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A comprehensive guide in prostate MR imaging providing an overview of current, advanced techniques, central pitfalls and correction strategies

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Introduction

The second most prevalent cause of death among men in Western Europe is prostate cancer, with an incidence above of 200 in each 100,000 males.[1] Currently, several clinical screening methods are employed in order to detect this neoplasm including elevated Prostate Specific Antigen Test (PSA), Digital Rectal Exam (DRE) and Trans-Rectal Ultrasound (TRUS)-Guided Biopsy. However, approximately 35% of prostate cancer is missing when using these examinations.[1] In the last few decades, there has been growing usage of Prostate Magnetic Resonance Imaging (MRI) as a non-invasive high accurate tool in the detection and diagnosis of prostate cancer.[2] MRI is beneficial not only in localisation, but also in assessment of lesion aggressiveness, which may overcome the sampling errors related to Transrectal Ultrasound guided prostate biopsy (TRUS) , which usually done to diagnose cancer cells in the prostate gland using ultrasound. Moreover, MRI protocol can be beneficially used in an Active Surveillance which means monitoring patients with low-volume and low-grade prostate cancer while they are under deferred immediate therapy.[3]

In the other hand, pelvic magnetic resonance imaging (MRI) involves many challenges that are not encountered to the same degree in other body regions. Complications that uniquely affect body MRI include physiologic motion from respiratory and bowel motion.[4] By introducing of technical innovations in MRI, such as the development of phased-array coils, high performance gradients, and methods to reduce motion-related artefacts, body imaging can be obtained with excellent contrast resolution in a reasonable scanning time.[5] In order to optimize prostate MR protocols and improve its efficiency, it is essential for the radiographer to be familiar with basic MR imaging principles and able to minimize the effects of motion artefact. Therefore, the purpose of this review is to discuss the prostate MRI technique and address some challenges that may encounter MR radiographers.

Normal location and anatomy of the prostate

The prostate is a cone shaped glandular organ with the apex of the cone lying caudally and the base lying cranially. Integrally linked to the bladder where the urethra starts. Traditionally, the prostate is divided into anatomical lobes (inferoposterior, inferolateral, superomedial, and anteromedial) by the urethra and the ejaculatory ducts as they pass through the organ. However, more important clinically is the histological division of the prostate into three zones (according to McNeal) (Figures 1 & 2).[6] Central zone – surrounds the ejaculatory ducts, comprising approximately 25% of normal prostate volume. The ducts of the glands from the central zone are obliquely emptying in the prostatic urethra, thus being rather immune to urine reflux. Appears as low signal intensity due to its high content of densely packed, smooth muscle fibers. Transitional zone – located centrally and surrounds the urethra, comprising approximately 5-10% of normal prostate volume. Will appear as low-intermediate signal intensity on T2WI. Peripheral zone – makes up the main body of the gland (approximately 65%), is located posteriorly, and shows High signal intensity on T2 WI.

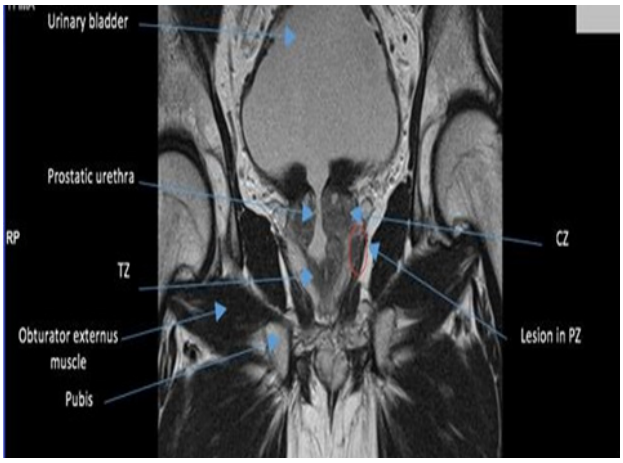

Figure 1 T2-weighted coronal image illustrates a prostate gland.

The ducts of the glands from the peripheral zone are vertically emptying in the prostatic urethra; that may explain the tendency of these glands to permit urine reflux. The fibromuscular stroma (or fourth zone for some) is situated anteriorly in the gland. It merges with the tissue of the urogenital diaphragm. This part of the gland is actually the result of interaction of the prostate gland budding around the urethra during prostate embryogenesis and the common horseshoe- like muscle precursor of the smooth and striated muscle that will eventually form the internal and external urethra sphincter.

