Chirurgia (2015) 110: 262-267
No. 3, May - June

Value of Endorectal MRI in Romanian Men for High Risk of Prostate Cancer: MRI Findings Compared with Saturation Biopsy

A. Lebovici[1], S. A. Sfrangeu[1], C. Caraiani[2], C. Lucan[3], M. Suciu[3], F. Elec[3], Gh. Iacob[4], M. Buruian[4]

[1]Department of Radiology, County Emergency Hospital, "Iuliu Hatieganu" University of Medicine and Pharmacy Cluj-Napoca, Romania
[2]Hiperdia S.A. Medical Center, Cluj-Napoca, Romania
[3]Department of Urology, Clinical Institute of Urology and Kidney Transplant, Cluj-Napoca, Romania
[4]Department of Pathology, Clinical Institute of Urology and Kidney Transplant, Cluj-Napoca, Romania
[5]Department of Radiology, County Emergency Hospital, University of Medicine and Pharmacy Targu-Mures, Romania

Rezumat

Valoarea IRM-ului endorectal la bărbații români cu cancer de prostată și risc crescut: rezultate IRM comparate cu biopsia de saturație

Scop: Evaluarea potențialului secvențelor ponderate T2 şi de difuzie în detectarea cancerului de prostată, stadializarea locală şi influența asupra planul terapeutic la paceinții din grupul cu risc crescut.
Material şi Metode: Examinarea IRM endorectală a fost efectuată la 17 bărbați (cu vârsta medie: 66 ani; interval: 58 – 75 ani), valori ale PSA-ului (medie: 20 ng/ mL; interval: 8.6 – 100 ng/mL) şi cancer de prostată confirmat bioptic (scor Gleason mediu: 8; interval: 7 - 9). Rezulatatele examinărilor IRM au fost comparate cu rezultatele histopatologice obținute prin biopsie de saturație standardizată din 20 de cadrane. Prostata a fost divizată în 16 sectoare (10 posteriaore şi 6 anteriaore).
Rezultate: În total, cancerul de prostată a fost detectat la 16 pacienți (94%) analizând numai secvența de difuzie şi la toți cei 17 pacienți (100%) analizând numai secvența ponderată T2 şi în analiza combinată. Pe secvența ponderată T2, 165 de sectoare din 272 au fost suspecte de cancer de prostată şi 124 (75%) au fost pozitive. Pe secvența de difuzie 126 de sectoare din 272 au fost suspecte şi 118 (95%) au fost pozitive. Pe analiza combinată 134 de sectoare din 272 au suspecte de cancer de prostată şi 126 (94%) au fost pozitive. Acestea relevă o acuratețe a diagnosticului per sector de 76% pentru secvența ponderată T2, 86% pentru difuzie şi 89% pentru analiza combinată. Cancerul de prostată multifocal a fost confirmat atât imagistic cât şi bioptic în 8 din cele 17 cazuri (47%) Extensia extracapsulară (ECE) şi invazia în veziculele seminale (SVI) au fost suspectate în 8 (47%) respectiv 7 (41%) din totalul de cazuri. 6 pacienți (35%) au prezentat atât ECE cât şi SVI. Rezultatele IRM au fost luate în considerare în planul terapeutic şi în nici unul din aceste cazuri nu s-a intervenit chirurgical curativ, în schimb au fost tratați paleativ prin crioterapie, radioterapie şi hormonoterapie.
Concluzii: Examinarea IRM endorectală are o acuratețe crescută în detectarea cancerului de prostată (PCa) în cadrul populației cu risc crescut de dezvoltare a acestei patologii şi joacă un rol important în stadializarea locală, precum şi în planul terapeutic, pentru populația României.

