Computed Tomography Of The Prostate- A Review

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Abstract

Computed tomography (CT), with its inferior soft tissue contrast, compared to magnetic resonance imaging (MRI) or transrectal ultrasound (TRUS) is not considered the primary imaging method when examining the prostate. Nevertheless, knowledge of the imaging features of prostatic disease on CT is important. The prostate is depicted in abdominal/ pelvic CT examinations and pathology of the prostate should not be missed. MRI is contraindicated in some patients and is in a global perspective not everywhere easily accessible. So patients with suspect findings on digital rectal examination or ultrasound may have the need for further CT imaging. After an overview of the normal anatomy the imaging features of common prostatic diseases with CT and its limitations are discussed.

INTRODUCTION

Because of the superior soft tissue contrast magnetic resonance imaging (MRI) is the preferred imaging evaluation of the pelvis. Especially in imaging of the prostate it is beside transrectal ultrasound (TRUS) the examination of choice (1). Computed tomography (CT) for diagnostic imaging of the prostate has been studied in the early days of this method in the late 70's and the 80's but has received little attention in the international medical literature of the last years (2-7). Nonetheless knowledge of the imaging features of prostatic disease on CT is important for the radiologist for a variety of reasons. The prostate is depicted in abdominal/ pelvic CT examinations being performed for wide range of indications, for example cancer staging, acute abdomen or fractures. In these examinations (incidental) pathology of the prostate should not be missed. MRI is contraindicated in some patients and is in a global perspective not everywhere easily accessible. So patients with suspect findings on digital examination or ultrasound may have the need for further imaging with computed tomography. In this review an overview of the normal anatomy and common imaging findings in prostatic diseases is given. Limitations and the possible impact of technical improvements with multislice CT (MS- CT) imaging are adressed.
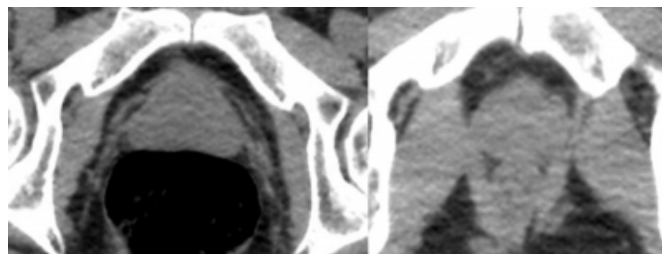
NORMAL ANATOMY

The normal prostate gland has a chestnut appearance. In the classic anatomic textbook by Henry Gray a normal size of about 3.8 x 2.5 x 3.2 cm (transverse diameter x sagittal diameter x height) (8). Generally a volume of less than 30 ml measured with TRUS is considered normal. This can be calculated by the formula 0.52 x length x width x height. Some older studies of radiotherapy planning showed that CT may overestimate the volume in contrast to TRUS up to 50% (9). This is explained with the limited soft tissue contrast, so that the differentiation of the gland itself from the bladder wall and sometimes the Levator ani muscles is not easily possible.

Figure 1

Figure 1: The prostate in two young patients showing a normal anatomy. On the left the neurovascular bundels within the rectoprostatic angle are clearly depicted. On the right side the levator ani muscles can be seen, sometimes differentiation is not straightforward and can lead to overestimation of the glandular size.


On detailed anatomic examination four different zones can be found. With imaging two of these can be depicted, a smaller central and a larger peripheral zone containing up to 70% of the gland volume. The zonal anatomy is of importance as most cancers arise in the peripheral zone.

Using adjusted window settings this zonal anatomy can also be observed with CT. The central zone is hyperdense with values between 40-60 Hounsfield units (HU) and the peripheral zone is hypodense with 10-25 HU (5).

Figure 2

Figure 2: With an adjusted window setting the central and the peripheral zone can be differentiated.
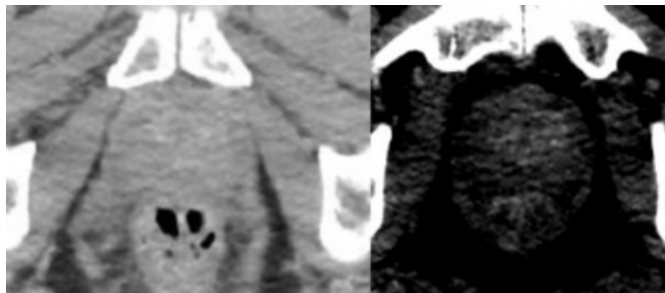
The percentage of patients in which the different zones can be depicted varies considerably in the literature. Mirowitz et al. and Rossen et al. could differentiate the zonal anatomy after administration of i.v. contrast media in 24 % and 75% of patients (10, 11). Dhawan et al. reported a possible differentiation of the zonal anatomy in 57% of healthy volunteers regardless if contrast media was used (5). These studies are describing a better depiction of zonal anatomy in elderly men, this has been shown for MRI as well (12). The above mentioned studies where all conducted before the era of MS- CT imaging, so it is unknown if the better spatial resolution with modern scanners may help in demonstrating zonal anatomy in more patients. Important anatomic structures in cases of malignant diseases are the neurovascular bundles, the rectoprostatic angle and the seminal vesicles.

