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CHAPTER SEVEN

Prostate MRI

After completing this chapter, the reader will be able to:

- **Identify the anatomy and function of the prostate gland**
- **Respond appropriately to the patient, given the sensitive nature of the prostate MRI exam**
- **Explain the basic imaging procedures for the prostate gland**

Pelvic imaging is virtually the same for men as for women. Obviously, the internal organs of the male and female pelvis are different, but imaging protocols, pulse sequences, and imaging weighting vary little by gender. The most obvious and significant role for MRI in a male-specific pelvic application is the prostate gland, and prostate cancer is by far the most common indication for pelvic MRI.

OVERVIEW

One in 35 men will die of prostate cancer, and prostate cancer is the second most common cancer after skin cancer. It is the second leading cancer death in men after lung cancer. In 2009, it is estimated that more than 190,000 men will be diagnosed with prostate cancer. However, due in part to advances in early detection, the five-year survival rate for men with prostate cancer is nearly 100%. The relative 10-year survival rate is nearly 91%, while the 15-year survival rate is approximately 76%.[1] For men diagnosed today with prostate cancer, the long-term outlook is even better.

As with pelvic floor imaging, this exam requires the utmost sensitivity to the patient to guarantee privacy and maintain dignity. The exam needs to be explained in detail prior to the beginning of the evaluation.

A private, reserved bathroom must be available to the patient immediately following the exam. While this is a fast, virtually pain-free, and highly-diagnostic exam, few MR facilities offer this application because of the nature of the exam.

POINTS FOR PRACTICE

1. The prostate gland is segmented into what three zones?
2. Which condition is typically associated with the central zone?
3. What is the role of SER?
4. Name some advantages of using MR spectroscopy.

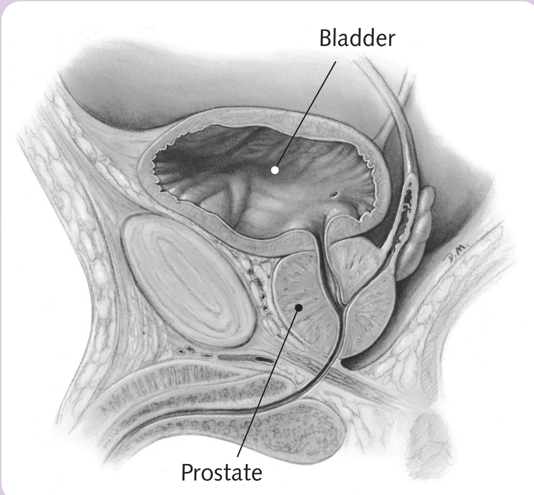

Figure 90. Bladder and prostate anatomy. The prostate has a variable position, sometimes leaning anteriorly or slightly posteriorly. Coronal MR imaging is best performed in the oblique coronal plane, tilted to coincide with the vertical axis of the prostate.

Figure 92. Coronal prostate anatomy.
A = transitional zone
B = central zone
C = peripheral zone
D = seminal vesicles

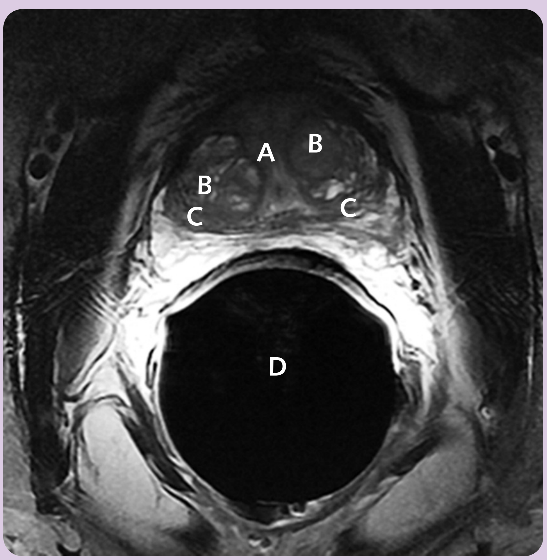

Figure 91. Axial prostate anatomy.
A = transitional zone
B = central zone
C = peripheral zone
D = air-filled rectum

ANATOMY

The purpose of the prostate gland is to secrete seminal fluid (approximately 30% in total), mixing with sperm and fluids from the seminal vesicles to make up the components of semen. The area of interest in prostate MRI includes the prostate gland itself, which is segmented into 3 zones: the **central zone**, the **transitional zone**, and the **peripheral zone**, as well as the seminal vesicles. The role of MRI is to evaluate tumor extension, either **extracapsular** or direct seminal vesicle invasion (Figures 90, 91, and 92).