Cuvinte cheie: difuzie, IRM, cancer de prostată, biopsie de saturație

Abstract

Purpose: To evaluate the potentials of T2 weighted (T2W) MRI and diffusion weighted (DW) MRI for prostate cancer (PCa) detection, local staging and treatment planning in high-risk group.
Material and Methods: Endorectal MRI was performed in 17 Romanian men (median age: 66 years; range: 58 – 75 years),

Corresponding author: Andrei Lebovici, MD
Department of Radiology
County Emergency Hospital
"Iuliu Hatieganu" University of Medicine and Pharmacy Cluj-Napoca, Romania
E-mail: andrei1079@yahoo.com

prostate specific antigen (PSA) serum levels (median: 20 ng/ mL; range: 8.6 – 100 ng/mL) with positive findings for PCa (median Gleason score: 8; range: 7 - 9). Imaging findings were compared to standarised 20-core transperineal saturation biopsy. The prostate was divided into 16 standart sectors (10 posterior and 6 anterior).

Results: Overall, prostate cancer was detected in 16 patients (94%) on DW-MRI alone and in all 17 patients (100%) on T2W-MRI alone, and on combined imaging. On T2W-MRI 165 sectors out of 272 were suspicious for PCa and 124 (75%) were cancer positive. On DW-MRI 126 sectors out of 272 were suspicious for PCa and 118 (95%) were cancer positive. On the combined imaging approach 134 sectors out of 272 were suspicious for PCa and 126 (94%) were cancer positive. This resulted in diagnostic accuracies per sector of 76% for T2W-MRI, 86% for DW-MRI and 89% for combined imaging. Multifocal PCa was confirmed both on MR imaging and by biopsy in 8 of the 17 men (47%) Extra capsular extension (ECE) or seminal vesicles invasion (SVI) was highly suspected in 8 (47%) respectively 7 (41%) of the 17 patients. 6 patients (35%) presented both ECE and SVI. MRI findings were taken into account for treatment planning and none of these patients underwent radical prostatectomy and instead was treated with palliative cryotherapy, radiotherapy and hormone therapy.

Conclusions: Endorectal MRI is highly accurate in PCa detection in the high-risk group and seems to have an important role in local staging and treatment planning for Romanian population.

Key words: diffusion, MRI, prostate cancer, saturation biopsy

Introduction

Prostate cancer is a major public health issue through out the world (1). We also noted an increase of PCa cases over the last years in our Romanian population mainly caused by prostate specific antigen (PSA) testing and rising life expectancy (2). The increased use of PSA testing for prostate cancer diagnosis has led to an increased of men scheduled for prostate biopsy in the last decade, which is associated with increased diagnosis of indolent prostate cancer, increasing costs, and biopsy-related complications. Up to 80% of newly diagnosed PCa patients will have localized disease, low PSA serum levels and low risk for tumor recurrence (3). This is true for developed countries with efficient screening programs but in countries with no prompt programme and large percent of the population with poor health education the probability of locally advanced disease in the moment of diagnosis associated with high PSA serum levels and high risk for recurrence, is more likely. The treatment options for PCa are highly variable and consist of watchful waiting, radical prostatectomy, hormone therapy, and radiation therapy and newly introduced focal therapy methods such as cryo-therapy or ablation therapy (4). In generally patient with localised disease will undergo radical prostatectomy while dose with locally advanced cancer will benefit from non-surgical procedures. Prediction of ECE or SVI will spare the patients from radical prostatectomy and its well-known complications (4) and will guide them to a more suitable treatment option. This is why accurate detection and staging prior to treatment decision is of extreme importance. MRI using endorectal coil combined with phased-array coils is the imaging technique of choice in detection and staging of PCa due to high spatial and contrast resolution and multiplanar reconstruction possibilities. This imaging technique is in constant development and it shown in the last decade an important improvement in technology with the introduction of multiparametric MR and increased reader experience (5). Therefore we evaluated a well-established imaging modality and considering the costs we tested T2W-MRI and DW-MRI for PCa detection, local staging and its influence on treatment decision.

Materials and Methods

Patients

Study data were obtained between January 2011 and October 2012. In this retrospective, single centre study 17 men (median age: 66 years; range: 58 – 75 years) with biopsy proven PCa, belonging to the high risk group having prostate specific antigen (PSA) serum levels (median: 20 ng/ mL; range: 8.6 – 100 ng/mL) and assigned Gleason score of (median 8; range 7 - 9) were included. All patients underwent endorectal MRI composed of T2W-imaging and DW imaging at 1.5T 4 to 6 weeks after PCa confirmation by standardized 20-core transperineal saturation biopsy. Patient characteristics are summarized in *Table 1*. Nobody of the participants has been excluded. Each participant provided written informed consent prior to endorectal MRI and systematic biopsy.