CALCIFICATIONS

Calcifications of the prostate are a common finding on imaging. Their incidence increases with age. For example in an ultrasonographic study calcifications where found in 23.1% of men between 20 and 29 years of age and in 83% of men aged between 60 and 69 (13.). The clinical significance of prostate calculi is unclear and most authors interpret these calcificatins as an age related phenomenon. An association of large calculi with lower urinary tract symptomes in middle aged men and chronic pelvic pain syndrome in young men was reported (14, 15). It seems that in some patients calcifications may indicate longstanding low grade inflammatory changes, whereas in most patients they are an incidental finding with no further clinical significance.

BENIGN PROSTATIC HYPERPLASIA

Benign prostatic hyperplasia is common in elderly men. With enlargement of the central parts of the prostate patients develop so called 'lower urinary tract sypmtoms', like weak stream, feeling of incomplete emptying and nocturia (16). The enlargement of the prostate is to some degree a normal ageing process and not all patients with enlarged prostate develop lower urinary tract syndromes, i.e. correlation with clinical symptoms is mandatory (16). Like described above a volume above 30 ml is considered enlarged. Interestingly it has been shown that growth rate in men with or without lower urinary tract symptoms is similar and about 1.7% per year, in symptomatic men enlargement of the gland does only start earlier in life (17). Enlargement of the prostate is a frequent finding on CT, but the problem of overestimation of the prostatic like described above should be kept in mind (9). In everyday practice an orientating measurement in the axial plane is often performed, with an enlargement of the transverse diameter above 4.5 cm considered pathologic. The growth of the central parts of the glands may diminish the peripheral zone and sometimes inhomogenity of the gland is found. A protrusion of the prostate into the bladder can be found with enlargement and seems to be correlated with severity of symptoms (18).

Figure 3

Figure 3: Protrusion of the enlarged prostate into the bladder in BPH.
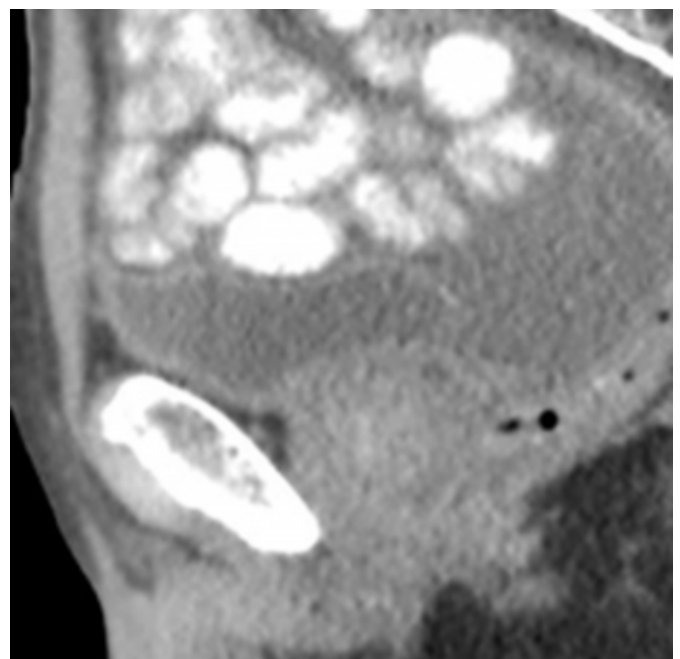

Massive enlargement of the prostate weighting more than 1 kg was reported, in this case CT showed a large mass filling

out the whole pelvis (19). Secondary findings like thickening of the bladder wall can also be found. If medical treatment fails transurethral resection of the prostate (TUR-P) is considered. The typical imaging finding after TUR-P is an enlargement of the first part of the urethra in a hypertrophic prostate.