IMAGING PROTOCOL

The prostate gland is optimally imaged using an inserted endorectal coil in conjunction with the pelvic phased-array coil, allowing for eval-

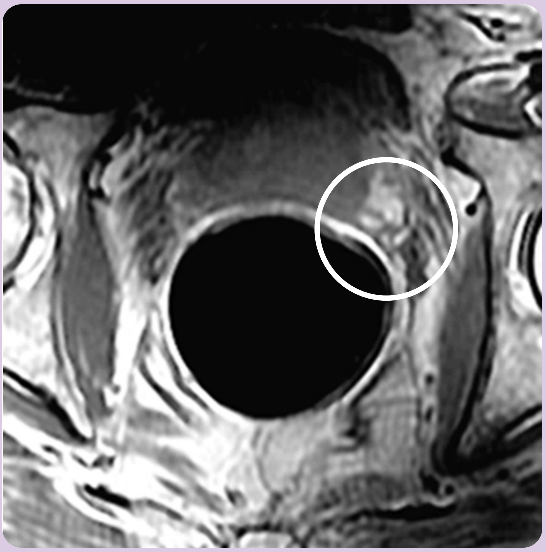

Figure 93. **Axial T1 of a patient 4 weeks post-biopsy. Note the residual blood in the left peripheral zone (circle). The exam did not proceed and was re-scheduled for 4 weeks later.**

uation of the entire pelvis for possible cancer involvement and providing high spatial resolution images of the prostate with high SNR.

History of Biopsy

If the patient has had a previous biopsy, a minimum of six to eight weeks should separate biopsy and MR imaging to allow any residual blood from the biopsy to resolve. Blood in the prostate can obscure, or worse, mimic carcinoma (Figure 93).

At the time of the exam, the patient's **PSA** (prostate-specific antigen) level, **Gleason score**, biopsy date, and whether radiation or hormonal therapy has been administered should be noted. This information is extremely useful for the radiologist when interpreting the MR images as prostate gland image contrast may be altered by therapy.

Standard Imaging Protocol

The typical prostate protocol consists of axial, sagittal, and coronal T2 imaging without fat suppression. Because high spatial resolution is required, the slice thickness is thin, usually 3.0 mm or less. See Table 14 on page 97.

Diffusion-Weighted Imaging

There is growing interest in the utility of diffusion-weighted imaging of the prostate. Apparent diffusion coefficient (**ADC**) maps show promise in demonstrating cancerous diffusion (Figure 94b). The use of parallel imaging and multi-direction diffusion tensor imaging **(DTI**) greatly decreases potential geometric distortion common in some DWI imaging, as well as increasing SNR (Figure 94a).

Endorectal Coil

Just as with female breast MRI and pelvic floor imaging, special considerations for the patient should be made for the prostate patient. The endorectal coil uses an inflated bulb to hold it in place. A water-soluble lubricant must be used for insertion, but care must be taken in determining how much to use because the gel lubricant produces a bright signal profile. Using too much lubricant can result in excessive ghosting caused by rectal spasms; using too little makes insertion painful.

The coil should be inserted so that the coil element is seated just posterior to the prostate. The bulb should be inflated to the patient's tolerance level, usually 90-110 mL of air but no more than 120 mL.