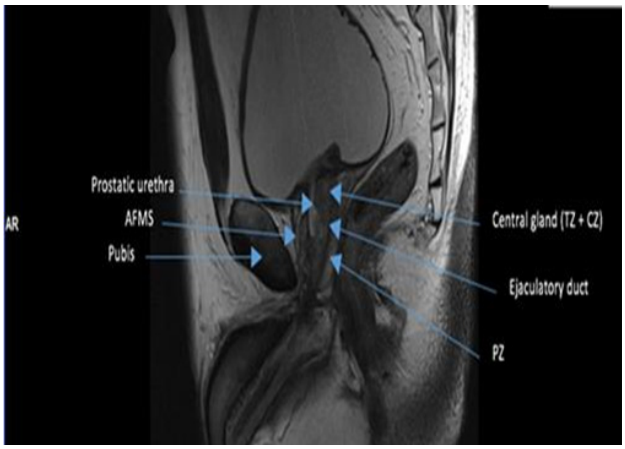

Figure 2 T2-weighted sagittal image focused on a prostate gland.

Technical challenges

a) Motion artefact:

- Bowel motion is reduced by compression and administrating antispasmodic agents IV, IM or subcutaneously prior to the examination. Compression also reduce respiratory motion by encouraging the patients to breathe from their upper abdomen and chest rather than their pelvis. Spatial pre-saturation pulses applied superior and inferior to the field of view reduce flow motion artefact in the IVC, aorta and iliac vessels.[7]
- Blade technique is a method of filling the k-space in a radial trajectory in which motion-related artefacts can be adjusted (Siemens Healthcare, 2018). It is used in prostate imaging to minimize motion artefact. However, in comparison to conventional spin echo, this technique result in reduction of the CNR that could obscure prostate cancer foci.[3]

b) Hemorrhage often has low T2 signal intensity, mimicking cancer, and may introduce significant artefact on DWI and 1H-MRSI, and confound results from DCE MR imaging. For this reason, an interval of at least 6 weeks between the most recent prostate biopsy and the MRI scan is recommended.[8]

c) Using of high b values requires a strong gradient system that able to switch on and off rapidly.

Consequently, this will induce eddy currents, resulting in superimposed magnetic field that cause local field inhomogeneity, and ending with anatomical distortion on DWI. As a result, the distortion will affect the shape, size and position of the prostate, and may obscure focal lesions. In addition, metal implants produce sever distortion artefacts. Rectal distention with stool or gas may distort the DWI.[9] To minimize distortion artefacts, parallel imaging techniques, reduce receiver bandwidth, decrease echo spacing and echo train length and use minimal echo time (TE). In addition, it would be better to apply left-right phase encoding direction rather than anterior-posterior to avoid artefacts from stool or urine.[9]

Equipment

For indicative assessment of the prostate, a magnetic field strength of at minimum 1.5 Tesla (T) is suggested. The new pattern is toward the utilization of 3T clinical MRI scanners, as they offer a higher signal-to-noise ratio. Ideal MR imaging of prostate malignancy for identification and local staging requires the use of an endo rectal coil in conjunction with a pelvic phased array coil.[10] However, the pelvis offers excellent SNR and contrast, especially when pelvic phased array coils are used.[7] To plan for MRI with an endo rectal coil, the patient is approached to eat light meals on the day before and upon the arrival of the test, which make it simpler to embed the coil into the rectum. General preparation for the prostate as all of other body parts must be performed such as MRI screening questionnaire, contrast administration form and change out of patient clothes.

Patient preparation, position and slice planning

All Patients with MRI contraindications should be excluded. Patients are usually scanned in the supine position to maximize patient comfort. Foam pads and compression band can be applied across the patient lower pelvis to reduce respiratory and bowel motion. If a local rectal coil is used, it should be carefully inserted prior to the examination with paying attention to be correctly positioned and fully inflated.[7] In order to obtain axial view, the slices should be tilted to be perpendicular to prostatic urethra or peripheral zone on sagittal plane. Coronal slices are placed on the sagittal plane and angled to be parallel to prostatic urethra, the whole prostate and seminal vesicles must be covered to provide coronal images. With regards to Sagittal view slices are planned on the axial and coronal localizers, and placed parallel to prostatic urethra with suitable angulation as needed. They must cover the whole prostate and seminal vesicles (Figure 3).[11]

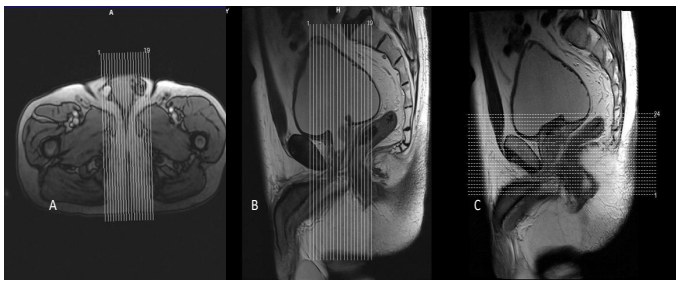

Figure 3 Shows the slice prescription for MRI prostate.