Figure 4

Figure 4: After TURP-P there are typical enlarged proximal parts of the urethra within an enlarged gland. The picture was taken from an CT- urography explaining the contrast media filled bladder.
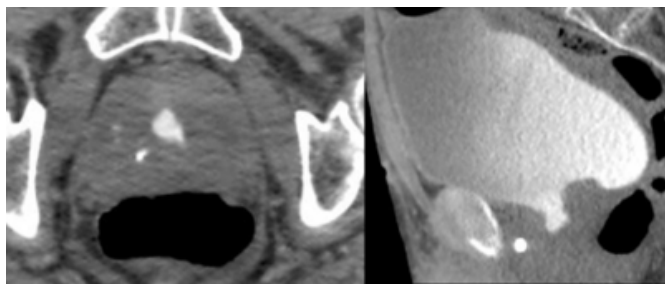

INFLAMMATION

Acute prostatitis is characterized by acute clinical syndroms like pain, fever, chills and dysuria. Despite clinical findings it can be occult at imaging. Acute focal as well as chronic prostatitis may resemble carcinoma on imaging. In the study of Prando and Wallace examining patients with helical CT focal contrast media uptake in prostatitis was indistinguishable from that in carcinoma (6). This is a known phenomenon from MRI, without further clinical data the differentiation of carcinoma or focal inflammation seems impossible (20). Abscess formation can easily be seen as a hypodense area within an enlarged gland after application of i.v. contrast media (21).

Figure 5

Figure 5: Central hypodensities caused by a prostatic abscess in a young male.
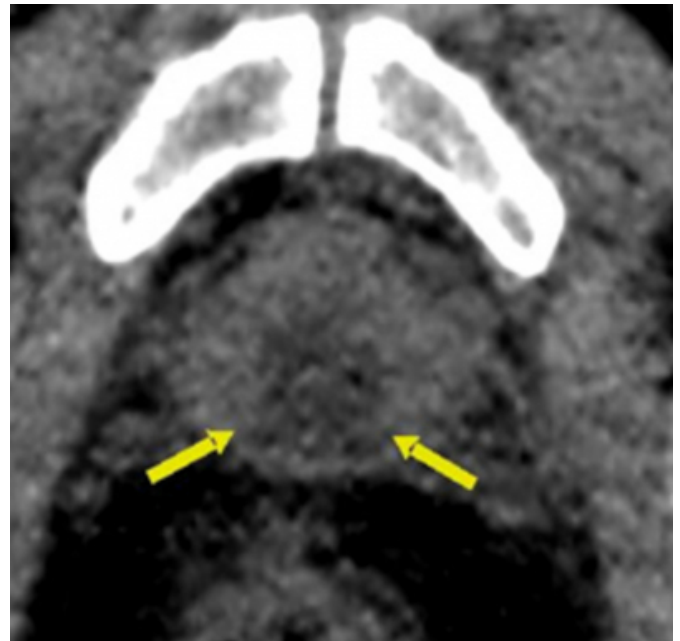
The prostate is the least affected urogenital structure in tuberculosis, but it may manifest with abcess formation. Subtle review for other manifestations of tuberculosis usually helps with the differential diagnosis, but a case of solitary involvement of the prostate in tuberculosis has been published (22). CT scans are commonly performed for acute abdomen, so radiologists should include prostatitis in their differential diagnosis for males undergoing imaging for acute pelvic pain and signs of inflammation.

PROSTATIC CANCER

Prostatic cancer is the most common malignancy in men. Screening with prostate- specific antigen (PSA) leads to a dramatic downstaging of newly diagnosed prostatic cancers. In western countries most prostatic cancers are now staged as T1 or T2, i.e. the tumor is still located within the prostate capsule (1). CT scanning is incorporated in actual guidelines for prostatic cancers only in patients with high PSA values and local extended disease (T3 or higher). The main purpose with CT is to determine the nodal status (23). Like all morphologic imaging it depends on the evaluation of the nodal size, i.e. a diameter of larger than 1 cm. This leads to problems with sensitivity as smaller lymph nodes could also contain malignant cells. Reported sensitivities for lymph node stageing in the literature vary widely between 25 and 85% (1)
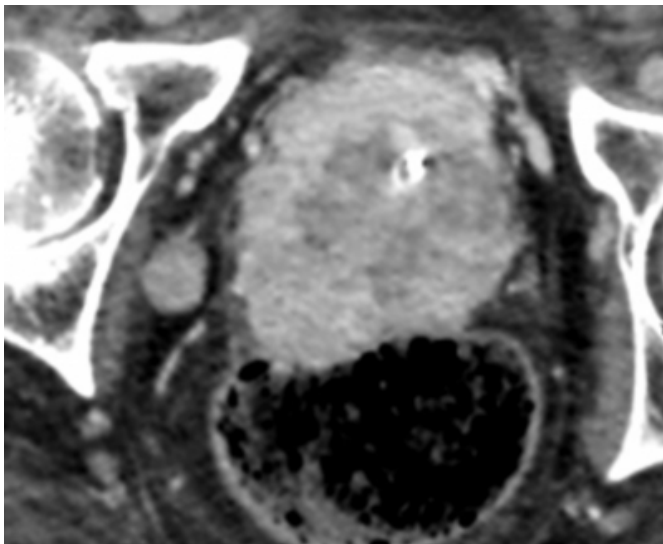
Figure 6