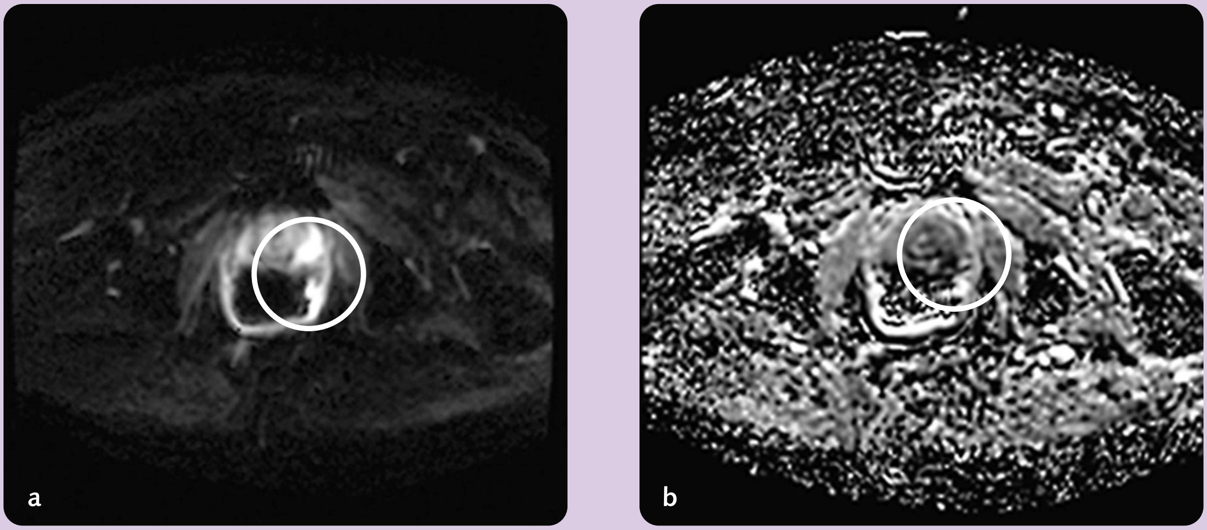

Figure 94. **Axial diffusion-weighted images of the prostate. (a) 6-direction diffusion tensor-weighted image indicating possible lack of normal perfusion in the left peripheral zone (circle). (b) The apparent diffusion coefficient (ADC) map of the same location. Dark area (circle) confirms diffusion deficit.**

MRI FINDINGS

Benign Prostate Hyperplasia (BPH)

Most prostate cancers occur in the peripheral zone but are not uncommon in other zones. The central zone is most commonly associated with **benign prostate hyperplasia (BPH)**. This condition often results in an acute need to urinate but with low yield. BPH is not always associated with cancer; however, cancer of the prostate can result in the same urinary dysfunction, so it is important to have this condition medically evaluated without delay.

Prostate Cancer

Prostate cancer (**PCa**) typically demonstrates as hypointense signal on T2-weighted imaging and is usually performed in all three planes to the prostate. This sequence is also essential for BPH evaluation. Axial T1-weighted imaging through the pelvis is useful for evaluating **adenopathy** related to prostate cancer (Figures 95 and 96).

Seminal Vesicle Invasion

Cancerous invasion of the seminal vesicles typically demostrates as hypointense signal on T2-weighted imaging as with prostate cancer within the zonal areas as discussed above. Moreover, the cancerous invasion usually appears as a "mass-effect" as it displaces normal seminal vesicle tissue as shown in Figure 97.

Prostatitis

Prostatitis is an inflammation of the prostate gland and can be chronic or acute. MR imaging of the prostate in an attempt to differeniate between prostate cancer and noncancerous prostatitis can be challenging

