cancer, especially in the transition zone, improving differential diagnosis between BPH and prostate cancer [3, 20, 21].
- Chiho Sato et al. demonstrated that the ADC values of prostate cancer in the peripheral zone and transitional zone were significantly lower than the ADC values of benign tissue in the corresponding zone [22].

- Meltem Esen et al. demonstrated the usefulness of ADC values in the differentiation of prostate cancer from normal prostate parenchyma and prostatitis using b values of 100, 600 and 1,000 s/mm$^2$; the ADC values of prostate cancer group were significantly lower at b values of 600 and 1,000 s/mm$^2$ [23].

**ESUR prostate MR guidelines 2012**

- In 2012, a group of experts from the European Society of Urogenital Radiology (ESUR) developed a clinical guidelines for mp-MRI of the prostate with the aim to standardize the interpretation and to improve communication with clinical colleagues preferably using a structured reporting scheme [2, 5].

- For optimal MRI examination protocols have been proposed three protocols: "detection", "staging" for evaluating minimal extra-capsular extension and "node and bone" to assess nodal size and bone marrow metastases [2].

- European urologists and radiologists introduced a scoring system similar to that employed successfully by breast radiologists expert; this scoring system is named the Prostate Imaging Reporting and Data System (PI-RADS) based on mp-MRI examinations [2, 24].

- The PI-RADS score should be assessed for each acquisition included in the mp-MRI examination [2].

- The PI-RADS scoring system uses a five-point scale as follows [2, 5]:
  - Score 1: clinically significant disease is highly unlikely to be present;
  - Score 2: clinically significant cancer is unlikely to be present;
  - Score 3: clinically significant cancer is equivocal;
  - Score 4: clinically significant cancer is likely to be present;
  - Score 5: clinically significant cancer is highly likely to be present.

- The criteria for each PI-RADS score are present in schematic form for each acquisition as follows: T2-wi in the peripheral zone (Fig. 5 on page 11); T2-wi in the transition zone (Fig. 6 on page 12); DCE MRI (Fig. 7 on page 13); DWI / ADC map (Fig. 8 on page 14).
- Extra-prostatic involvement should also be scored using the same scale range of 1 to 5 [2]. The criteria for PI-RADS score are shown in the following figure (Fig. 9 on page 15); these include extra-capsular extension and infiltration of the seminal vesicles, distal sphincter and bladder neck [2].

**Local staging of prostate cancer**

- Local staging of prostate cancer is based on primary tumor classification proposed by the American Joint Committee on Cancer [25]; this classification is shown in the following figure (Fig. 10 on page 16).

- Local staging of prostate cancer is usually performed using T2-wi acquisition, but mp-MRI may also improve prostate cancer staging [3].

- Jurgen J. Fütterer et al. demonstrated in a large prospective study with 99 patients that staging accuracy of the prostate cancer diagnostic was significantly improved when acquisitions T2-wi and DCE-MRI were combined [3, 17].

- Acquisition mp-MRI is also useful in differentiating stage T1 / T2 (tumor confined to prostate) to stage T3 (early advanced disease regarding extracapsular extension or seminal vesicle invasion) and is preferred to other imaging methods [26].

**Images for this section:**
Fig. 1: The anatomy of the prostate - schematic representation.

AFT  anterior fibromuscular tissue
CZ  central zone
ED  ejaculatory duct
NVB  neurovascular bundle
PUT  periurethral tissue
PZ  peripheral zone
U  urethra
TZ  transitional zone

Adapted from
Young Jun Choi, Jeong Kon Kim, Namkog Kim et al. Functional MR Imaging of Prostate Cancer, Radiographics 2007; 27:63–77; Published online 10.1148/rug.271065078
**Fig. 2:** The zonal anatomy of prostate gland. T2-w MR image depicts the central gland and peripheral zone (PZ). Central gland is hypointense (arrows) compared to hyperintense PZ (arrowheads).
Fig. 3: Dynamic Contrast-Enhanced MRI - Principles. IV-injected contrast agent reaches to the tissue microvasculature and extravasate within seconds to the extravascular extracellular space.
Fig. 4: Dynamic Contrast-Enhanced MRI - Image analysis. After initial uptake, three types of time-intensity curves can be identify, persistent increase (type 1), plateau (type 2) and decline after initial upslope (type 3).