Suggested protocol and parameters

To evaluate the prostate accurately, using of multiple pulse sequences that provide complementary information is required, such as sagittal, axial and coronal T2 TSE sequences, Axial T1W, DWI and DCE- MR (Table 1).[3]

T2-weited imaging (T2WI)

T2 weighted imaging with its high contrast and resolution is ideal for identifying zonal anatomy, which aids in correct TNM staging. On T2WI prostate cancer appears as low signal intensity, indicating a lower density of water molecules and a more tightly bound cell structure.[1] Turbo spin-echo (TSE) sequences function extremely well, although the degree of contrast between transition and peripheral zone is slightly reduced compared with the standard SE sequences, as the Turbo spin-echo (TSE) sequences depends on the effective time echo (TE) to reduce echo train length (ETL) effects. It is completely useful to acquire T2WI in all scan planes, applying small FOVs with thin slices (3mm) in order to illustrate small structures within the prostate, such as the ejaculatory ducts, urethra and verumontanum.[12] This sequence facilitates the visualization of prostate zonal anatomy, prostatic margin and internal structures. In case of prostate cancer, T2WI clearly shows extra-prostatic extension, seminal vesicle and neurovascular bundle invasion, assisting in tumour staging.[13]

The normal peripheral zone (PZ) usually appears hyper-intense, whereas tumors in this region commonly reflect low signal intensity.[13] Moreover, most of the prostate adenocarcinomas originates within

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this zone. However, some tumors, small/ low-grade, may show isointense signal relative to background PZ, which makes it difficult to distinguish.[12] Transitional (TZ) and central zone (CZ) represent low signal intensity compared to hyper-intense PZ.[8]

T1-weited imaging (T1WI)

T1W MRI is mainly used within the framework of MRI to rule out post-biopsy hemorrhage in the prostate and to survey the entire pelvis for enlarged pelvic lymph nodes and possible bone metastases.[14] Translation of MR images is regularly confounded by post biopsy drain inside the prostate, which can bring about signal anomaly on T2-weighted images. On T2-weighted images, both tumor and hemorrhage show up as dull areas. T1-weighted images can be utilized to distinguish post-biopsy intra-glandular hemorrhage and diminish false positive discoveries in the seminal vesicles (SVs). On T1-weighted images, the ordinary prostate organ shows homogeneous intermediate-to-low signal intensity and it is assumed that post-biopsy hemorrhage is present in regions with high signal-intensity. Furthermore, T1 spectral fat saturation-weighted images and SPARE are helpful in differentiating abnormal anatomy from blood in patients post biopsy.[10]

Diffusion weighted imaging (DWI)

DWI is a functional MR sequences that depends on the characterization of random Brownian motion of water molecules within biological tissue in multiple directions. B values in DWI control the signal intensity of the image by altering gradient amplitudes and pulse lengths.[1] Mid-range b values produce higher SNR, while high b values decrease the signal from normal tissue, resulting in increased sensitivity to pathological cellular tissue.[8] In practice, b values of 800-1000 are used, and higher values up to 2000 could improve lesion detection and to avoid T2 shine through, which happens when T2 of tissue is very long and TE is not long enough to diphase, such as post biopsy's hemorrhage and prostatitis.[13] Prostate cancer will cause restricted diffusion because there is no movement within extracellular space. Diffusion images with at least two b values, low and high, are used to generate apparent diffusion coefficient (ADC) map, which is particularly helpful for prostate cancer identification.[12] Lower b values representing T2W images usually range between 0–100.[8] The ADC map used to measure the diffusivity of water molecules from both diffusion and T2 weighting. Generally, prostate cancers represent high signal intensity on high b value DWI and decreased ADC.[13]

Dynamic contrast enhancement (DCE)

This sequence is characterized by the intravenous injection of Gadolinium based contrast media (CM) that shorten T1 relaxation time of enhanced tissue.[8] This means that the CM passes through arteries into tissue microvasculature and then rapidly leaks into the extravascular extracellular space, resulting in hyperintense signal on T1W images.

DCE-MRI produces 3D volume images using T1W spoiled gradient recalled echo (SPGR) sequences, and collected before, during and after the administration of CM.[12] Because of the high vascularity structure of prostate cancer, it shows earlier faster enhancement leading to hyper-intense appearance and earlier washout than normal prostate tissue. Therefore, the bolus injection has to be very fast, within a rate of 2-4 ml/s followed by a 20 ml saline flush. Additionally, image acquisition requires high temporal resolution in which images must be acquired sequentially every 5-10 seconds for up to 5-10 minutes .T1W-SPGR sequences are used because they offer fast image acquisition with high SNR and provide high sensitivity to T1 changes. However, their SR is not high as in T2W images to maintain high SNR and short scan time. It is important to compensate the SR and temporal resolution to minimize partial volume artefacts.[15]

Additional sequences may be performed which have beneficial diagnostic properties:

Sagittal STIR: to see if there is any cancer spread through spine and sacrum (Table 1).