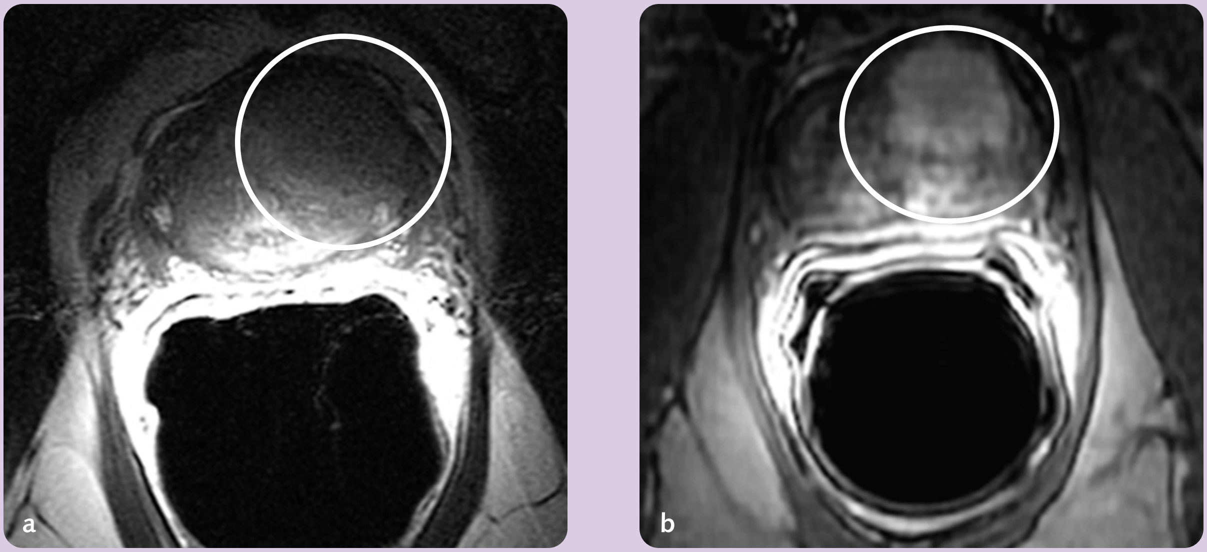

Figure 95. (a) Axial T1 of the prostate. Large central zone cancer of the prostate in a 65-year-old male. The circle indicates a large, hypointense tissue along the anterior wall of the prostate. (b) Axial post-contrast. Post-dynamic gadolinium contrast injection of the same patient. Circle indicates rapid contrast uptake indicative of a cancerous prostate gland.

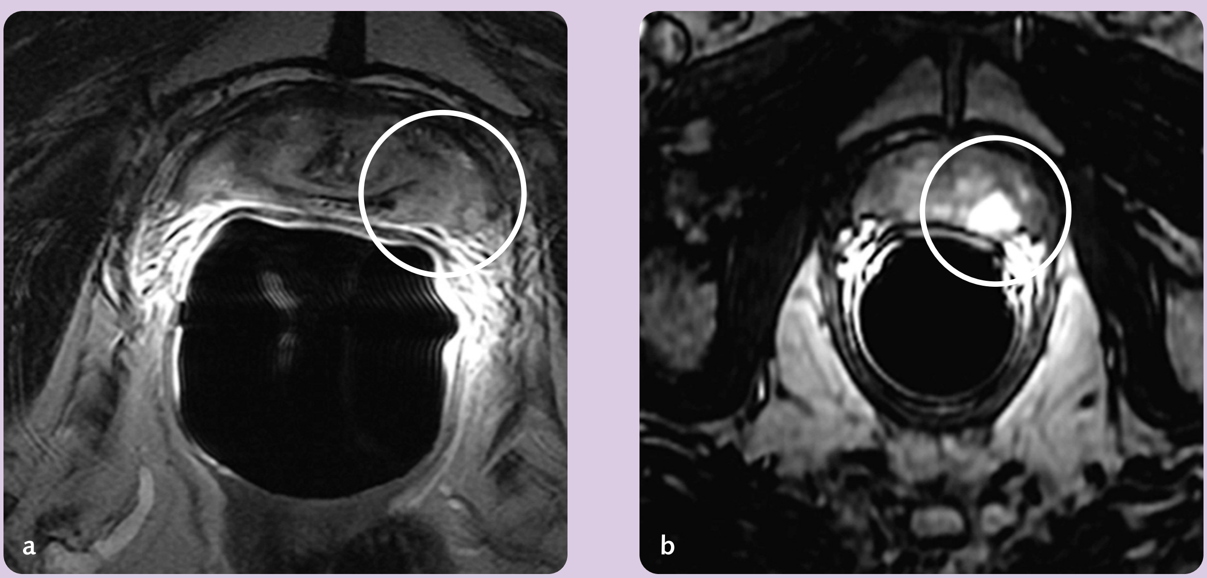

Figure 96. (a) Axial T2 of the prostate of a 77-year-old male. The circle indicates a recurrence in the mid-left peripheral zone posterior and lateral. (b) Axial post-dynamic gadolinium enhancement of the same patient. The circle indicates strong contrast uptake indicative of prostate gland carcinoma.

