PROSTATE MRI

Stephen McManus, MD

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Prostate MRI - *Indications*

- INITIAL DETECTION, STAGING, RECURRENT TUMOR LOCALIZATION, RADIATION THERAPY PLANNING

- INITIAL DETECTION
  - Clinically suspected prostate cancer before or after TRUS negative biopsy
- STAGING in patients with biopsy proven prostate cancer
  - Low risk: confirm absence of more significant tumor
  - Intermediate risk: detect extra-capsular disease, assess neurovascular bundles
  - High risk: detect extra-capsular disease, nodes and bones
- RADIATION THERAPY PLANNING
  - Limit collateral damage
- RECURRENT TUMOR LOCALIZATION
  - PSA relapse after definitive therapy

Dynamic Contrast-enhanced–magnetic Resonance Imaging Evaluation of Intraprostatic Prostate Cancer: Correlation with Radical Prostatectomy Specimens

Philippe Puech, Eric Potiron, Laurent Lemaitre, Xavier Leroy, Georges-Pascal Haber, Sebastien Crouzet, Kazumi Kamoi, and Arnauld Villers

OBJECTIVES To determine the diagnostic performance of dynamic contrast-enhanced–magnetic resonance imaging (DCE-MRI) in the identification of intraprostatic cancer foci related to cancer volume at histopathology, in patients with clinically localized cancer treated by radical prostatectomy, with whole-mount histopathologic sections as the reference standard.

METHODS Eighty-three consecutive radical prostatectomy specimens from patients referred for a prostate-specific antigen elevation were correlated with prebiopsy MRI. MRI results ranked on a 5-point scale were correlated with the findings of histopathology maps in 8 prostate sectors, including volume, largest surface area, and percentage of Gleason grade 4/5. The area under the receiver operating characteristic curve was used.

RESULTS Median prostate-specific antigen was 8.15 ng/mL. DCE-MRI was suspicious in 55 (66%) out of 83 patients. A separate cancer foci (mean 2.55 per patient) was present in 212 (34%) of 664 octants and DCE-MRI was suspicious in 68 of 212. Sensitivity and specificity of DCE-MRI at score 3.4 or 5 for identification of cancer foci at any volume was 32% and 95%, respectively. For identification of cancer foci > 0.5 mL, the sensitivity and specificity were 86% and 94%, respectively, with the under the receiver operating characteristic curve of 0.874. Mean volume of DCE-MRI detected and missed cancers were 2.44 mL (0.02-14.5) and 0.16 mL (0.005-2.4), respectively. Sensitivity and specificity of DCE-MRI for identification of > 10% of Gleason grade 4/5 were 81% and 82%, respectively.

CONCLUSIONS DCE-MRI can accurately identify intraprostatic cancer foci. Possible applications are guidance for biopsies, selection of patients for watchful waiting, and focal treatment planning. UROLOGY 74: 1094–1100, 2009.

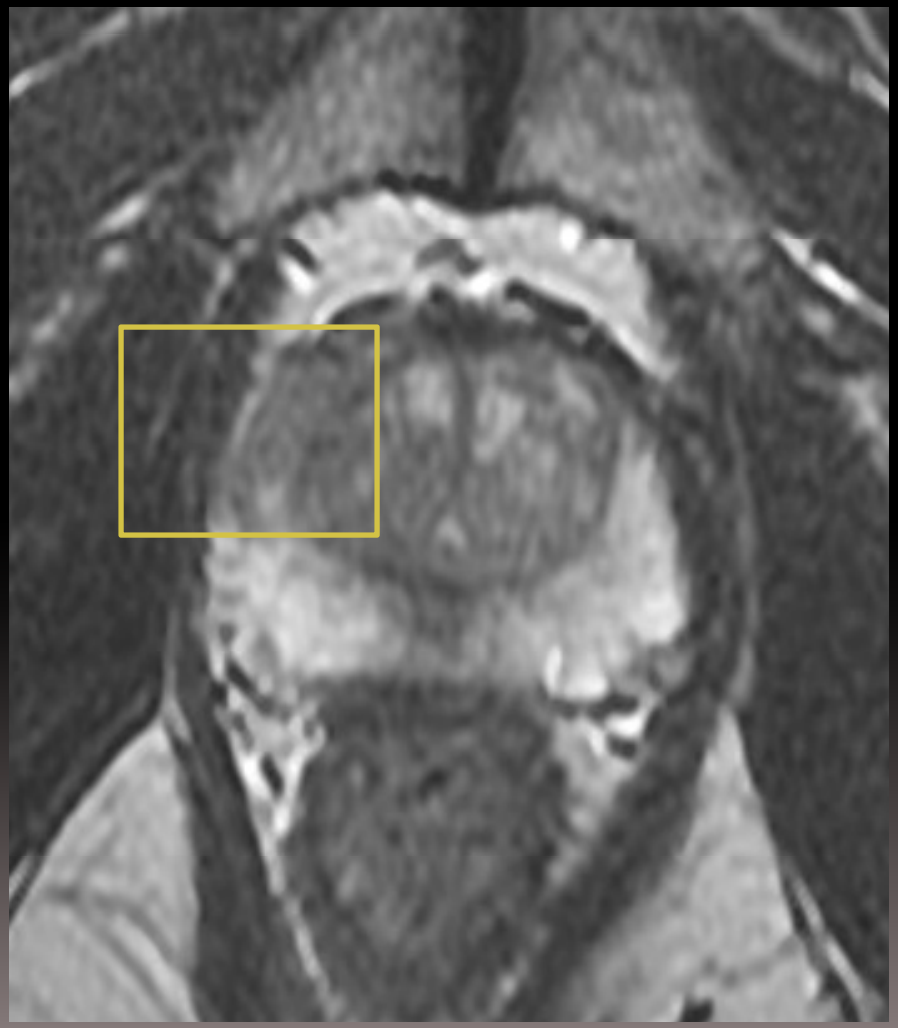
The detection of a prostatic cancer relies on systematic biopsies in case of increased prostate-specific antigen (PSA) or abnormal digital rectal examination. Magnetic resonance imaging (MRI) is commonly used after a negative systematic transrectal ultrasound (TRUS)-guided biopsy and a high cancer suspicion, to find an abnormality and/or to detect extraprostatic or lymph node invasion. A better knowledge of preoperative cancer characteristics, that is, location, size, surface area, cancers than in benign prostate tissues.[1] It was shown that prostate MRI using a high-resolution pelvic phased-array (PPA) coil either stand alone[2] or combined with endorectal coil[3] and of T1-weighted imaging (T1-WI) sequences may result in higher localization rates due to better signal homogeneity, especially in the anterior compartment.[4] Current MRI protocols can combine other MRI sequences including proton spectroscopy or diffusion-weighted imaging.[5,6] In a recent review of the