MRI technique and image interpretation

Endorectal MRI was performed with a 1.5T scanner (Symphony, Siemens AG, Erlangen, Germany) using a-8 – channel phased array body coil combined with an endorectal coil (MEDRAD, Inc, Warrendale, PA) After DRE the balloon of the endorectal coil was inflated with 60 mL of air.

T2W-MRI

T2W-MR images were obtained in axial, coronal and sagittal planes using T2W turbo spin echo sequences and the entire prostate was investigated. T2W-MRI parameters are shown in *Table 2*. Low-signal intensity nodules or ill-defined

Table 1. *Patient characteristics*

Characteristic	Value
Median age (range), years	66 (58 – 75)
Median prostate specific antigen (range), ng/mL	20(8.6 – 100)
Median Gleason score (range)	8 (7 – 9)
Median prostate volume (range), mL	42 (32 – 65)

Table 2. *MRI parameters*

	T2W-MRI	DW-MRI
Sequence	Fast spin echo	Spin echo EPI
TR (ms)	5500	3200
TE (ms)	104	90
Flipangle	150°	
FOV (mm^2)	180 x 180	300 x 300
Matrix	256 x 256	128 x 128
Voxel size (mm^3)	0.8 x 0.8 x 3	2.3 x 2.3 x 4
Slice thickness (mm)	3	4
Gap (mm)	0.3	0.3
Spectral suppression	No	Yes
b-values	-	0/400/800
NEX	1	2
TA (min:sec)	4:09	2:40

low-signal intensity areas were considered suspicious for PCa. The criteria for diagnosis of extra-capsular extension included the following: focal bulging of the prostatic contour, disruption of the prostatic capsule, low signal intensity indicative of cancer in periprostatic fat (*Fig. 1*), asymmetry of the neuro-vascular bundle and obliteration of the recto-prostatic angle. Seminal vesicle (SV) invasion was suspected by direct invasion of tumor to the Seminal vesicle, low signal intensity within the Seminal vesicle (*Fig. 2*) and asymmetric seminal vesicles (6).

DW-MRI

DW-MR images were obtained in axial planes using EPI sequences at three b-values (b0, b400 and b800) and restriction of diffusion was quantified by the apparent diffusion coefficient (ADC) value. DW-MRI parameters are shown in *Table 2*. DW-MRI demonstrates PCa as areas with reduced water diffusion due to the high cell density in cancers. To avoid T2-shine-through-effects the ADC value is calculated. On ADC maps PCa is demonstrated as an area with low signal intensity compared to surrounding normal prostatic tissue (7) (*Fig. 3, 4* and *5*). ADC values $< 1.0 \times 10^{-3}$ mm^2/sec were considered suspicious for PCa. Low ADC values ($< 1.0 \times 10^{-3}$ mm^2/sec) outside the prostatic capsule or within the seminal vesicles (*Fig. 2*) were suspicious for extracapsular extension and/or invasion to the seminal vesicles.

Imaging interpretation

Image interpretation was performed by two radiologists with 4 years of experience in uro-radiology and prostate imaging (L.A., C.C.) in consensus. The readers were unaware to the results of biopsy and clinical data. Tissue alterations on MRI were assigned to a 16 region standardised prostate reporting scheme including 10 posterior and 6 anterior glandular sectors (*Fig. 3*) as recommended from a consensus meeting (8). Only areas suspicious for PCa with at least a size of ≥ 5 mm were considered for uro-radiological interpretation and statistical analysis.

Saturation biopsy

Saturation biopsy was done in general anaesthesia and in the supine position. The biopsy needle was guided with trans-rectal ultrasound into the sectors according to the above-mentioned scheme and twenty transperineal cores were obtained.