Figure 6: Retroperitoneal lymph node metastasis in a patient with prostate cancer.
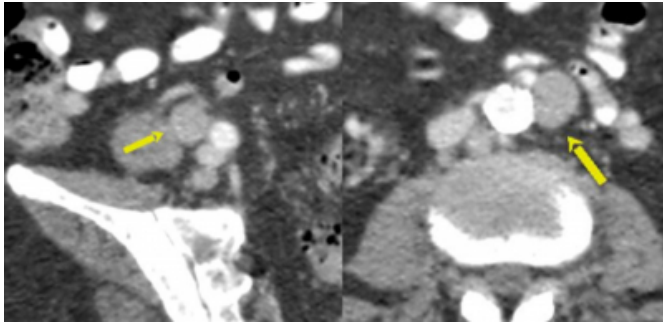
In the early days several publications concernig the T-Staging of prostate cancer were published with different results. Triller et al reported about 77 patients. In about 50% of patients with clinical suspected T2 stages CT showed extracapsular extension and on the other hand 20% of clinical T3 tumors where downstaged after a CT examination (2). Giri et al. reported about 25 patients in whom 28% of patients showed a change in cancer stage after CT in comparison to the clinical examination (3).

Figure 7

Figure 7: Large prostatic carcinoma with extension beyond the prostate capsule obscuring the right rectoprostatic angle. Note the enlarged regional lymph node.

In the study of Platt et al. the overall accuracy of CT in T-staging was only 67%. The invasion of periprostatic fat tissue showed a sensitivity of 75% whereas the invasion of the seminal vesicles showed only a sensitivity of only 33% (4).

Figure 8

Figure 8: Prostate cancer with seminal vesicle invasion.
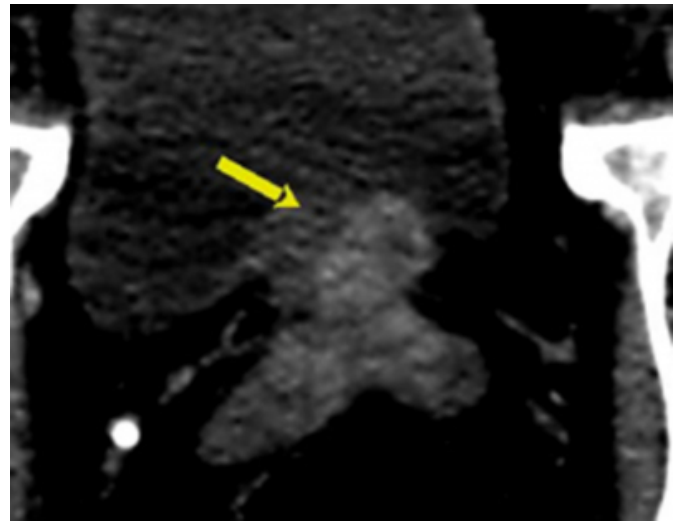
After the implementation of TRUS and MRI in clinical practice in one of the first comparative studies CT performed significantly worse than TRUS and MRI (24). With modern 1.5 Tesla scanners sensitivities between 77% and 91% using T2- weighted imaging can be achieved and with dynamic contrast enhanced T1- weighted images sensitivity further increases (25). Given in the inferior sensitivity CT imaging is considered not reliable for T1 or T2 cancers (1). Interestingly there are only three studies published in english language examining prostate cancer after the implementation of helical- CT into clinical practice (5, 6, 7). Prando and Wallace used a contrast enhanced protocol and a 3.5 mm slice thickness in patients with mostly T1 and T2 cancers. Areas of focal contrast media uptake were considered pathologic. In 23 of the examined 25 patients with cancer they found abnormalities on CT imaging (88%). In direct comparison with endorectal ultrasound 43% small biopsy proven carcinomatous foci were missed, nonetheless in these patients there were pathologic findings CT. Interestingly almost 10% of enhancing lesions were not malignant. With higher PSA values the enhancement of the malignant foci increased (6). Similar results were reported by Dhawan et al. They used 5 mm slice thickness and a mix of enhanced as well as unehanced scans and reported disturbed zonal pathology in 83% of patients with prostatic cancer (5). It seems that CT shows pathological changes in most patients with prostate cancer in early stages, but the exact localization of multiple small malignant foci is problematic.