Initial detection

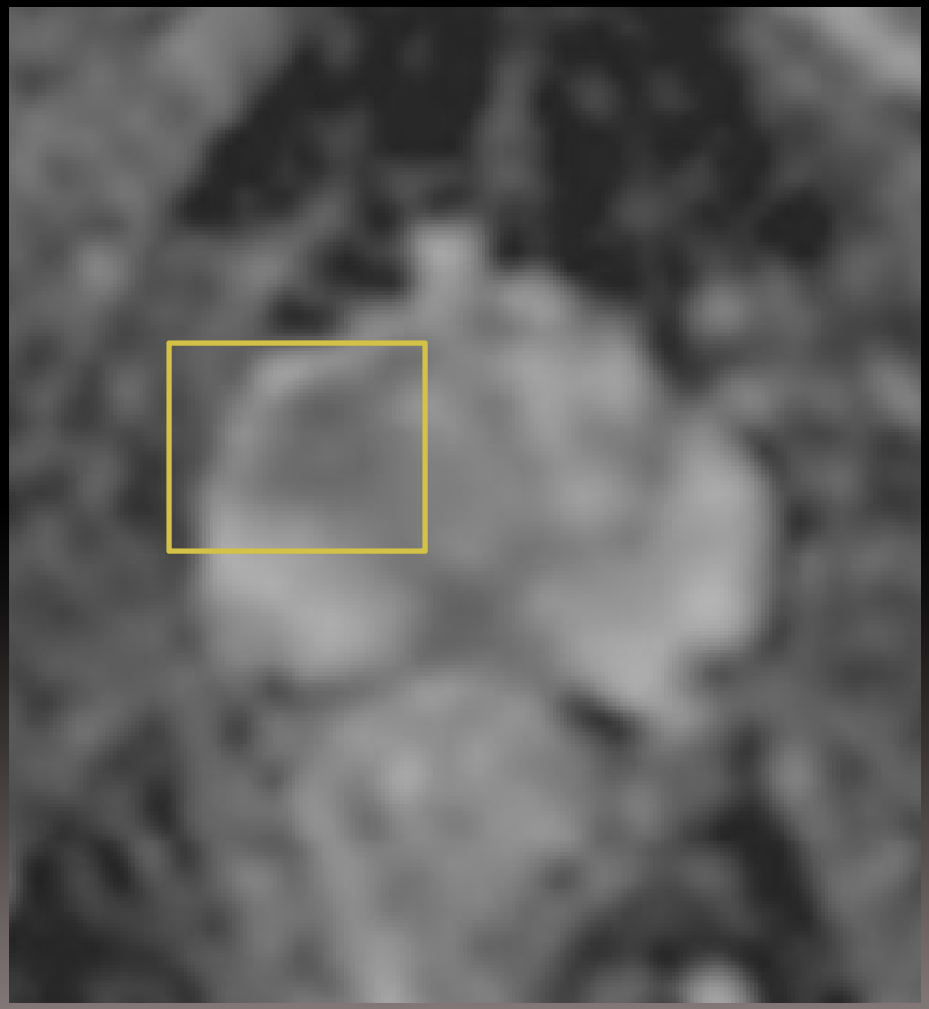
- 83 patients
  - Pre-biopsy MRI followed by radical prostatectomy
  - Specimens compared with pre-biopsy MRI results
- PPV of MRI was 76% (68/90)
- NPV of MRI was 75% (498/664)
- For cancer > 0.5 cc:
  - sensitivity of 86%
  - specificity of 94%

Puech P, Potiron E, Lemaitre L, et al. Dynamic contrast-enhanced-magnetic resonance imaging evaluation of intraprostatic prostate cancer: Correlation with radical prostatectomy specimens. Urology 2009;74:1094-99.

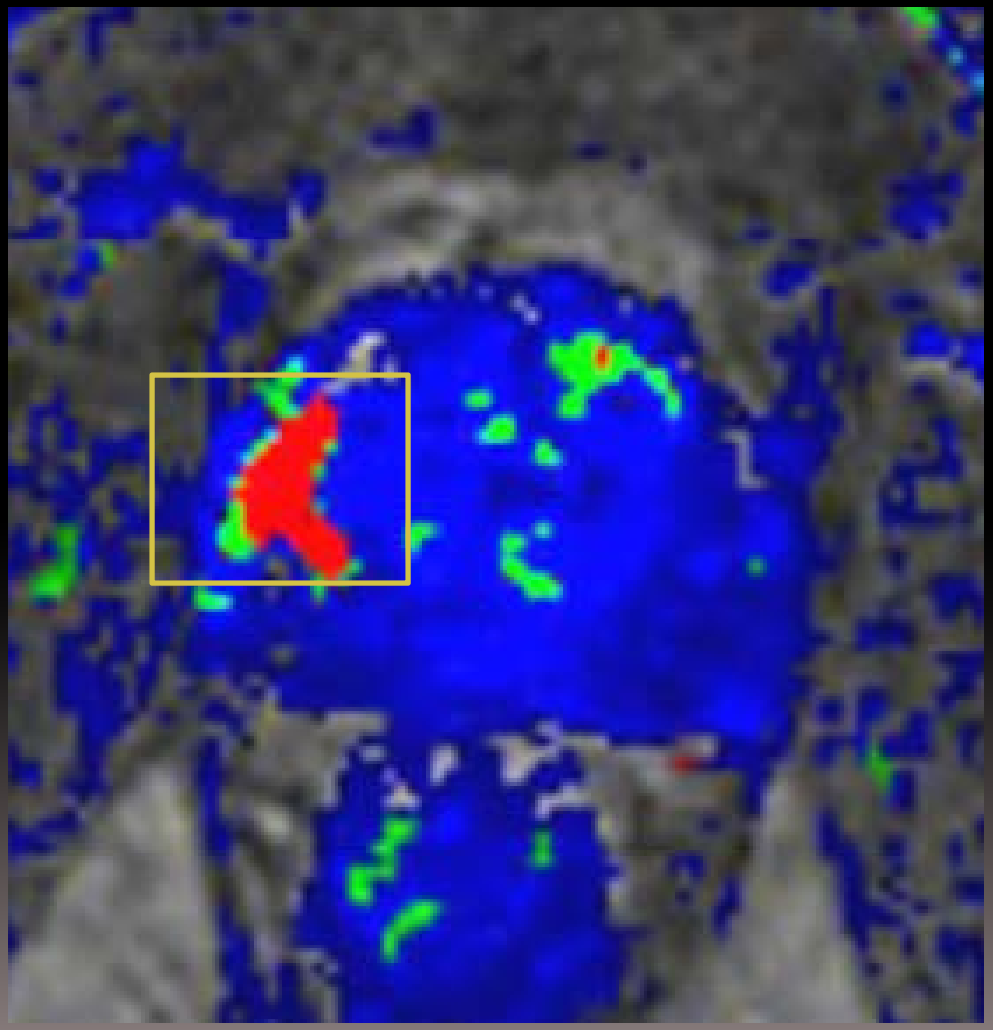
65 yo PSA=5.9
Negative TRUS biopsy



ADC map= restricted diffusion



Color Map =
Rapid wash in & washout



Targeted rebiopsy: Gleason 6 cancer

Staging low risk patients prior to active surveillance

Percentage of men under active surveillance for insignificant prostate cancer reclassified as significant cancer at 2 years is :

20–30%

BJUI

Preoperative nomograms incorporating magnetic resonance imaging and spectroscopy for prediction of insignificant prostate cancer

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*Departments of *Medical Physics, †Radiology and §Urology, Memorial Sloan-Kettering Cancer Center, New York, NY, ‡Department of Quantitative Health Sciences, Cleveland Clinic, Cleveland, OH, USA, and ¶Department of Urology and Department of Urology and Microbiology, Faculty of Medicine, Saga University, Saga, Japan*

Accepted for publication 10 June 2011

Study Type – Prognosis (case series)
Level of Evidence 4

What's known on the subject? and What does the study add?
Nomograms are available that combine clinical and biopsy findings to predict the probability of pathologically insignificant prostate cancer in patients with clinically low-risk disease. Based on data from patients with Gleason score 6, clinical stage ≤ T2a and PSA <20 ng/ml, our group developed the first nomogram models for predicting insignificant prostate cancer that incorporated clinical data, detailed biopsy data and findings from MRI or MRI/MRSI (BJU Int. 2007;99(4):786–93). When tested retrospectively, these MR models performed significantly better than standard clinical models with and without detailed biopsy data.