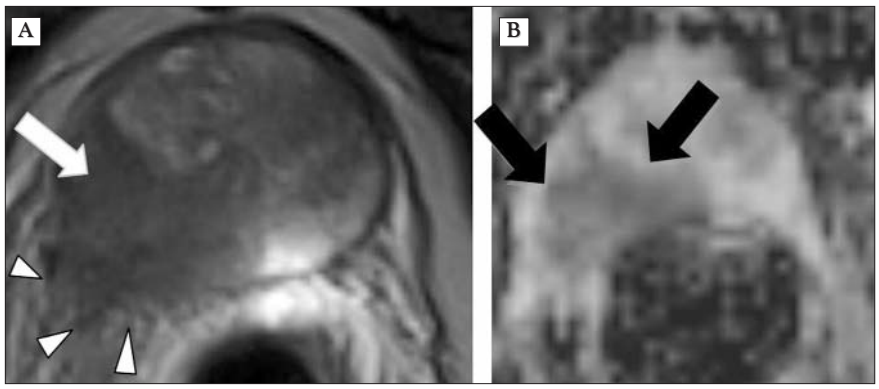

Figure 1. *59 year old patient with PSA level of 26 ng/mL.* ***(A)*** *Axial T2Wi shows multifocal low signal intensity in the right PZ with extension to the inner gland(white arrow) and disruption of the prostate capsule (arrow head) and another low signal intensity foci on the left side (black arrow).* ***(B)*** *ADC map shows the same lesions(black arrows) with low signal intensity values (0.66 x 10^{-3} mm^2 /sec).Histology revealed Pca with assigned Gleason score of 8(4+4)*

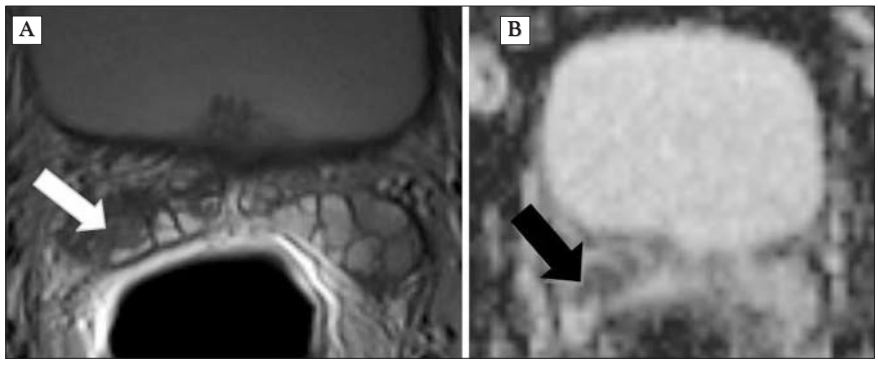

Figure 2. *76 year old patient with PSA level of 21 ng/mL.* ***(A)*** *Axial T2Wi shows low signal intensity within the seminal vesicles on the right side(white arrow).* ***(B)*** *ADC map shows low signal intensity values (0.6 x 10^{-3} mm^2/sec) (black arrows) in the same region. Histology revealed Pca with assigned Gleason score of 7(4+3)*

