Normal MR anatomy of the prostate gland

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Authors: K. Sklinda, M. Frčzek, B. Mruk, J. Walecki; Warsaw/PL
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Learning objectives

The aim of this poster is to review the prostate gland normal anatomy using MR imaging. The complexity of this anatomical structure makes the male pelvis a radiological challenge. This presentation gives a detailed description of the anatomy and illustrates it with image examples.
Background

Preferable modality of visualisation of the prostate gland anatomy is MR imaging that allows high anatomical resolution. This anatomical region is rich in details that radiologist needs to know in order to make an accurate diagnosis. PI-RADS v. 2 provides useful hints for sensitive and specific MRI based diagnosis of prostate cancer. It is meant to serve a minimal protocol, so if there is a need accessory planes or sequences may be performed.

According to the guidelines it is advised to perform a study using 3 T scanner. The anatomic structures of the male pelvis should be appreciated on T2-weighted images in axial plane, covering whole pelvis, as well as T2-weighted images focused on prostate gland which provide better delineation of the prostatic tissue itself.

Imaging of the arterial vasculature of the prostate gland is still an issue, although evaluation of major arteries supplying the prostate is easily performed within standard MR-evaluation of the patient referred to embolisation due to BPH. However PI-RADS v. 2 does not mention this topic, developing standards of treatment demand sufficient method of imaging.
Findings and procedure details

Genitory part:

Basic anatomic landmarks:

The prostate gland consists of glandular and fibromuscular elements. It is a structure located in the pelvis, cncuffing the proximal part of the male urethra and the ejaculatory ducts. The pubic symphisis, retropubic space (cave of Retzius) puboprostatic ligaments and Santorini venous plexus are located anteriorly from the prostate gland. Posteriorly from the prostate gland the rectal ampula, Denonvilliers fascia, dorsal venous plexus and prostatic nervous plexus can be appreciated. Symetrically on both lateral sides the levator ani muscles (levator prostaticae), parietal and visceral layers of pelvic peritoneum and neurovascular angles can be found. The neck of the urinary bladder and the internal urethral sphincter (sphincter vesicea) are seen superiorly from the prostate gland. The urogenital diaphragm and the external urethral sphincter are situated inferiorly from the prostate gland.

So called prostate capsule is in fact a condensation of pelvic fascia (pseudocurrency) separated from the prostate by the prostatic venous plexus but histologically the prostate gland has no true capsule.

A thin, dark rim on T2W images which occurs due to compression of the prostatic tissue between transition and peripheral zones is a prostatic pseudocurrency or a surgical capsule.

Prostate shape may be compared to sweet chestnut - it is cone shaped gland, flattend from front to back. From superior to inferior the prostate is divided into base, midgland and apex.

Base is the largest part of the gland. Its surface is directed superiorly and slightly posteriorly adjoining neck of the urinary bladder. This is where the prostatic part of the urethra enters the prostate gland. A deep transverse cleft occurs in the posterior part of the prostatic base where the ejaculatory ducts formed by vas deferens and seminal vesicles enter.

Midgland is middle 1/3rd of the prostate. It includes the verumontanum located in the midprostatic urethra. The verumontanum (also known as seminal colliculus) is distinctive elevation of urothelium with orifices of the ejaculatory ducts, prostatic ducts and prostatic utricle.
Apex aims inferiorly and slightly anteriorly and adjoins directly deep perineal pouch penetrating its muscular tissue. The apex of the prostate is in close relationship with the bulb of penis and the bulbourethral glands.

Zonal anatomy:

Zonal anatomy introduced by McNeal divides prostate into four zones: Peripheral zone (PZ), Transition zone (TZ), Central zone (CZ) and Anterior Fibro-Muscular Zone (or stroma).

Peripheral zone is the largest zone of the prostate gland and accounts for 70% of its volume in young men. Around 75% of prostate cancers originate from peripheral zone.

It comprises the posterior aspect of midgland and most of the apex. On T2W images the normal peripheral zone can be easily distinguished from central gland by its hyperintense signal which is homogeneous in young healthy men, whereas the central gland is typically hypointense or isointense compared to skeletal muscle.

Peripheral zone abuts bilaterally neurovascular bundles which course anteriomedially entering prostate at 5 and 7 o’clock.

Central gland:

The transition zone and central zone of the prostate show similar signal intensity on MRI and therefore often cannot be resolved at MR imaging. They used to be collectively referred as the central gland.

Transition zone:

The transition zone is the innermost section of the prostate and forms 5% of the gland in young adult. It consists of two small lobules and surrounds urethra superiorly to veromontanum - the posterior part of urethra at base and anteriolateral part at midgland.