We prospectively validated the previously published MR-based nomogram models in a population of patients with Gleason score 6, clinical stage ≤ T2a and PSA <10 ng/ml. Based on data from this same population, we also developed two new models for predicting insignificant prostate cancer that combine MR findings and clinical data without detailed biopsy data. Upon initial testing, the new MR models performed significantly better than a clinical model lacking detailed biopsy data.

OBJECTIVES

- To validate previously published nomograms for predicting insignificant prostate cancer (PCa) that incorporate clinical data, percentage of biopsy cores positive (%BC+) and magnetic resonance imaging (MRI) or MRI/MR spectroscopic imaging (MRSI) results.
- We also designed new nomogram models incorporating magnetic resonance results and clinical data without detailed biopsy data. Nomograms for predicting insignificant PCa can help physicians counsel patients with clinically low-risk disease who are choosing between active

- There were four models incorporating MRI or MRI/MRSI and clinical data with

and similarly to the more comprehensive clinical model.

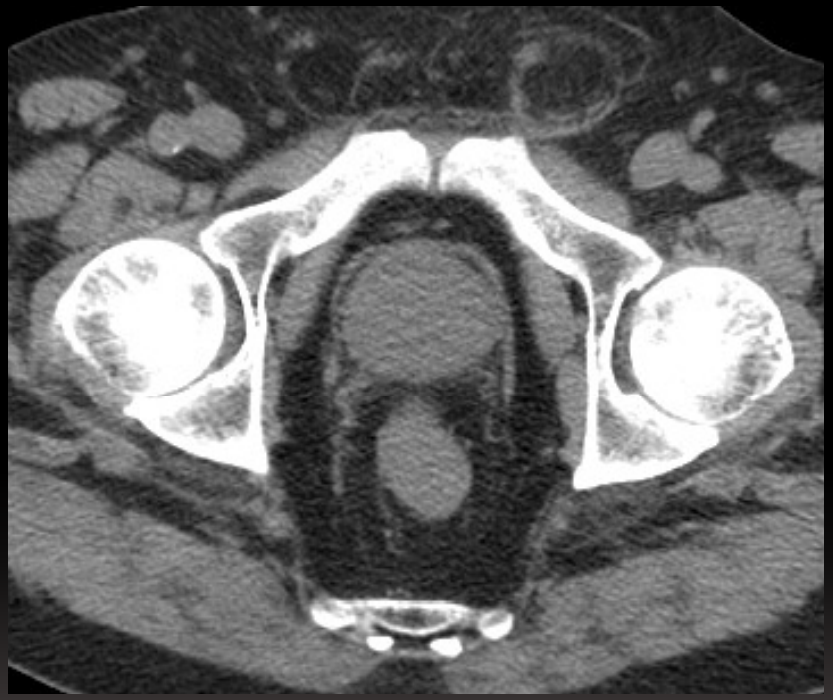
Low risk patients

- 181 low risk prostate cancer patients
- All had MRI before prostatectomy
- At surgical pathology, Gleason score was upgraded in 56% of patients
- MRI performed better than regular clinical models in predicting likelihood of insignificant disease

Shukla-Dave A, Hricak H, Akin O, et al. Preoperative nomograms incorporating magnetic resonance imaging and spectroscopy for prediction of insignificant prostate cancer. BJU International 2011;109:1315-22.

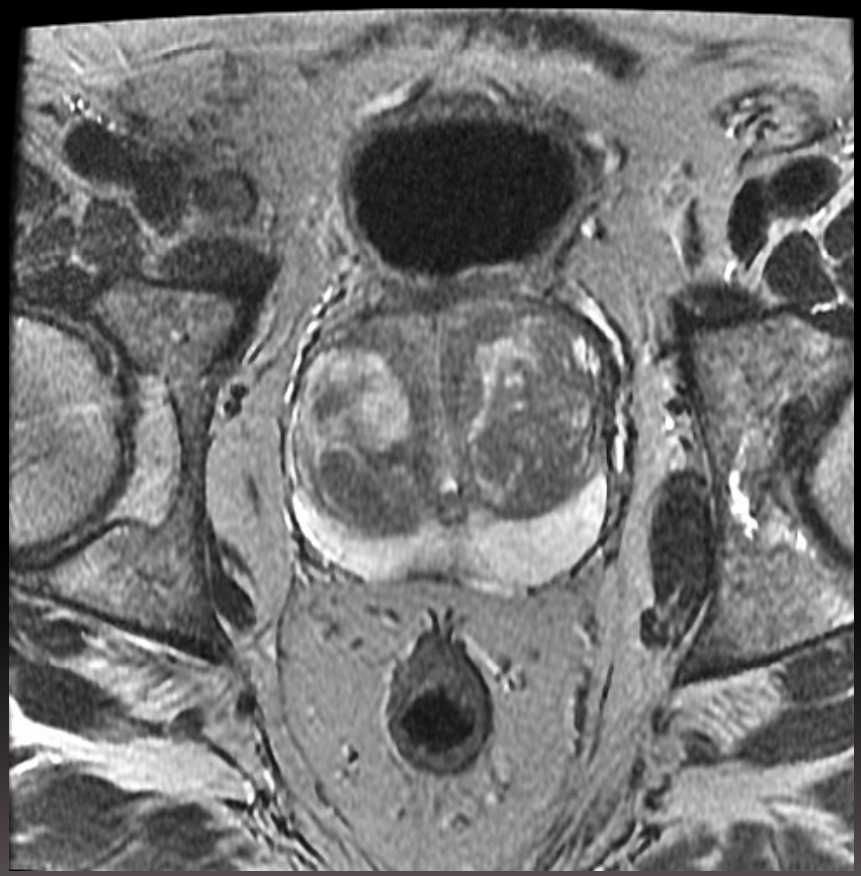
Imaging for radiation therapy planning

- CT typically used for external beam therapy due to ability to acquire 3D data set
- CT however is limited by:
  - Poor organ delineation
  - Ability to acquire images only in axial plane



MRI for radiation therapy planning

- MRI offers three main benefits:
  - Better spatial resolution = detailed anatomy and less collateral damage
  - Multiplanar acquistion
  - Target lesions for boosting



Strahlentherapie
und Onkologie

Original Article

Definition of the CTV Prostate in CT and MRI by Using CT–MRI Image Fusion in IMRT Planning for Prostate Cancer

Bettina Hentschel[1], Wolfgang Oehler[1], Dirk Straußß[1], Andreas Ulrich[2], Ansgar Malich[2], Bettina Hentschel[3]

Purpose: To determine the prostate volumes defined by using MRI and CT scans, as well as the difference between prostate delineation in MRI and CT in three dimensions (3D). A further goal was to use MRI to identify subgroups of patients in whom seminal vesicle irradiation can be avoided.