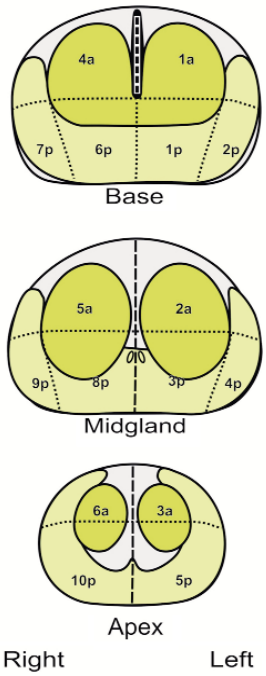

Figure 3. *Prostate segmentation*

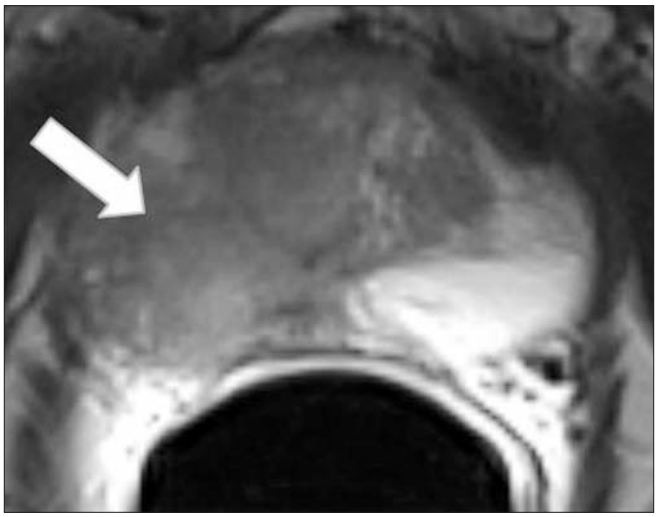

Figure 4. *76 year old patient with PSA level of 100 ng/mL. Axial T2Wi demonstrates an ill defined with low signal intensity lesion located in the mid gland, on the right side (arrow) with invasion of the inner gland. Histology revealed Pca with assigned Gleason score of 9(5+4)*

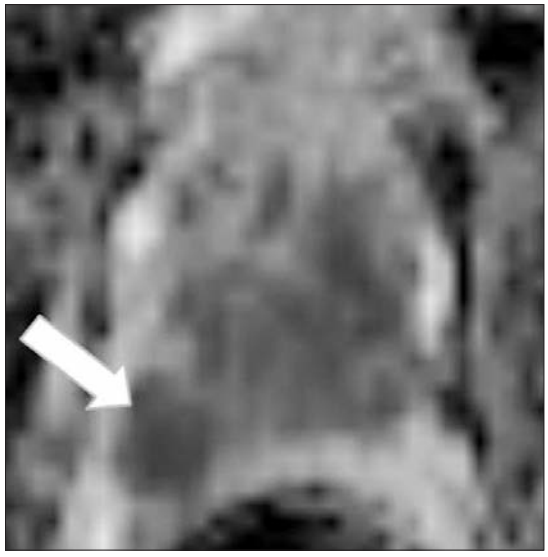

Figure 5. *59 year old patient with PSA level of 50 ng/mL. The ADC map shows marked restricted diffusion (0.62 x 10^{-3} mm^2/sec) in the right posterior peripheral zone (arrow). Histology revealed Pca with assigned Gleason score of 8(4+4)*

Analysis

Histopathological analysis

Each biopsy core was numbered, assigned to a sector and reviewed by a pathologist. Results were reported as cancer with an assigned Gleason score or as benign tissue.

Statistical analysis

Patient characteristics were summarized with frequencies and percentages or with median, range, minimum and maximum values. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy were calculated on a per patient and on a per sector basis. The chi-square test was used to calculate significant differences between both methods for PCa diagnosis. All statistical calculations were performed using SPSS® 18.0 software and a $p < 0.05$ was considered statistically significant.

Saturation biopsy findings

On saturation biopsy cancer was detected in 147 of the 340 probes (43%) at a median prostate volume of 42 ml (range: 32 – 65 ml). The median Gleason score was 8 (range: 7 – 9).

Imaging findings

On T2W-MRI cancer was suspected in all 17 men (100%; false positive findings n = 0) and in 165 of the 272 sectors (85%, false positive findings n = 41). On DW-MRI cancer was suspected in 16 men (94%; false positive findings n = 0) and in 126 of the 272 sectors (80%, false positive findings n = 8). On combined imaging cancer was suspected in all 17 men (100%; false positive findings n = 0) and in 134 of the 256 sectors (91%, false positive findings n = 8).

PCa detection rates

By patient

DW-MRI detected cancer in 16 patients (94%). T2W-MRI, and combined imaging detected cancer in all 17 patients (100%). This resulted in 94% sensitivity, 100% PPV and an overall diagnostic accuracy of 94% by patient for DW-MRI and 100% sensitivity, 100% PPV and an overall diagnostic accuracy of 100% by patient for T2W-MRI, and combined imaging.

By sector

T2W-MRI detected cancer in 124 sectors (84%), DW-MRI in 118 sectors (80%) and combined imaging in 126 sectors (86%). Cancer was detected by T2W-MRI alone in 20/147 sectors and by DW-MRI alone in 10/147 (14% vs 7%, chi-square $p < 0.05$).