The transition zone abuts anteriorly anterior fibromuscular stroma, posteriorly central zone at the base and peripheral zone at the midgland and apex.

Central zone:

The central zone is a symetrical wedge shaped structure located at the base of the prostate between the peripheral and transition zones surrounding the ejaculatory ducts and narrowing to an apex at the verumontanum. It comprises up to 25% of the glandular tissue.

Anterior fibromuscular stroma:
It is thick sheath of tissue which forms anterolateral border of glandular prostate, contiguous with detrusor. It does not contain glandular tissue and is thought to be without importance for prostatic function and pathology. At the base of the prostate it contacts urethra anteriorly. Puboprostatic ligament connects AFMS and the inferior edge of pubic symphysis.

The anterior fibromuscular stroma is hypointense on T2-weighted images due to a lack of glandular tissue.

**Urinary part:**

The urinary bladder is located superiorly to the prostate gland. It is divided to base located superiorly and neck pointing inferiorly.

The base of urinary bladder adjoins ureters laterally and posteriorly with their orifices penetrating obliquely the wall of the bladder in the posteriolateral angles of trigone of the bladder. The neck of the bladder narrows anteriorly to become internal orifice of the urethra. Posterior wall of the bladder touches seminal vesicles, ampulae of vas deferens and bladder venous plexus.

The prostatic uretra is 3-4cm long. It descends from the base to the apex of the prostate forming anteriorly concave curve. Highest part of urethra called intramural part is subtended anteriorly by the internal urinary sphincter, and the prostate laterally and posteriorly. The urethral crest lies in the posterior aspect of the urethra, in extension of vesical uvula with the seminal colliculus, where ejaculatory ducts and prostatic duct open.

After leaving prostate membranacus part of urethra begins where it passes through muscles of urogenital diaphragm - external urethral sphincter, deep and superficial transverse perineal muscles.

**Regional lymph nodes:**

The most common pathways of lymphatic spread of the prostate cancer are to the obturator and the internal iliac lymph nodes. The other channels aim at external iliac, common iliac, presacral and paraaortic lymph nodes.

Lymph vessels are merged with venous plexuses and drain mostly to internal iliac lymph nodes, some smaller vessels direct to obturator lymph nodes. Some vessels can also drain to the sacral nodes.
Internal and external iliac lymph nodes drain along venous pathways to the common iliac lymph nodes.

Lymph vessels draining from the posterior surface of the prostate run together with lymph vessels of the bladder to the posterior, lateral and anterior lymph nodes of the bladder and to a lesser extent external iliac lymph nodes.

Seminal vesicles lymphatic drainage ends up in external and internal iliac lymph nodes.

**Muscles surrounding the prostate gland:**

Levator prostatae (puboprostatic) is the anterior part of the levator ani - the innermost muscle of pelvic floor musculature. Together with puborectal muscle it plays the active role in abrupt stop of micturition. In the apex peripheral zone adjoins laterally and inferiorly the pubococcygeus muscles, anteriorly puboprostatic (levator prostate) muscles and inferiorly puboanalis muscles which are parts the complex of levator ani muscle. The relationship is depicted on figures.

**Blood supply:**

Arteries supplying the prostate are small branches of the inferior vesical arteries (branches of the internal iliac artery) and to a lesser extent inferior rectal artery. They run together with veins and nerves of prostatic plexus forming neurovascular bundles and course anteriomedially entering prostate gland bilaterally. They are visualized within the rectoprostatic angle at the 5 o’clock and 7 o’clock positions. Apart from that, the middle rectal artery which is the more distant branch of internal iliac artery releases small prostatic branches before it enters rectum. The third source of arterial blood supply for the prostate gland are the branches of the internal pudendal artery.

Proper identification of arteries and characterisation of their anatomical variants (branches of internal iliac artery, accessory pudendal arteries, number and origin of prostatic pedicles) is essential in patients referred to prostatic embolisation. The anterior-lateral prostatic pedicle which provides blood mainly to the cranial pole and the central zone of the gland and posterior-lateral prostatic pedicle providing blood to the caudal pole and peripheral zone of the gland are the main object of interest. Identification of accessory or aberrant pudendal arteries responsible for arterial blood supply to corpora cavernosa their preservation during prostatectomy may avoid erectile dysfunction caused by penile arterial insufficiency. DSA and CTA are considered to be a method of choice in evaluation of these vessels due to highest temporal resolution. Nonetheless, multiparametric MRI including DCE phase allows for proper recognition of PAs.
Fig. 1: Schematic segmentation of the prostate gland blue - PZ, yellow - TZ+CZ, green - AFMS, purple - uretra