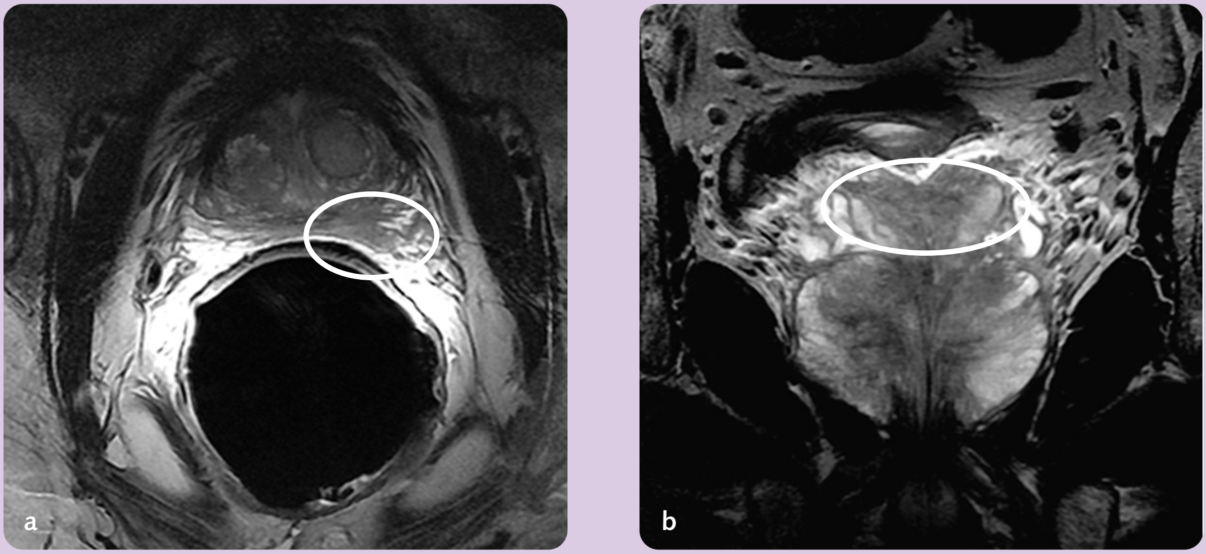

Figure 97. **Axial (a) and coronal (b) T2- weighted images of a 64-year-old male with prostate carcinoma with seminal vesicle invasion (circles).**

as prostatitis demonstrates many of the same signal characteristics as prostate cancer. Low signal intensity of homogeneous tissue in the peripheral zone is present in both prostate cancer and prostatitis. Focal hypointense tissue signal that is not specfic for cancer is the most common MR finding in chronic prostatitis.[2]

SIGNAL ENHANCEMENT RATIO

The role of IV gadolinium contrast in prostate MRI is not well-defined, as studies thus far have yielded differing results as to the utility of using a GBCA. A normal, noncancerous prostate gland will show modest contrast uptake enhancement. However, a cancerous gland also enhances. Use of **Signal Enhancement Ratio (SER)** maps can be useful for determining contrast-uptake differences between normal and cancerous tissue where a normal gland enhances slower than a cancerous gland (Figures 98 and 99).

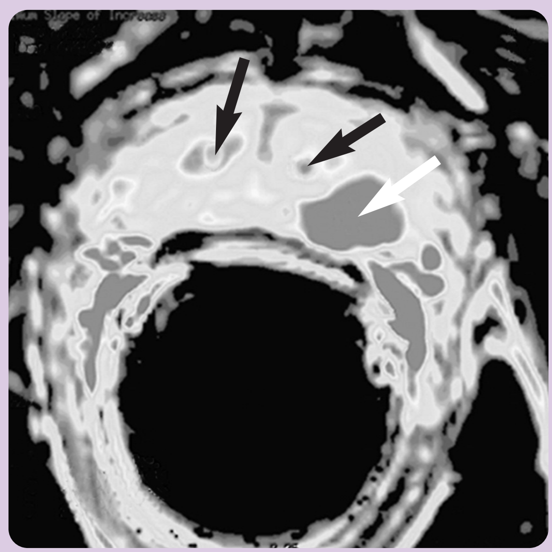

Figure 98. **Signal Enhancement Ratio map showing the maximum rate of contrast uptake. Large dark area (white arrow) in the left peripheral zone is much larger and darker compared to the smaller, less dark areas of the central zone (black arrows).**