This resulted in 84% sensitivity, 67% specificity, 75% PPV, 78% NPV and an overall diagnostic accuracy of 78% by sector for T2W-MRI, in 80% sensitivity, 93% specificity, 93% PPV, 80% NPV and an overall diagnostic accuracy of 86% for DW-MRI and in 85% sensitivity, 94% specificity, 94% PPV, 84% NPV and an overall diagnostic accuracy of 89% for combined imaging (*Table 3*)

Multifocal PCa, ECE and SVI detection rates

Multifocal PCa was suspected in 8 of the 17 men (47%) and was confirmed by biopsy in all 8 (100%). ECE was highly suspected in 8 out of the 17 patients (47%). SVI was detected in 7 out of the 17 patients (41%). 6 patients (35%) presented both ECE and SVI. Sensitivity, specificity, PPV, NPV and diagnosis accuracy couldn't be calculated because of no histopathological confirmation.

Table 3. *Detection of prostate cancer by lesion*

	T2W-MRI	DW-MRI	Combined imaging
Sensivity	84%	80%	85%
Specificity	67%	93%	94%
Positive predictive value	75%	93%	94%
Negative predictive value	78%	80%	84%
Diagnostic accuracy	76%	86%	89%

Discussion

T2W-MRI demonstrates PCa as low-signal intensity areas and reveals only structural tissue information (*Fig. 4, 5* and *6A,B*). High NPVs and high sensitivities are reported for this technique, which may exclude patients with elevated PSA serum levels from systematic biopsy in case of negative imaging findings (9). Nevertheless, benign tissue changes like prostatitis; benign prostatic hyperplasia or adenomyomatosis can also cause low signal intensity on T2W-MRI, which makes this modality more unspecific (10).

Nowadays, it is recommended to add functional MRI techniques to raise specificity of T2W-MRI (11).

Our data suggest that using endorectal MRI in our Romanian population provide excellent diagnostic accuracy for prostate cancer diagnosis, but we have to state that a considerable number of cancers were large. Transrectal ultrasound normally is used in the B-mode to assess prostate anatomy and to guide the biopsy to standardized areas of the prostate. Unfortunately, B-mode ultrasound has low diagnostic accuracy for prostate cancer detection and staging therefore other imaging modalities should be chosen for a targeted approach (12). We have to keep in mind that enhanced transrectal ultrasound techniques, i.e. elastography or contrast media ultrasound lack of availability with its possibility of targeted biopsy under real-time conditions. MRI targeted biopsy of the prostate show cancer detection rates nearly of 60%, but is only available in few centres and need long procedure time (13).

When regarding the overall diagnostic accuracy by patient of 94% for DW-MRI an 100% for T2W-MRI and combined imaging and by lesion of T2W-MRI (76%); DW-MRI (86%) and combined imaging (89%) of this study it should be valuable to report the urologists areas suspicious for PCa on MRI to directly guide the biopsy needle there. Our data has slightly better results than other studies probably due to investigating biopsy confirmed PCa patient in the high-risk group with relatively larger tumors.

A recently published paper of Vilanova et al. investigated MRI before biopsy and reported diagnostic accuracies of 73.5% % for T2W-MRI alone, of 81.8% for DW-MRI alone and of 84.8 % for combined imaging (14). They also recommended combining at least one functional technique with free-to-total PSA ratio to raise diagnostic accuracy. Beside these high detection rates, the authors stated that functional MRI has the potential to help avoid a large number of negative biopsies.

Also Choi MS et al. described the usefulness of pre-biopsy and post-biopsy MRI (15) with sensitivities of 84.8% and 92.4%, PPVs of 75.7% and 92.4%. The MRI location match percentage before and after biopsy was 89.3% and 94.1%. The authors concluded that MRI before prostate biopsy can provide