Methods and Materials: A total of 294 patients with biopsy-proven prostate cancer (MRI stages: T_1, 16 [5%]; T_2, 84 [29%]; T_3, 191 [65%]; T_4, 3 [1%]) underwent pelvic CT and MRI scans before intensity-modulated radiation therapy (IMRT) planning. 3D images were used to compare the prostate volumes defined by superimposed MR and CT images. Prostate volumes were calculated in cm^3.

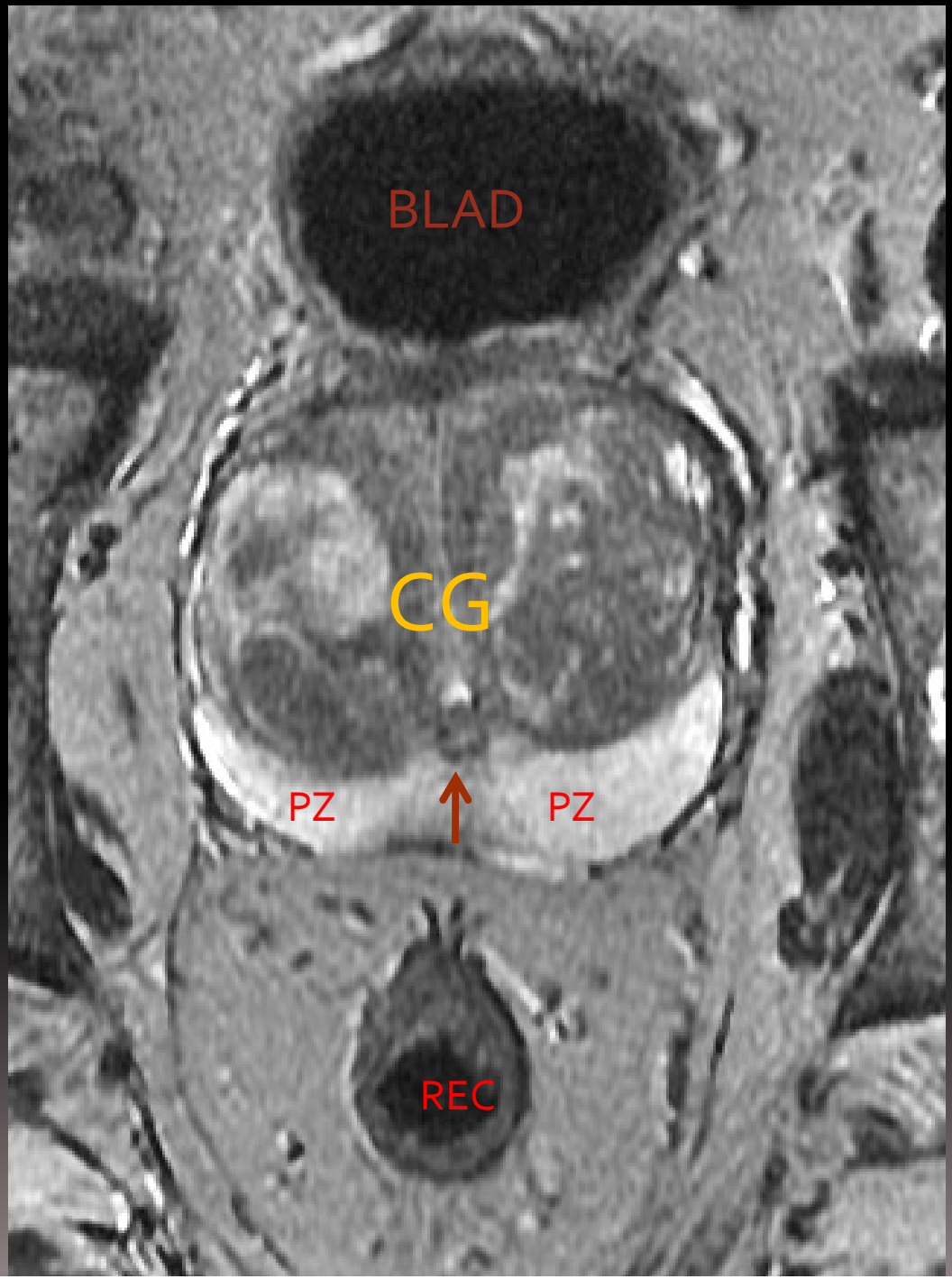
Results: The mean prostate volume defined by MRI (44.3 cm^3 [range, 8.8–182.8 cm^3]) was 35% smaller than that defined by CT (68.5 cm^3 [range, 15.2–241.3 cm^3]). The areas of nonagreement were observed predominantly in the most superior and inferior portions of the prostate. The incidence of seminal vesicle invasion (SVI) identified by MRI was 63% (n = 182 of 290). The median length of SVI was 2.6 cm (range, 1.1–4.7 cm; 62% of the median SV length). The low-risk patients (59%, n = 171 of 290) calculated by applying the Roach and Diaz formula had a SVI rate of 57% (n = 97 of 171), the high-risk patients (41%, n = 119 of 290) of 71% (n = 85 of 119).

Conclusions: Compared with MRI, CT scans overestimate prostate volume by 35%. CT–MRI image fusion-based treatment planning allows more accurate prediction of the correct staging and more precise target volume identification in prostate cancer patients.