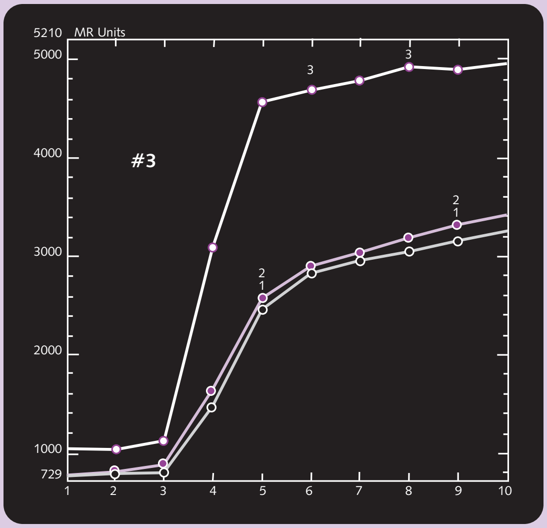

Figure 99. **Signal Enhancement Ratio curve. Contrast update map of the ROI shown in Figure 98 indicating volume and rate of enhancement. ROI #3 shows a visibly greater rate and volume of enhancement versus ROI #1 and 2, consistent with prostate carcinoma.**

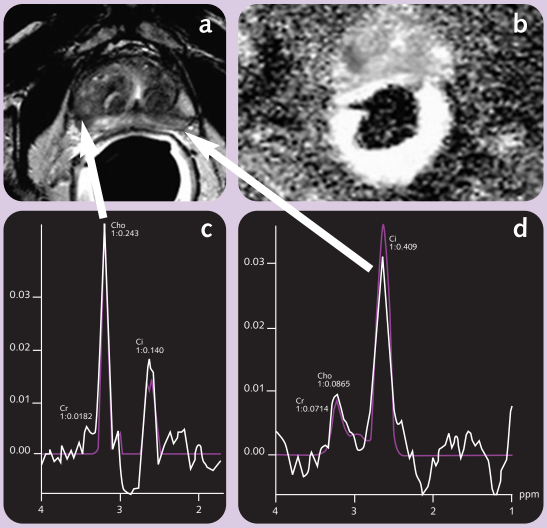

Figure 101. **Prostate spectroscopy. (a) Axial T2-weighted image. (b) Apparent diffusion coefficient map. (c, d) Spectrums of the areas indicated by the arrows. Note the high choline (c) and citrate (d) peaks, indicating prostate carcinoma.** *Courtesy of UCLA.*

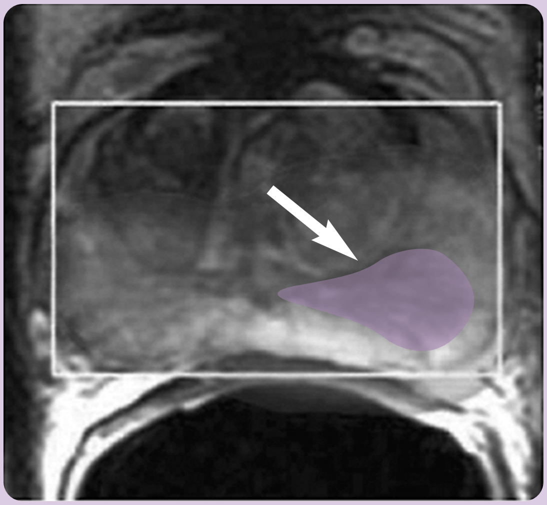

Figure 100. **Prostate spectroscopy metabolite map showing high concentrations of choline.** *Courtesy of GE Healthcare.*

MRI findings of extracapsular extension include irregular bulge of the prostate margin, contour deformity with step-off or angulated margin, breach of the capsule with direct tumor extension, obliteration of rectoprostatic angle, and asymmetry of neurovascular bundles. Axial images are essential in the evaluation of extracapsular invasion.

MR SPECTROSCOPY

MR spectroscopic (**MRS**) imaging has recently expanded the diagnostic assessment of the prostate beyond simple anatomic information. MRS provides metabolic information specific to the prostate through the detection of the cellular metabolites citrate, creatine, and choline. Information obtained from MRS allows an expanded assessment of tumor aggressiveness and risk of disease progression. Typically, high concentrates of choline and low concentrates of citrate are indicative of prostate gland carcinoma. However, normal prostate gland may display lower citrate concentrations following some hormonal therapies, such as androgen deprivation therapy[3] (Figures 100 and 101).