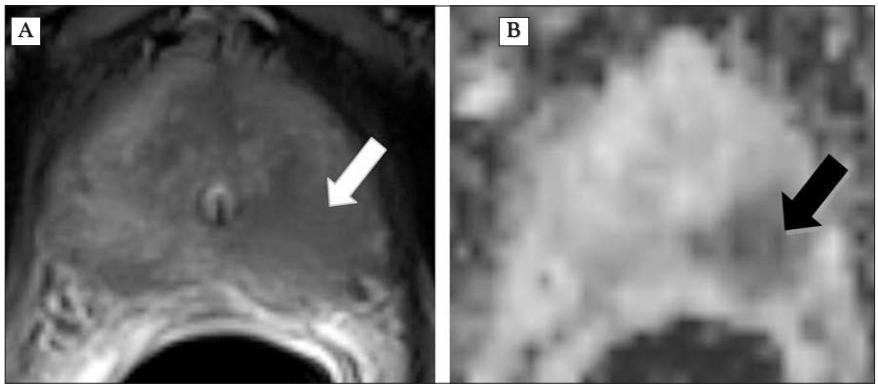

Figure 6. *76 year old patient with PSA level of 21 ng/mL.* ***(A)*** *Axial T2Wi shows diffuse low signal intensity at the level of the left midgland(white arrow).* ***(B)*** *ADC map shows the same lesion(black arrow) with low signal intensity values (0.73 x 10^{-3} mm^2/sec). Histology revealed Pca with assigned Gleason score of 7(4+3)*

more information by which to identify prostate cancer during prostate biopsy and thus reduce the false-negative rate.

Kpandemoi Abu V. reports of a growing interest in the use of imaging techniques like MRI as first-line specialist investigation for suspicious PCa (16). This is an interesting idea, but MRI screening for PCa is not practicable in our country.

In future we tend to implement endorectal MRI for patients with previous negative biopsies but ongoing suspicion of cancer to avoid biopsy in case of negative findings or in case of positive findings to directly guide the biopsy needle towards suspicious areas.

ECE was suspected in 8(47%) of the patients while 7(41%) men were suspected of SVI and in total 6(35%) men had both ECE and SVI. Our urologists took in consideration the MRI report and together with the age, PSA serum levels and Gleason score the treatment plan was decided. As a result none of this patients underwent radical prostatectomy and instead was treated with palliative cryotherapy, radiotherapy and hormone therapy.

Jager GJ et al. analysed the usefulness of preoperative MRI for moderate or high risk of ECE and concluded that preoperative MRI in this group of patients is cost-effective (17).

Ren j et al. evaluated the usefulness of DWi-MRI in the detection of SVI and he reported the AUC for T2W-MRI in combination with DW-MRI (0.897) was significantly higher accuracy than T2W-MRI alone (0.779) in the detection of SVI (18).

Prostate cancer remains a national healthcare problem with increased prevalence (19) a larger well-designed study should be performed in the future to obtain normative references for signal intensity characteristics and ADC values of normal prostate tissue and cancer.

We have to state several limitations: (1) we used systematic biopsy as the reference standard, even though it may miss a substantial percentage of prostate cancers. However, it is the method of choice for cancer detection. (2) Our study population was relatively small. (3) We did not use MR spectroscopy and dynamic contrast enhanced MRI, even we know the improved PCa detection rates and local staging using all 4 MRI techniques. (4) we do not have data on intra-observer and interobserver variability.

Conclusions

The combined use of T2W-MRI and DW-MRI endorectal MRI yields highly accurate PCa detection rates in the high risk group men. In our study endorectal MRI seems to have an important role in local staging and treatment planning. Further studies with a prospective design and in comparison to prostatecomy specimen should be done to reevaluate MRI for prostate cancer diagnosis in our population.