Key Words: Prostate cancer · MRI · Definition of prostate CTV · IMRT

Defining CTV with MRI vs. CT

- 294 patients with prostate cancer underwent MRI and CT prior to IMRT
- 3D images were used to calculate volume on MRI and CT
- Mean prostate volume was 35% smaller than mean CT volume
- MRI also more correctly identified SV invasion when compared with Roach-Diaz model
  - Limiting SV radiation reduces irradiated rectal volumes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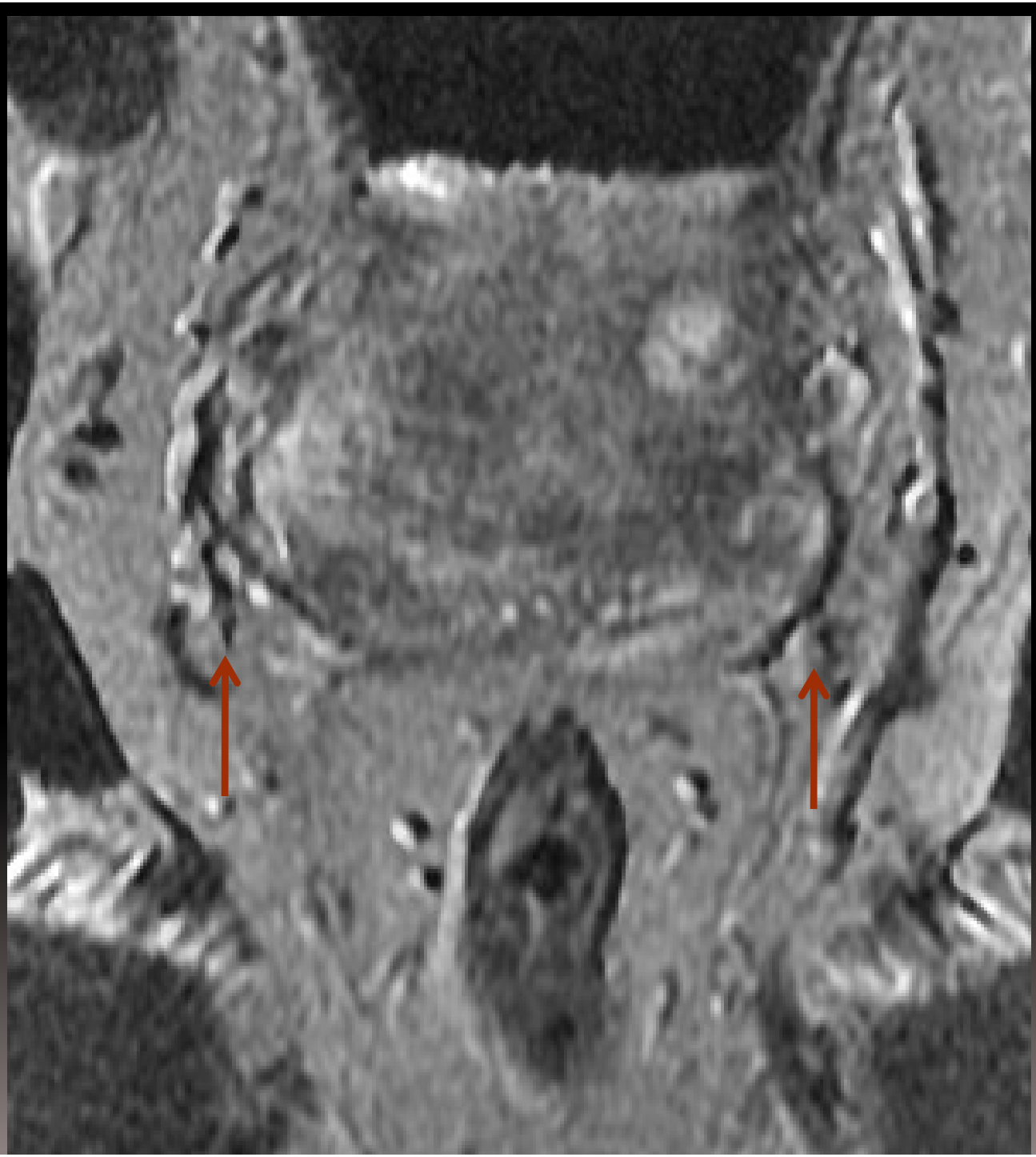