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Fig. 2: Structures adjacent directly to the prostate gland or present within the gland. pink - seminal vessels, black - verumontanum, white - urethra, red - external sphincter, green - AFMS + detrusor, blue - peripheral zone, yellow - central zone, orange dotted - prostate capsule, yellow dotted - prostate pseudocapsule

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Fig. 3: Structures adjacent directly to the prostate gland or present within the gland. pink - seminal vesicles, black - verumontanum, white - urethra, red - external sphincter, green - AFMS + detrusor, blue - peripheral zone, yellow - central zone, orange dotted - prostate capsule, yellow dotted - prostate pseudocapsule

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Fig. 4: Structures adjacent directly to the prostate gland or present within the gland. pink - seminal vesicles, black - verumontanum, white - urethra, red - external sphincter, green - AFMS + detrusor, blue - peripheral zone, yellow - central zone, orange dotted - prostate capsule, yellow dotted - prostate pseudocapsule

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Fig. 5: Course of the major nerves within male pelvis. In rare situations they undergo iatrogenic injury. Patients suffering from metastases may complain on specific symptoms if a neural structure is affected. red - sciatic nerve, yellow - sacral nerves, green - obturator nerve, blue - pudendal nerve

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Fig. 6: Course of the major nerves within male pelvis. In rare situations they undergo iatrogenic injury. Patients suffering from metastases may complain on specific symptoms if a neural structure is affected. red - sciatic nerve, yellow - sacral nerves, green - obturator nerve, blue - pudendal nerve

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Fig. 7: Course of the major nerves within male pelvis. In rare situations they undergo iatrogenic injury. Patients suffering from metastases may complain of specific symptoms if a neural structure is affected. red - sciatic nerve, yellow - sacral nerves, green - obturator nerve (anterior and posterior), blue - pudendal nerve

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Fig. 8: Course of the major nerves within male pelvis. In rare situations they undergo iatrogenic injury. Patients suffering from metastases may complain on specific symptoms if a neural structure is affected. red - sciatic nerve, yellow - sacral nerves, green - obturator nerve (anterior and posterior), blue - pudendal nerve

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**Fig. 9:** The muscular architecture of the pelvis is complex therefore the knowledge of the attachments and course of the main pelvic muscles holding the prostate gland needs revision. blue - obturator internus muscle, pink - puboprostatic muscle, green - pubococcygeus muscle, red - levator ani muscle, yellow - puborectal muscle, white - deep transverse perineal muscle, pink dotted - external sphincter. Bluish dotted - ureter.

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Fig. 10: The muscular architecture of the pelvis is complex therefore the knowledge of the attachments and course of the main pelvic muscles holding the prostate gland needs revision. blue - obturator internus muscle, pink - puboprostatic muscle, green - pubococcygeus muscle, red - levator ani muscle, yellow - puborectal muscle, white - deep transverse perineal muscle, pink dotted - external sphincter. Bluish dotted - ureter.

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Fig. 11: The muscular architecture of the pelvis is complex therefore the knowledge of the attachments and course of the main pelvic muscles holding the prostate gland needs revision. Blue - obturator internus muscle, pink - puboprostatic muscle, green - pubococcygeus muscle, red - levator ani muscle, yellow - puborectal muscle, white - deep transverse perineal muscle, pink dotted - external sphincter. Bluish dotted - ureter.

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Fig. 12: The muscular architecture of the pelvis is complex therefore the knowledge of the attachments and course of the main pelvic muscles holding the prostate gland needs revision. blue - obturator internus muscle, pink - puboprostatic muscle, green - pubococcygeus muscle, red - levator ani muscle, yellow - puborectal muscle, white - deep transverse perineal muscle, pink dotted - external sphincter. Bluish dotted - ureter.

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Fig. 13: Arterial supply of the prostate gland. Comparison of MRI axial images and DSA. red arrow - gluteal-pudendal trunk, long blue arrow - internal pudendal artery, short blue arrow - inferior gluteal artery, yellow arrow - prostatic artery

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Fig. 14: Regional lymph nodes of the prostate: common iliac lymph nodes

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Fig. 15: Regional lymph nodes of the prostate: internal iliac lymph nodes

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Fig. 16: Regional lymph nodes of the prostate: external iliac lymph nodes

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Fig. 17: Regional lymph nodes of the prostate: obturatory lymph nodes

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Conclusion

Zonal anatomy of prostate serves as the base of modern prostate imaging. Implementation of new sequences and high field systems enable assessment of prostate and male pelvis anatomy allowing better assessment of surrounding structures including lymph nodes and vessels. Very fine structures as small nerve branches although cannot be directly seen on imaging, can be assessed with implementation of knowledge of their normal anatomy and relationship of structures.
References