Table 1 Depicts sequence's parameters for MRI prostate protocol

Sequence	FOV (mm)	Slice Thickness (mm)	Distant Factor (%)	TR (ms)	TE (ms)	Flip Angle	Matrix Size (mm)	Turbo Factor	Scan Time
SAG. T2W--FSE	270 x 244	4	10	3860	103	180	512 x 255	15	3.03
AX. T2W-FS	200 x 200	4	10	4000	100	180	320 x 275	15	4.16
COR. T2W--FSE	230 x 208	4	10	3710	103	180	512 x 255	15	5.17
AX. DWI	260 x 221	4	0	4000	87		160 x 95		4.54
AX. T1W--FSE	380 x 249	4	20	441	10	150	512 x 252	3	1.36
AX. 3D VIBE	259 x 259	3.5	20	4.38	1.55	15	192 x 138		5.13

MR spectroscopy

MRS detect changes in the relative concentration of metabolites in the prostate gland the normal prostate gland contains a high concentration of citrate. In prostate cancer citrate level is decreased but the level of choline is increased. The increase in choline concentration in prostate cancer reflects a high turnover of cell membranes in the tumour tissue. Hence, tumour tissue show an increase in the choline to citrate ratio compared with normal prostate gland.[11]

Conclusion

To conclude, MRI is vital tool in the assessment interaction of prostate cancer. Moreover, it can be valuable to direct designated biopsy when prostate cancer is clinically suspected and previous ultrasound-guided biopsy results are negative, localize and stage prostate malignant growth and give a guide to therapy arranging and to identify locally repetitive malignant growth after treatment. In order to provide metabolic and practical data that can work on the precision of prostate malignancy location and characterization, the suggested protocol includes T2WI, T1WI, diffusion-weighted imaging (DWI) and contrast-enhanced MRI (CE-MRI).

Acknowledgments

None.

Conflicts of interest

Authors declare that there is no conflict of interest.

References

1. Czarniecki M, Jakuciński M, Królicki L. Prostate MRI-an update for the referring urologist. Central European Journal of Urology. 2016;69(2):162–169.

2. Yu J, Fulcher AS, Turner MA, et al. Prostate cancer and its mimics at multiparametric prostate MRI. *British Journal of* Radiology. 2014;87(1037):20130659.

3. Quon JS, Moosavi B, Khanna M, et al. False positive and false negative diagnoses of prostate cancer at multi-parametric prostate MRI in active surveillance. Insights into Imaging. 2015;6(4):449–463.

4. Yang RK, Roth CG, Ward RJ, et al. Optimizing Abdominal MR Imaging: Approaches to Common Problems1. Radiographics. 2010;30(1):185–199.

5. Olivia R, Mortele KJ, Erturk SM, et al. Magnetic resonance imaging of the pancreas. *Applied Radiology*; 2006.

6. McLaughlin PW, Troyer S, Berri S, et al. Functional anatomy of the prostate: implications for treatment planning. *Int J Radiat Oncol Biol Phys*. 2005;63(2):479–491.

7. Westbrook C. *Handbook of MRI technique*. 3rd ed. Oxford: Wiley-Blackwell; 2008.

8. Starobinets O, Korn N, Iqbal S, et al. Practical aspects of prostate MRI: hardware and software considerations, protocols, and patient preparation. *Abdominal Radiology*. 2016;41(5):817–830.

9. Rosenkrantz AB, Taneja SS. Radiologist, Be Aware: Ten Pitfalls That Confound the Interpretation of Multiparametric Prostate MRI. *American Journal of Roentgenology*. 2014;202(1):109–120.

10. Mazaheri Y, Shukla-Dave A, Muellner A, et al. MR imaging of the prostate in clinical practice. *Magnetic Resonance Materials in Physics, Biology and Medicine (MAGMA)*. 2008;21(6):379–392.

11. Reimer P. *Clinical MR imaging: a practical approach*. 3rd ed. Berlin: Springer; 2010.

12. Gupta RT, Kauffman CR, Polascik TJ, et al. The state of prostate MRI in 2013. *Oncology*. 2013;27(4):262–270.

13. Kierans AS, Taneja SS, Rosenkrantz AB. Implementation of Multi-parametric Prostate MRI in Clinical Practice. *Current Urology Reports*. 2015;16(8):56.

14. Berman RM, Brown AM, Chang SD, et al. DCE MRI of prostate cancer. *Abdominal Radiology*. 2016;41(5):844–853.

15. Verma S, Turkbey B, Muradyan N, et al. Overview of dynamic contrast-enhanced MRI in prostate cancer diagnosis and management. *American Journal of Roentgenology*. 2012;198(6):1277–1288.

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