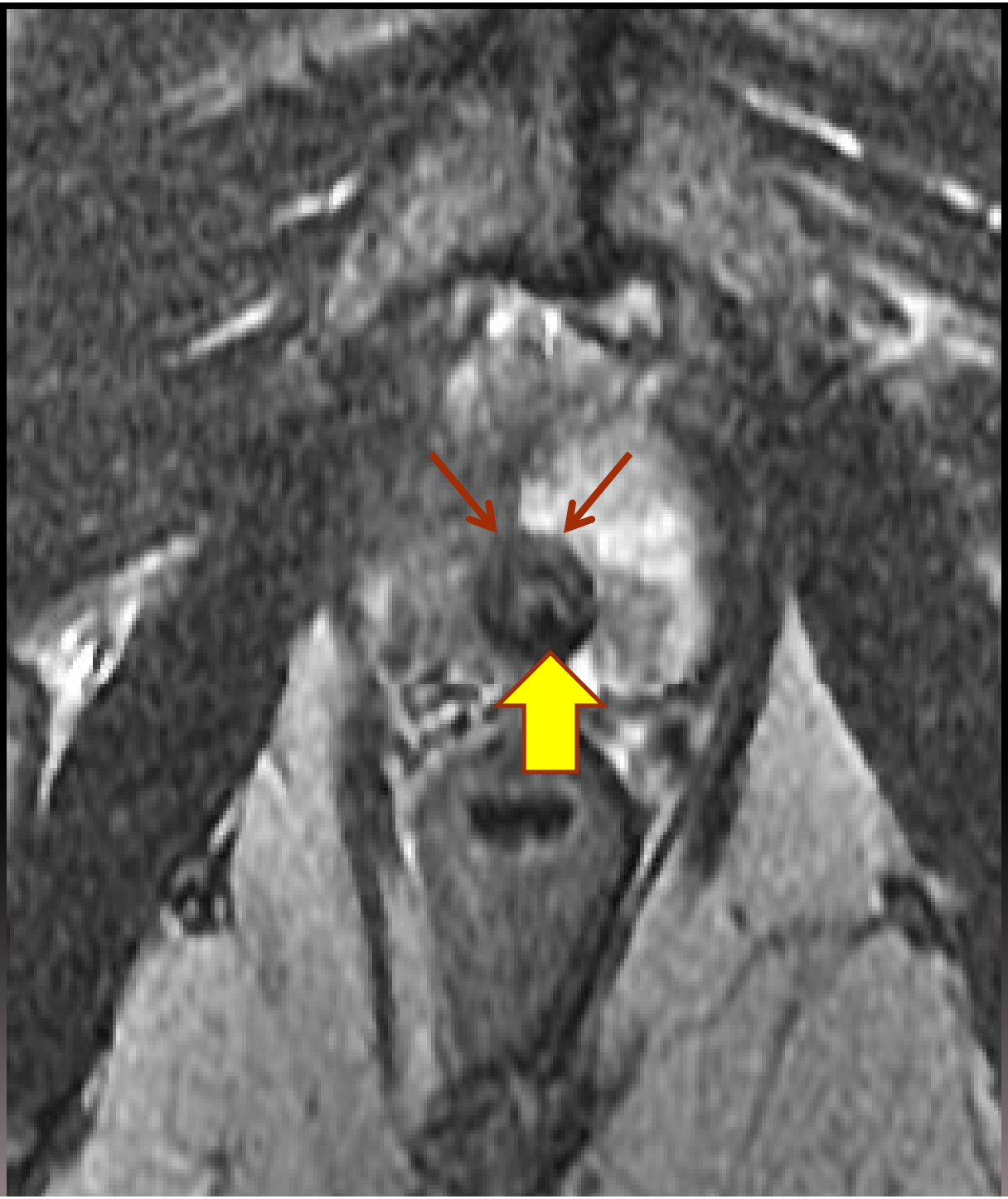

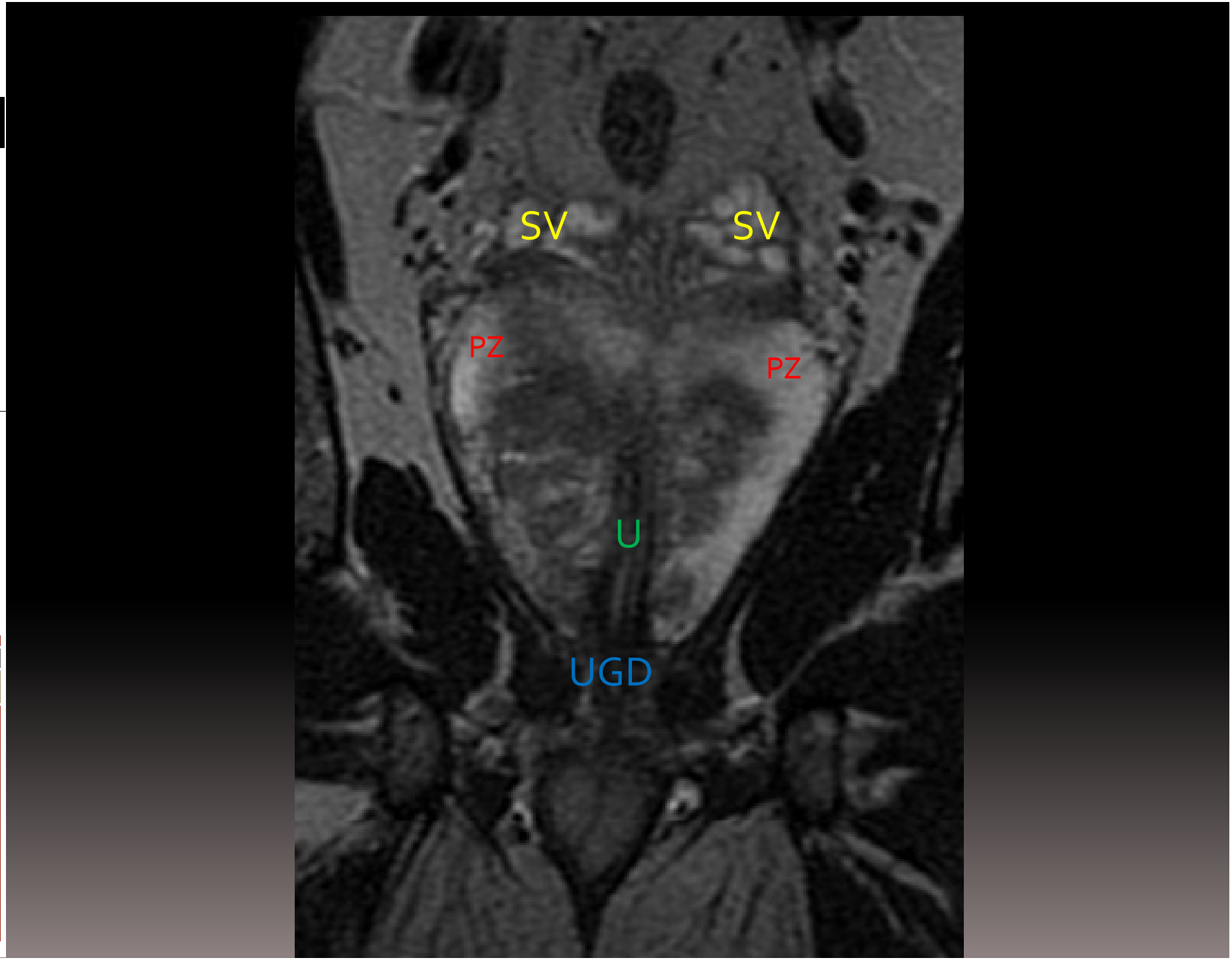
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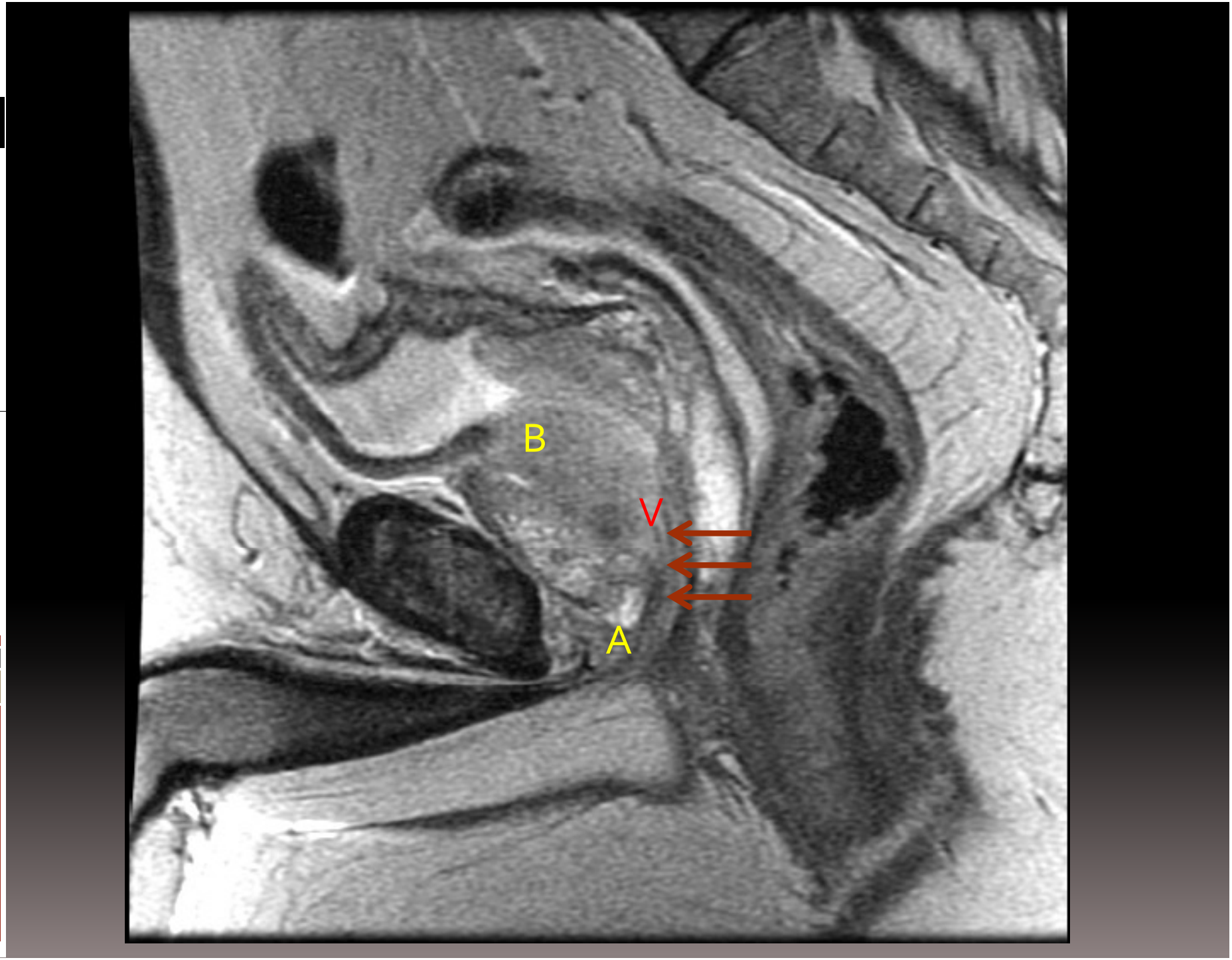
B
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Recurrent tumor localization

- Evaluate patients with biochemical failure
- Biopsy proven recurrence rate after radical prostatectomy: 32-54%
- Digital rectal examination and TRUS are often inadequate in detecting recurrent disease

Endorectal and Dynamic Contrast-Enhanced MRI for Detection of Local Recurrence After Radical Prostatectomy

Emanuele Casciani[1]
Elisabetta Polettini[1]
Enrico Carmenini[2]
Irene Floriani[3]
Gabriele Masselli[1]
Luca Bertini[1]
Gian Franco Gualdi[1]

OBJECTIVE. The objective of our study was to evaluate the sensitivity and specificity of endorectal MRI combined with dynamic contrast-enhanced MRI to detect local recurrence after radical prostatectomy.

MATERIALS AND METHODS. A total of 51 patients who had undergone radical prostatectomy for prostatic adenocarcinoma 10 months to 6 years before underwent a combined endorectal coil MRI and dynamic gadolinium-enhanced MRI before endorectal sonographically guided biopsy of the prostatic fossa. The MRI combined with MR dynamic imaging results were correlated with the presence of recurrence defined as a positive biopsy result or reduction in prostate-specific antigen level after radiation therapy.