Adapted from
**Fig. 5:** PI-RADS scoring system - T2-wi for the peripheral zone (PZ) - schematic representation.
Fig. 6: PI-RADS scoring system - T2-wi for the transition zone (TZ) - schematic representation.
**Fig. 7:** PI-RADS scoring system - Dynamic Contrast-Enhanced MRI - schematic representation.

<table>
<thead>
<tr>
<th>PI-RADS score</th>
<th>Criteria</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Type 1</td>
</tr>
<tr>
<td>2</td>
<td>Type 2</td>
</tr>
<tr>
<td>3</td>
<td>Type 3</td>
</tr>
<tr>
<td>+1</td>
<td>Focal enhancing lesion with curve types 2-3</td>
</tr>
<tr>
<td>+1</td>
<td>Asymmetric lesion or lesion at an unusual place with curve types 2-3</td>
</tr>
</tbody>
</table>


**Fig. 8:** PI-RADS scoring system - DWI and ADC map - schematic representation.
### Scoring of extraprostatic disease

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Findings</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra-capsular extension</td>
<td>Abutment</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Irregularity</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Thickening of the neurovascular bundle</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Bulge or loss of capsule</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Measurable extra-capsular disease</td>
<td>5</td>
</tr>
<tr>
<td>Seminal vesicles</td>
<td>Expansion</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Low T2-wi signal</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Filling in of angle</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Enhancement and impeded diffusion</td>
<td>4</td>
</tr>
<tr>
<td>Distal sphincter</td>
<td>Adjacent tumour</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Effacement of low signal sphincter muscle</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Pathological enhancement extending into sphincter</td>
<td>4</td>
</tr>
<tr>
<td>Bladder neck</td>
<td>Adjacent tumour</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Loss of low T2-wi signal in bladder muscle</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Pathological enhancement extending into bladder neck</td>
<td>4</td>
</tr>
</tbody>
</table>


**Fig. 9:** Scoring of extraprostatic disease.
<table>
<thead>
<tr>
<th>T stage</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX</td>
<td>Tumor cannot be assessed</td>
</tr>
<tr>
<td>T0</td>
<td>No evidence of primary tumor by any method</td>
</tr>
<tr>
<td>T1</td>
<td>Clinically inapparent tumor (palpable or by imaging)</td>
</tr>
<tr>
<td>T1a</td>
<td>Tumor in 5% or less of tissue resected</td>
</tr>
<tr>
<td>T1b</td>
<td>Tumor in more than 5% of tissue resected</td>
</tr>
<tr>
<td>T1c</td>
<td>Tumor identified by needle biopsy (for elevated PSA)</td>
</tr>
<tr>
<td>T2</td>
<td>Tumor palpable, but confined within prostate</td>
</tr>
<tr>
<td>T2a</td>
<td>Tumor involves one-half of one lobe or less</td>
</tr>
<tr>
<td>T2b</td>
<td>Tumor involves more than one-half of one lobe</td>
</tr>
<tr>
<td>T2c</td>
<td>Tumor involves both lobes</td>
</tr>
<tr>
<td>T3</td>
<td>Tumor extends through the prostate capsule</td>
</tr>
<tr>
<td>T3a</td>
<td>Extracapsular extension (unilateral / bilateral)</td>
</tr>
<tr>
<td>T3b</td>
<td>Seminal vesicle(s) invasion</td>
</tr>
<tr>
<td>T4</td>
<td>Tumor invades adjacent structures other than seminal vesicles</td>
</tr>
</tbody>
</table>

Adapted from
American Joint Committee on Cancer / Prostate Cancer Staging / 7th edition
https://cancerstaging.org/references-tools/quickreferences/Documents/ProstateSmall.pdf

**Fig. 10:** Prostate Cancer Staging - Primary Tumor (T).
Findings and procedure details

Procedure details

- Based on the recommendations of the European Society of Urogenital Radiology (ESUR) we use the following MR protocol to investigate prostate cancer on a 1.5 T MRI unit with the body coil. We recommend the use of anti-peristaltic drugs. We also recommend using the same scan parameters for acquisitions in the axial plane for a proper evaluation of the prostate: thickness, spacing, matrix and FOV.