References

1. Jemal A, Siegel R, Xu J, Ward E. Cancer statistics, 2010. CA Cancer J Clin. 2010 Sep-Oct;60(5):277-300 .
2. Vrdoljak E, Wojtukiewicz MZ, Pienkowski T, Bodoky G, Berzinec P, Finek J, Todorović V, Borojević N, Croitoru A; Cancer epidemiology in Central, South and Eastern European countries. Croat Med J. 2011 Aug 15;52(4):478-87.
3. Jemal A, Siegel R, Ward E, Hao Y. Cancer statistics 2009. CA Cancer J Clin 2009;59:225-249.
4. Turini M, Redaelli A, Gramegna P, Radice D. Quality of life and economic considerations in the management of prostate cancer. Pharmacoeconomics 2003; 21:527-541.
5. Hricak H. MR imaging and MR spectroscopic imaging in the pre-treatment evaluation of prostate cancer. Br J Radiol 2005; 78:Spec No 2:S103-S111.
6. Hoeks C, Barentsz JO, Hambrock T, Yakar D. Prostate cancer: Multiparametric MR imaging for detection, localization and saging. Radiology 2011; 261:46-66.
7. Franiel T. Multiparametric magnetic resonance imaging of the prostate - technique and clinical applications. Rofo. 2011 Jul;183(7):607-17. Epub 2011 Apr 12. Review. German.
8. Dickinson L, Ahmed HU, Allen C, Barentsz JO, Carey B, Futterer JJ, Heijmink SW, Hoskin PJ, Kirkham A, Padhani AR, Persad R, Puech P, Punwani S, Sohaib AS, Tombal B, Villers A, van der Meulen J, Emberton M. Magnetic resonance imaging for the detection, localization, and characterization of prostate cancer: recommendations from a European consensus meeting. Eur Urol. 2011 Apr;59(4):477-94.
9. Aigner F, Pallwein L, Schocke M, Lebovici A, Junker D, Schäfer G, Mikuz G, Pedross F, Horninger W, Jaschke W, Halpern EJ, Frauscher F. Comparison of real-time sonoelastography with T2-weighted endorectal magnetic resonance imaging for prostate cancer detection. J Ultrasound Med. 2011 May;30(5):643-9.
10. Aigner F, Pallwein L, Pelzer A, Schaefer G, Bartsch G, Nedden D, Frauscher F. Value of magnetic resonance imaging in prostate cancer diagnosis. World J Urol. 2007 Aug;25(4):351-9. Epub 2007 Jun 14. Review.
11. Kurhanewicz J, Vigneron D, Carroll P, Coakley F (2008) Multiparametric magnetic resonance imaging in prostate cancer: present and future. Curr Opin Urol 18: 71-7.
12. Frauscher F, Klauser A, Berger AP, et al. The value of ultrasound (US) in the diagnosis of prostate cancer. Radiologe 2003;43(6):455–63.
13. Franiel T, Stephan C, Erbersdobler A, Dietz E, Maxeiner A, Hell N, Huppertz A, Miller K, Strecker R, Hamm B. Areas suspicious for prostate cancer: MR-guided biopsy in patients with at least one transrectal US-guided biopsy with a negative finding--multiparametric MR imaging for detection and biopsy planning. Radiology. 2011 Apr;259(1):162-72.
14. Vilanova JC, Barceló-Vidal C, Comet J, Boada M, Barceló J, Ferrer J, Albanell J. Usefulness of prebiopsy multifunctional and morphologic MRI combined with free-to-total prostate-specific antigen ratio in the detection of prostate cancer. AJR Am J Roentgenol. 2011 Jun;196(6):W715-22.
15. Choi MS, Choi YS, Yoon BI, Kim SJ, Cho HJ, Hong SH, Lee JY, Hwang TK, Kim SW. The Clinical Value of Performing an MRI before Prostate Biopsy. Korean J Urol. 2011 Aug;52(8):572-7. Epub 2011 Aug 22.
16. Kpandemoi Abu V. The use of MRI scanning to triage patients. Br J Nurs. 2011 Nov 11-24;20(20):1310-4.
17. Jager GJ, Severens JL, Thornbury JR, de la Rosette JJ, Ruijs SH, Barentsz JO. Prostate cancer staging: should MR imaging be used?- A decision analytic approach. Radiology 2000;215:445-451.
18. Ren J, Huan Y, Wang H, Ge Y, Chang Y, Yin H, Sun L. Seminal vesicle invasion in prostate cancer: prediction with combined T2-weighted and diffusion-weighted MR imaging. Eur Radiol 2009; 19:2481-2486.
19. Chirila DN, Turdeanu NA, Constantea NA, Coman I, Pop T, Popp RA, Balacescu O, Vesa SC, Ciuce C. Multiple malignant tumors. Chirurgia (Bucur). 2013;108(4):498-502.