RESULTS. Overall data of 46 (25 recurred, 21 nonrecurred) out of 51 evaluated patients were analyzed. All recurrences showed signal enhancement after gadolinium administration and, in particular, 22 of 24 patients (91%) showed rapid and early signal enhancement. The overall sensitivity and specificity of MR dynamic imaging was higher compared with MRI alone (88%, [95% CI] 69–98% and 100%, 84–100% compared with 48%, 28–69% and 52%, 30–74%). MRI combined with dynamic imaging allowed better identification of recurrences compared with MRI alone (McNemar test: chi-square$_1$ = 16.67; p = < 0.0001).

CONCLUSION. MRI combined with dynamic contrast-enhanced MRI showed a higher sensitivity and specificity compared with MRI alone in detecting local recurrences after radical prostatectomy.

Keywords: contrast-enhanced MRI, MRI, prostate neoplasm, recurrence

In patients with prostate cancer, the site of disease recurrence after radical prostatectomy is a critical issue because it may greatly influence the subsequent therapeutic strategy and patient management. Local recurrence of prostate cancer after radical prostatectomy is a fundamental issue for therapy and follow-up of these patients.

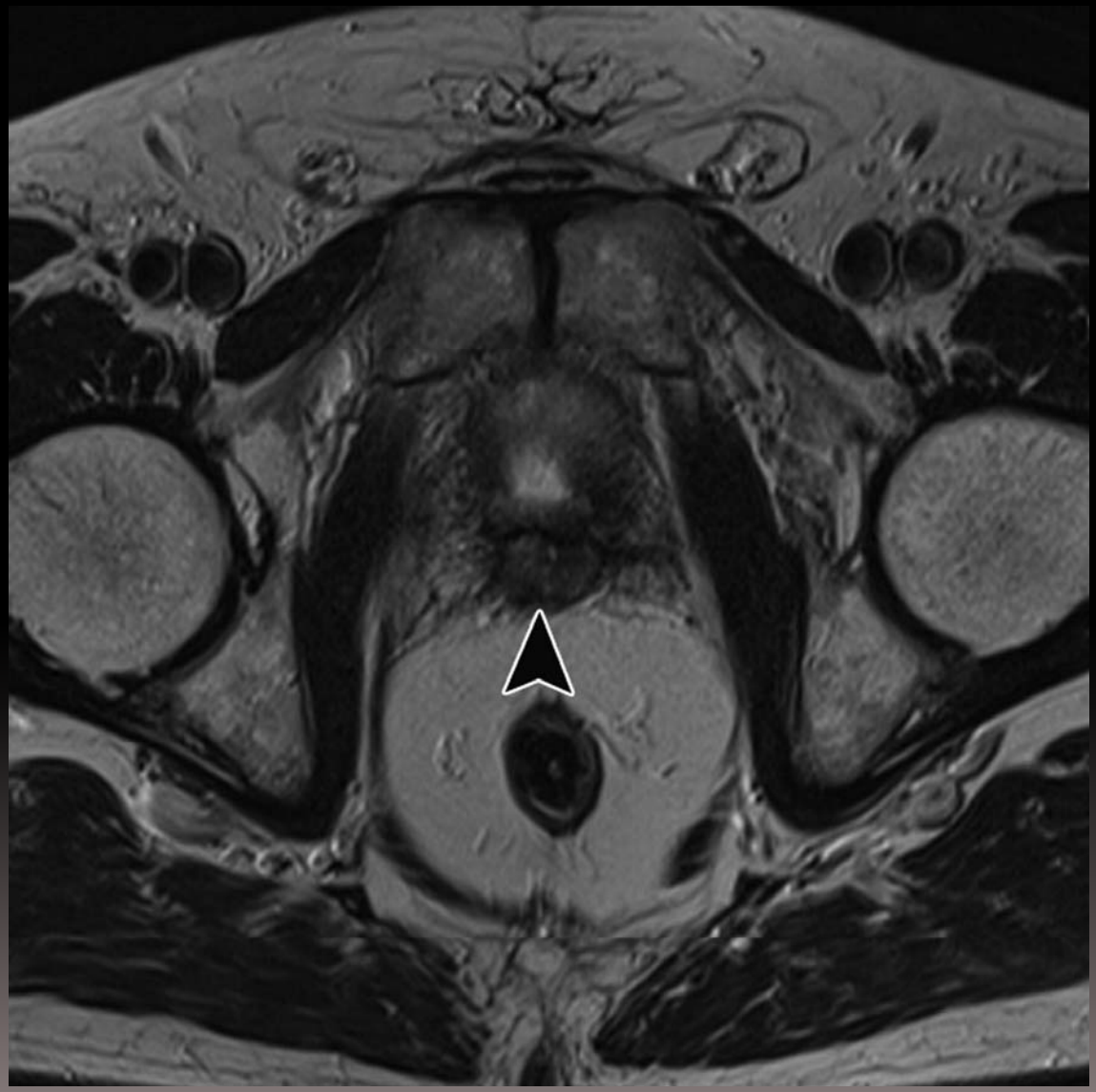
Digital rectal examination (DRE) has been shown to be inadequate in detecting local recurrences [5]. Although endorectal sonography (transrectal ultrasonography, TRUS) is better than DRE for detecting local recur-

Recurrent tumor localization

- 46 patients with biochemical failure underwent MRI followed by TRUS biopsy
  - 25 patients: recurrent tumor
  - 21 patients: no tumor
- DCE MRI for detection of recurrent tumor
  - sensitivity of 88% (22/25)
  - specificity of 100% (21/21)

Casciani E, Polettini E, Carmenini E, et al. Endorectal and dynamic contast-enhanced MRI for detection of local recurrence after radical prostatectomy. AJR 2008;190:1187-92.

Recurrent tumor localization



Sample Report

The following is a report on the examinations performed on the above captioned patient at the GALLOWAY office.

MRI PROSTATE WITH AND WITHOUT INTRAVENOUS CONTRAST

HISTORY: Elevated PSA.

PSA: 6.

COMPARISON: None.

TECHNIQUE: Magnetic resonance imaging of the prostate was performed on a 3 Tesla magnet with a surface phased array coil utilizing multiplanar T1, T2 weighted, diffusion weighted, and dynamic post contrast sequences. Postprocessing was performed with iCAD VividLook software.

CONTRAST: 20 cc IV Optimark.

FINDINGS:

Prostate size: 5.5 x 4.8 x 3.5 cm.
Prostate volume: 46 cc.

Central gland: Heterogenous with no discrete nodule. There is prominence of the median lobe.

Peripheral zone: There are 2 lesions which are low suspicion for malignancy and requires targetedrebiopsy including:

Left mid PZ: 19 x 12 x 9 mm lesion series 9 image 17 and series 5 image 9. This lesion is located 14 mm anterior to the posterior capsule. The midportion of this lesion is 15 mm from the midline. This lesion fills segment 4A. The lesion is low signal on T2, has a type II enhancement and no restricted diffusion.

Left apex: 8 x 8 x 7 mm lesion series 9 image 21 and series 10 image 10. This lesion abuts on the posterior capsule. The center of the lesion is 7 mm from the midline. This lesion straddles segments 5p and 6p. This lesion is low signal on T2, has a type II enhancement and mild restricted diffusion.