- **T2-wi sagittal through the entire pelvis.** Sequences included: type FSE JET, TR = 5907 ms, TE = 120 ms, NAQ = 1, Speeder 1, Thickness/Spacing = 4 mm / 0.4 mm, Resolution = 0.8 x 0.8 mm. This acquisition helps us to program the next acquisitions focused on the prostate.

- **T2-wi axial cover the entire prostate.** Sequences included: type FSE, TR = 4876 ms, TE = 120 ms, NAQ = 2, Speeder 1, Thickness/Spacing = 4 mm / 0.4 mm, Resolution = 1.1 x 0.7 mm.

- **T2-wi oblique cover the entire prostate with sections positioned perpendicular to the interface between prostate and rectum, respectively in the plane of the seminal vesicles and ejaculatory ducts.** Sequences included: type FSE, TR = 4389 ms, TE = 120 ms, NAQ = 4, Speeder 1, Thickness/Spacing = 4 mm / 0.4 mm, Resolution = 0.7 x 0.7 mm.

- **T1-wi axial cover the entire prostate.** Sequences included: type SE, TR = 625 ms, TE = 15 ms, NAQ = 1, Speeder 1, Thickness/Spacing = 4 mm / 0.4 mm, Resolution = 0.9 x 1.2 mm.

- **DWI axial cover the entire prostate with b values of 0, 1000 and 1500 s/mm².** Sequences included: TR = 4218 ms, TE = 84 ms, NAQ = 9, Speeder 2, Thickness/Spacing = 4 mm / 0.4 mm, Resolution = 1 x 1 mm.

- **MR-dynamic contrast enhanced (DCE MRI) cover the entire prostate in axial plane.** Sequences included: type 3D FFE (Fast Field Echo) FatSat Dynamic, TR = 4.8 ms, TE = 1.9 ms, NAQ = 1, Speeder 2 (parallel imaging), Thickness/Spacing = 4 mm / 0 mm interpolated to 2 mm / 0 mm, Resolution = 0.6 x 0.6 mm, duration 10 seconds per cover; repeated as many times as necessary (eg 5-10 minutes continuous scan).
- **T1-wi late phase cover the entire prostate.** Sequences included: type 3D FFE Flow Compensation Isotropic Fat Sat, TR = 30 ms, TE = 5.5 ms, NAQ = 1, Speeder 2, Thickness/Spacing = 0.6 mm / 0 mm, Resolution = 0.6 x 0.6 mm.

- **STIR coronal through the entire pelvis, optional sequence when we evidentiated bone lesions.** Sequences included: type FSE STIR, TR = 3950 ms, TE = 48 ms, NAQ = 1, Speeder 1, Thickness/Spacing = 4 mm / 1 mm, Resolution = 1.2 x 0.9 mm.

**MR findings in the prostate cancer using mp-MRI**

- **T2-wi acquisitions.** Prostate cancer is easily detected in the peripheral zone, which appears as an area of low signal intensity, in contrast cancer located in the central gland in older patients is difficult to distinguish from benign prostatic hyperplasia using only T2-wi sequences (Fig. 11 on page 21).

- **MR-dynamic contrast enhanced (DCE).** A lesion is suggestive of prostate cancer if it shows early intense enhancement and fast washout of contrast agent with type 3 of time-intensity curve, especially if associated a focal asymmetric enhancing lesion or lesion at an unusual place (Fig. 12 on page 21, Fig. 13 on page 22). When the tumoral lesion is located in the transitional zone in older patients is difficult to differentiate from adenomatous nodules of benign prostatic hyperplasia, using only DCE-MRI sequence, these showing more frequently a type 2 of time-intensity curve (plateau).