In the localization of PCa, combined MRI and MRS demonstrate 91% specificity, the highest value obtained by a noninvasive method.[4] The combined use of MRI and MRS significantly improves evaluation of extracapsular spread and decreases interobserver variability, significantly increasing the value of MRI in the evaluation of prostate cancer.

SUMMARY

When performed with close attention to high spatial resolution and signal-to-noise ratio, MRI of the prostate provides highly detailed and useful information in the detection and staging of prostate cancer and benign prostate hyperplasia. However, high-quality prostate imaging is invasive in that it requires the use of an endorectal prostate coil, which may be uncomfortable for the patient. Emerging techniques such as prostate spectroscopy, diffusion tensor imaging, and functional post-processing of dynamic contrast images into signal enhancement maps may be useful additional tools in cancer evaluation of the prostate.

Table 14.

SAMPLE PROSTATE SCAN PROTOCOL USING ENDORECTAL PROBE

Parameter	3 Plane Localizer	Axial T1	Axial T2	Coronal T2	Sagittal T2
Patient Position					
Orientation	Feet first, Supine	Feet first, Supine	Feet first, Supine	Feet first, Supine	Feet first, Supine
Coil	Torso phased array	Torso phased array	Torso phased array and endorectal	Torso phased array and endorectal	Torso phased array and endorectal
Plane	3 Planes	Axial	Axial	Oblique	Sagittal
Imaging Parameters					
Pulse Sequence	GRE	SE	FSE	FSE	FSE
Scan Timing					
Number of Shots					
TE (msec)		Minimum	120	120	120
TR		600	6,000	4,500	5,500
TI					
FA			90	90	90
ETL			12	12	20
Options		Resp Comp, NPW	Flow Comp, NPW, VBw	Flow Comp, NPW, VBw	Flow Comp, NPW, VBw
Scanning Range					
FOV (cm)	48	24-28	14	14	16
Slice Thickness (mm)	8	5	3	3	4
Slice Spacing (mm)	2	1	0	0	1
SAT Bands		Inferior/Superior Anterior/Posterior	Inferior/Superior Anterior/Posterior	Inferior/Superior	Inferior/Superior
Acquisition Time					
Acquisition Matrix Frequency	256	256	256	256	256
Acquisition Matrix Phase	128	192	192	192	256
NEX	2	1	4	4	3
Phase FOV	1	1	1	1	1
Frequency Direction		R/L	A/P	S/I	S/I
Auto Center Frequency	Water	Water	Water	Water	Water
Autoshim	Yes	Yes	Yes	Yes	Yes

Notes

- When using a probe, be sure the probe lies flat against the prostate; if it is rotated make the proper adjustments before continuing past the localizer.
- The T1 axials should be placed from the bifurcation of the iliac arteries to the pubis symphysis.
- The T2s should cover from just above the seminal vesicle to just below the prostate gland.
- The use of a compression belt will help reduce respiratory artifact.
- Make the patient as comfortable as possible, offer music, elevate knees with a wedge or pillow.

POINTS FOR PRACTICE

1. **The prostate gland is segmented into what three zones?**

   The gland is comprised of the central zone, the transitional zone, and the peripheral zone, as well as the seminal vesicles. The role of MRI is to evaluate tumor extension, either extracapuslar or direct seminal vesicle invasion.

2. **Which condition is typically associated with the central zone?**

   BPH – benign prostate hyperplasia – is most commonly associated with the central zone. BPH is a condition that often results in the frequent need to urinate but with low yield. Urinary dysfunction can also be a result of prostate cancer, making it imperative to have this condition medically evaluated.

3. **What is the role of SER?**

   A Signal Enhancement Ratio Map can be useful in determining contrast-uptake differences between normal and cancerous tissue as a normal gland will enhance more slowly than a cancerous gland.

4. **Name some advantages of using MR spectroscopy.**

   In the localization of prostate cancer, combined MRI and MRS demonstrate 91% specificity, the highest value obtained by a non-invasive method. This significantly improves the evaluation of extracapsular spread while reducing inter-observer reliability.

REFERENCES

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