Capsule: Intact and smooth without bulging.

Neurovascular bundle: Intact with no evidence of invasion.
Seminal vesicles: Symmetric and within normal limits.

Bladder: Within normal limits.
Pelvic soft tissues: Within normal limits.
Lymph nodes: No adenopathy.
Bones : No aggressive bone lesions.

IMPRESSION:

Parkwood Professional Park · Suite 101 · 44 E. Jimmie Leeds Road · Galloway, NJ 08205 · (609) 677-XRAY (9729) · Fax: (609) 652-6512

[redacted]

Sample Report

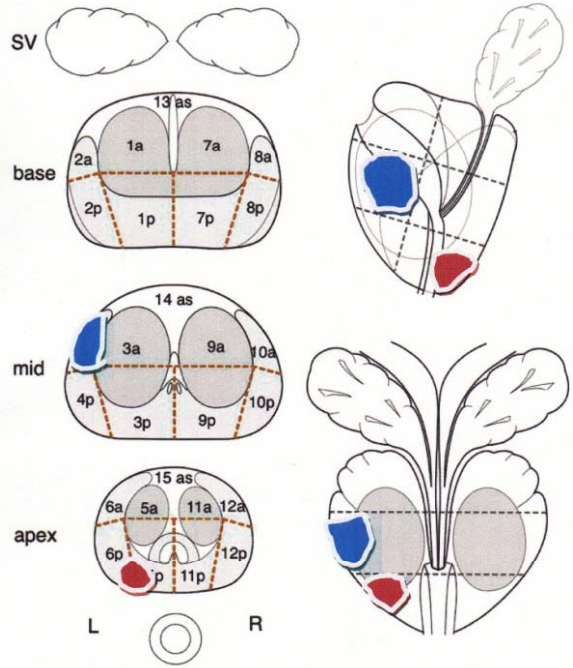
Atlantic Medical Imaging

❒ 44 E. Jimmie Leeds Road, Galloway, NJ 08205
❒ 30 E. Maryland Avenue, Somers Point, NJ 08244
❒ 3100 Hingston Avenue, Egg Harbor Township, NJ 08234
(609) 677-XRAY (9729)

MRI PROSTATE

Patient Name: [redacted] **MRN:** [redacted]
Date of Procedure: August 24, 2012

Twenty-seven Regions of Interest



Twelve posterior (p) and twelve anterior (a) glandular regions - mediolobar and lateral at base, mid and apex.
Three anterior stroma (as) central regions.

PI-RADS: Prostate Imaging- Reporting and Data System

1: Benign features

2: Low suspicion

3: Intermediate suspicion

4: High suspicion

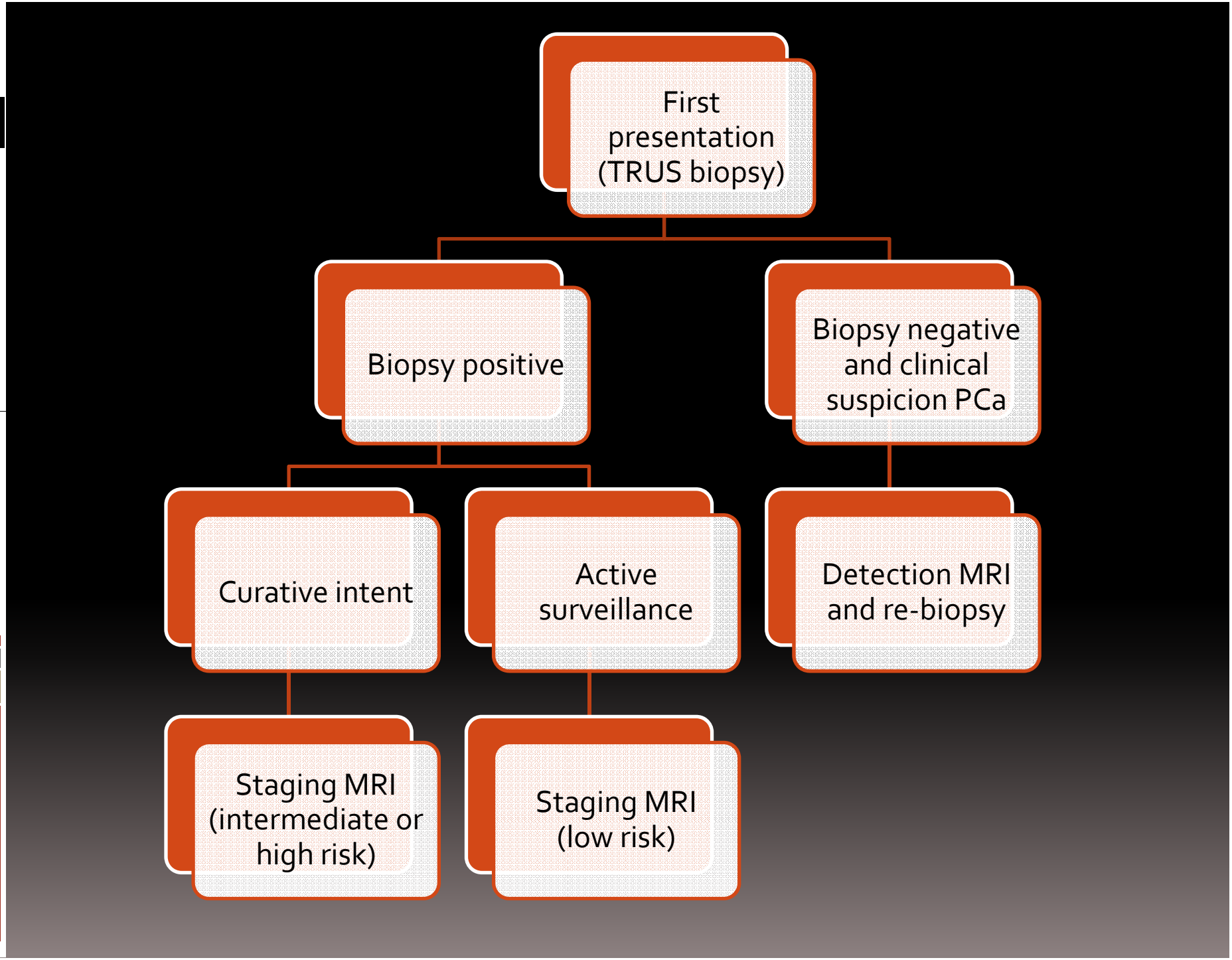
5: Consistent with cancer

Prostate MRI Summary

- MRI is the OPTIMAL modality for imaging the prostate
- Multiparametric approach required to maximize sensitivity and specificity of exam
- Endorectal coil not required
- MRI before radiation therapy affords less collateral damage and better lesion targeting

Prostate MRI Summary

- TRUS negative biopsy : 50% will be recommended for targeted rebiopsy.
- Targeted rebiopsy: 30% positive.
- Active surveillance: MR outperforms standard nomograms for confirming insignificant disease.
- Pre-op ECE/NVB: 72% accuracy
- Suspected recurrent tumor: 88% sensitive.


First presentation (TRUS biopsy)
Biopsy positive
Biopsy negative and clinical suspicion PCa
Curative intent
Active surveillance
Detection MRI and re-biopsy
Staging MRI (intermediate or high risk)
Staging MRI (low risk)