- **DWI / ADC map.** The prostate cancer appears as a lesion with high signal intensity on DWI corresponding to low signal intensity on ADC map indicating restricted diffusion (Fig. 14 on page 23). Using a high b values increase the detection of prostate cancer, especially in the transition zone and it helps the differential diagnosis between malignant and benign lesions (Fig. 15 on page 24).

- For a better detection and characterization of prostate cancer is recommended to use all these MR acquisitions.

**The PI-RADS scoring system**

- In the following figures each PI-RADS score are present with MRI examples for each acquisition as follows:

- T2-wi in the peripheral zone (Fig. 16 on page 25);
- T2-wi in the transition zone (Fig. 17 on page 26);
- DCE MRI (Fig. 18 on page 27, Fig. 19 on page 28);
- DWI / ADC map (Fig. 20 on page 29, Fig. 21 on page 30).

**Local staging of prostate cancer**

- Using mp-MRI improves detection of prostate cancer, and also its characterization, indicating more accurate extracapsular extension and invasion of seminal vesicle, distal sphincter, bladder neck or other surrounding structures.

- This improved staging of prostate cancer, especially in differentiating stages T2 and T3a. It is much easier to identify abutement, irregularity, bulge or loss of the prostatic capsule.

- In the following figures are present MRI examples regarding the T staging of prostate cancer (Fig. 22 on page 31, Fig. 23 on page 32, Fig. 24 on page 33, Fig. 25 on page 34).

**The differential diagnosis of the prostate cancer**

The differential diagnosis of the prostate cancer is mainly performed with these pathological entities:

- **Benign prostatic hyperplasia** appears as a well-defined area with nodular structure located in the central gland that compress the peripheral zone (Fig. 26 on page 35).

- **Chronic prostatitis, scars or post-radiation therapy changes** usually appears as an area of low signal intensity with a wedge/linear shape and a diffuse distribution within prostate without mass, more easily identified in the peripheral zone (Fig. 27 on page 36). Acute prostatitis appears as an area with high signal intensity on T2-wi and low signal intensity on T1-wi; acute prostatitis can extend through the prostatic capsule into the surrounding structures.

- **Prostatic changes after biopsy.** Blood within prostate after biopsy appears as areas with high signal intensity on T1-wi and low signal intensity on T2-wi. We suggest to avoid MRI examination for 6-8 weeks after the procedure (Fig. 28 on page 37).

- **Prostatic calcifications** appears as punctuate areas with low signal intensity on both T1-wi and T2-wi sequences (Fig. 29 on page 38).
Images for this section:

**Fig. 11:** Prostatic tumoral nodule. An area of low signal intensity in the left PZ suggestive of prostate cancer (arrows).
**Fig. 12**: Dynamic Contrast-Enhanced MRI. The central gland is enlarged with well defined adenomatous nodules (arrowheads); T1-wi sequences show several small areas with early enhancement and slightly washout of contrast agent (arrows) in the central gland.
**Fig. 13**: Dynamic Contrast-Enhanced MRI (the same patient as in Fig.12). The region of interest (ROI) placed on the right side of the central gland shows a type 3 of time-intensity curve suggesting cancerous tissue, and the ROI placed on the right side of the PZ shows a type 1 of time-intensity curve.
Fig. 14: Tumoral lesion in the left PZ. Hypointense tumoral lesion in the left PZ on T2-wi acquisition with extracapsular extension invading the left seminal vesicle (arrow); DWI and ADC map show diffusion restriction (intermediate signal on DWI, respectively low signal intensity on ADC map) (arrows).
Fig. 15: Small areas with diffusion restriction in the central gland. The central gland is enlarged with multiple and well defined adenomatous nodules; DWI and ADC map show several small areas with diffusion restriction (arrows), suspicious for malignancy, appearing with low signal intensity / intermediate signal on T2-wi acquisition (arrowheads).
Fig. 16: PI-RADS scoring system - T2-wi for the peripheral zone (PZ). MRI examples.
**Fig. 17:** PI-RADS scoring system - T2-wi for the transition zone (TZ). MRI examples.
**Fig. 18:** PI-RADS scoring system - Dynamic Contrast-Enhanced MRI. T2-wi: the central gland is enlarged (arrows) with multiple and well defined adenomatous nodules. DEC-MRI: heterogeneous and persistent enhancement expressed in the central gland; DWI and ADC map: no diffusion restriction.
**Fig. 19:** PI-RADS scoring system - Dynamic Contrast-Enhanced MRI (the same patient as in Fig. 18). All ROIs placed on the prostate show a type 2 of time-intensity curve. MRI findings suggest benign prostatic hyperplasia.
**Fig. 20:** PI-RADS scoring system - DWI and ADC map. Chronic inflammatory changes in the left PZ appears as diffuse area of low-signal-intensity without mass on T2-wi acquisition (arrow) corresponding to slightly low-signal-intensity on ADC map (arrowhead).
Fig. 21: PI-RADS scoring system - DWI and ADC map. T2-wi: hypointense tumoral nodule located in the central gland at the level of the base of the prostate (arrow); DWI/ADC map: high signal in the lesion on DWI corresponding to low signal on ADC map indicating restricted diffusion (arrowheads).
**Fig. 22:** T2 stage. T2-wi: small hypointense tumoral nodule located in the right PZ (arrow); DWI/ADC map: high signal in the lesion on DWI corresponding to low signal on ADC map indicating restricted diffusion (arrowheads).
Fig. 23: T3a stage. Hypointense tumoral lesion located in the right PZ (arrows) with extracapsular extension; this tumor does not invade the seminal vesicles.
**Fig. 24:** T3b stage. Hypointense tumoral lesion located in the left PZ (arrows) with extracapsular extension invading the left seminal vesicle (arrowheads).
**Fig. 25**: T4 stage. Prostate tumor invading both seminal vesicles (blue arrows) and distal rectum (white arrowheads); obliteration of the fat plane between tumor and the bladder wall (blue arrowhead); left iliac adenopathy (white arrow).
**Fig. 26:** Benign prostatic hyperplasia. Multiple and well defined adenomatous nodules in the central gland; the postero-inferior wall of the bladder is elevated due to the enlarged central gland (arrows).
Fig. 27: Inflammatory changes in the PZ. Small diffuse areas of low-signal-intensity with a wedge shape without mass on T2-wi acquisition (arrowheads) corresponding to slightly low-signal-intensity on ADC map (arrows).
**Fig. 28:** Prostate changes after biopsy. Blood product in the PZ, after biopsy, appears in high signal intensity on T1-w images (arrows), respectively low signal intensity on T2-w images (arrowheads).
**Fig. 29:** Prostatic calcifications. Punctuate areas within in the central gland with low signal intensity on both T1-wi and T2-wi sequences (arrows).
Conclusion

- Conventional sequences are useful to evaluate prostate cancer in the peripheral zones.

- DWI and DCE extent the MR diagnostic accuracy particularly in central and anterior fibromuscular stroma zones.

- Multiparametric MRI can provide superior informations regarding detection and staging in prostate cancer, including extra-capsular extension.

ACKNOWLEDGEMENT: This work received financial support through the project entitled "CERO - Career profile: Romanian Researcher", grant number POSDRU/159/1.5/S/135760, cofinanced by the European Social Fund for Sectoral Operational Programme Human Resources Development 2007-2013.

Personal information

Dr. Popa Gelu-Adrian

geluadrianpopa@yahoo.com

Fundeni Clinical Institute, Department of Radiology

"Carol Davila" University of Medicine and Pharmacy

Bucharest, Romania

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