Figure 9

Figure 9: Contrast enhancing carcinomatous tissue within the peripheral zone in a patient with prostate carcinoma.
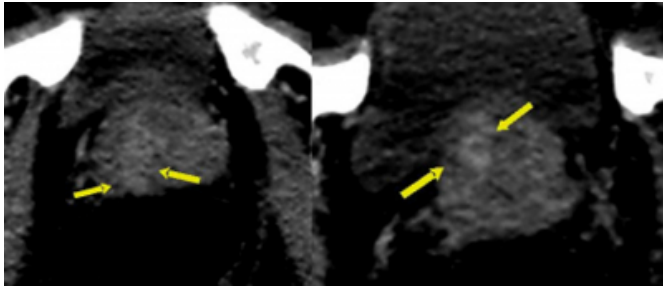
These two studies used single slice scanners. Ives et al. studied the perfusion of prostatic carcinomas in 10 patients with a 16- slice CT scanner and correlated it to whole mount pathology. In contrast to the above mentioned study they found visible contrast enhancing lesions in only 10% of their patients with prostatic cancer., CT perfusion parameters performed better and showed abnormalities in 50% of their patients, they could be correlated to poor differentiation and larger tumor volumes (7). Recently there were several published articles from chinese investigators examining prostatic cancer with MS- CT, but unfortunately there are only abstracts published in english language. Two of these studies seem to be particulary interesting. Liu et al. used CT perfusion imaging and reported differences in perfusions parameters (time densitiy curve and peak time) between BPH and prostatic cancer (26). With the use of a 16- slice CT scanner and multiplanar reformations Ye et al. reported about improved anatomic depiction of prostate cancer (27). If this leads to more accuracy in the T- staging in prostate cancer is unclear, but this has recently be shown for rectal cancer (28). These results seem to be preliminary and have to be reproduced in larger series, i.e. more research with modern MS- CT scanners is thoroughly needed. Interestingly MS- CT showed promising results in patients with breast cancer, another area of medical imaging where CT has been thought to be dramatically inferior to MRI (29). The sensitivity for recurrent prostatic cancer after radical prostatectomy was low using an incremental or a singleslice helical CT scanner (30). Bone metastasis are common and are reliable shown, in this case CT imaging is the examination of choice if there are questions about the stability of the affected bones.

Figure 10

Figure 10: Typical osteoblastic bone metastasis in prostate cancer.
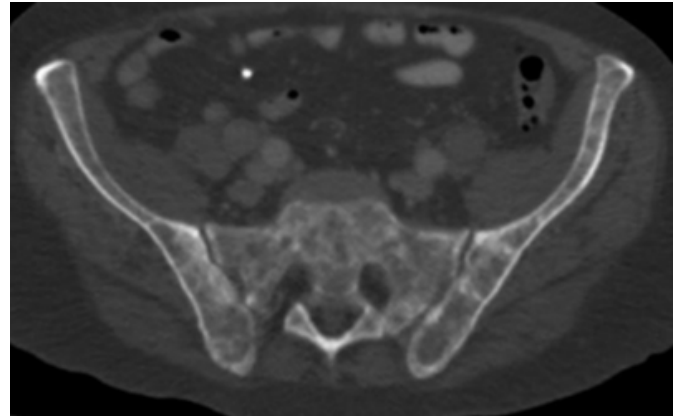
After operation or interventional treatment comlications like hematoma, perforation or urinoma can be easily diagnosed with CT.

CONCLUSION

Despite the shortcoming of inferior soft tisue contrast compared to MRI or TRUS pathologies of the prostate can be seen on CT imaging. Radiologists reporting abdominal and pelvic CT scans should be aware of these findings. In selected patients and scenarios CT imaging may help in diagnosing prostatic disease. More research of possible improvement of diagnostic imaging of the prostate with the use of modern MS- CT scanners with submilimeter slice thickness and hig quality reformations is thoroughly needed to make sure we use the full potential of our scanners.

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