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Practical Significance of Transrectal Doppler Ultrasonography and Ultrasonography in Prostate Cancer

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Abstract: Transrectal ultrasonography (TRUS) has traditionally been regarded as the primary test for prostate imaging and is clinically important in both benign and malignant lesions, including benign prostatic hyperplasia (BPH), prostatitis, obstructive infertility, and prostate cancer (PCa). provides information. Currently, the main reasons patients are referred for TRUS are ultrasound for the detection and evaluation of prostate cancer and prostate biopsy. The accuracy of these studies depends in part on the cost of stationary ultrasound scanners. Transrectal ultrasonography (TRUS) has traditionally been regarded as the primary test for prostate imaging, providing clinically important information on both benign and malignant lesions, including benign prostatic hyperplasia (BPH), prostatitis, obstructive infertility, and prostate cancer (PCa). gives information. Currently, the main reasons patients are referred for TRUS are ultrasound for the detection and evaluation of prostate cancer and prostate biopsy.

Key points: Anterior fibromuscular tissue, Capsule, Periprostatic adipose tissue, Periprostatic lymph nodes, Neurovascular bundles, Ejaculatory ducts.

SONOGRAPHIC ANATOMY

The average dimensions of the normal adult prostate are 4.0 to 4.5 cm, 2.5 to 3.0 cm, and 3.0 to 4.0 cm in the transverse, anteroposterior, and craniocaudal directions, respectively. up to cm. This gland is surrounded by a thin pseudocapsule, which is almost indistinguishable from the surrounding fascial planes. Anatomically, the neurovascular bundles that pierce the prostate capsule are very important, because they are the main site of weakness of the capsule apparatus and are likely to be involved in the tumor process. The picture of a normal gland in TRUS depends on age. While younger men have less hyperplasia of glandular tissue, older men develop BPH and the prostate becomes a larger gland with a more rounded shape.

On average, 70% of the normal prostate gland consists of glandular elements, and the remaining 30% is fibromuscular stroma. The glandular tissue of the prostate gland usually consists of internal glands, which include the transition zone and periureteral glandular tissue, and external glands occupying the peripheral and central zones. TRUS can distinguish the transition zone, which is usually located anteriorly as a hypoechoic region, from the peripheral zone, which is echogenic and uniform in echotexture compared to the rest of the gland. On the other hand, the central zone is almost no different from the peripheral zone in healthy adult males. The transition zone is the main site for hyperplastic changes and constitutes the majority of prostate tissue in older men, and may be the site of development of approximately 20% of prostate cancer. It should be noted that 1% to 5% of prostate cancers are located in the central zone. The peripheral zone, which is the main site of development of chronic prostatitis, causes about 70% of prostate cancer. On the other hand, cancerous lesions in the transition zone are unlikely to be distinguished from BPH nodules on TRUS.

Scanning technique

Today, biplane sensors together with end and side sensors enable multi-plane imaging in semi-coronal, axial and sagittal projections during transrectal scanning of the prostate gland. Technically, 5 to 8 MHz transducers provide high accuracy for the peripheral part of the gland, which is very important for accurate sample selection during biopsy. Air bubble artifacts adversely affect image quality, which can be avoided by using ultrasound gel applied to a latex condom placed on the transducer. Self-enema before the procedure helps to evacuate gas and debris, another factor that can cause TRUS image distortion. Concurrent digital rectal examination may be useful in identifying suspicious findings on physical examination associated with TRUS abnormalities. Many specialists prefer the left lateral decubitus position because it is well tolerated. In conclusion, a full bladder provides a clear view of the base of the prostate, which helps to better visualize the prostate. However, according to the authors, clinical practice shows that the bladder should not be overdistended, as this may lead to urinary incontinence during the biopsy procedure.

TRUS evaluation of the prostate begins with a systematic scan in the transverse or semicoronal plane, starting at the level of the seminal vesicles adjacent to the base of the prostate and continuing to the apical level, which visualizes the gland. zones. A sagittal plane examination is then performed to detect lobar asymmetry, as well as to confirm suspicious lesions detected on axial or coronal scans. Prostate and extraprostatic structures evaluated in a systematic approach are listed in Table 1. It should be noted that the ellipsoid formula allows you to calculate the size of the prostate using diameters along orthogonal axes:

Anatomic structures evaluated by TRUS

External gland

Internal gland

Anterior fibromuscular tissue

Capsule

Periprostatic adipose tissue

Periprostatic lymph nodes

Neurovascular bundles

Ejaculatory ducts

Seminal vesicles

Rectal wall

Urethra

In patients diagnosed with prostate cancer, an assessment of prostate size may be necessary to prescribe appropriate therapy. Appropriate evaluation may also be useful in treating patients with undiagnosed cancer, as it may direct therapy to patients with symptoms of lower urinary tract obstruction. The transrectal ultrasound approach to the prostate also allows the operator to perform various diagnostic and therapeutic interventions for prostate cancer due to its significantly higher accuracy compared to other ultrasound scanning methods.

PROSTATE CANCER

PCa is the second leading cause of cancer-related death in men. In addition to being a major medical problem, this disease is also an important public health problem because of its high economic costs. Although early detection of the disease is important for adequate treatment, small foci of cancer can be found in addition to significant tumor lesions. Today, the main tools used to diagnose the disease are digital rectal examination, serum prostate-specific antigen (PSA) levels, and TRUS-guided prostate biopsy. Currently, the positive predictive value of prostate biopsy based on digital rectal examination, PSA, and TRUS results is low and leads to a significant number of

unnecessary biopsies. Therefore, there is a clear need to improve the accuracy of diagnostic methods for prostate cancer.

The most common indication for TRUS of the prostate gland is the diagnostic evaluation of suspected prostate cancer. It seems that the early detection of prostate cancer is closely related to the reduction of mortality, because detection in the early stages of the disease is often the only chance for treatment. Before diagnostic tools such as digital rectal examination, TRUS and PSA tests were widely introduced to detect the disease at an early stage, prostate cancer was often diagnosed at an advanced stage, resulting in patients dying sooner. Although a serum total PSA (TPSA) level above 4 ng/mL may indicate the presence of prostate cancer, patients with BPH and inflammatory prostate disease may also have elevated serum total PSA levels. The lack of specificity of serum total PSA for PCa screening inevitably led to further efforts to identify an ideal protocol combining PSA, TRUS, and digital rectal examination to improve specificity without compromising sensitivity. Although TRUS is recognized as the best method of ultrasound guidance for biopsy, its low positive predictive value in the diagnosis of malignant tumors is an important drawback.

There have been steady improvements in TRUS technology since its first clinical introduction in the 1960s. Although there is a consensus on the use of TRUS to evaluate prostate size and ultrasound for biopsy, its limited value for accurate detection of early stage PCa and detection of local tumor spread still precludes its use. raises the main clinical question about its effectiveness. However, gray-scale ultrasound can clearly define the zonal anatomy of the prostate gland, and the gland can be easily distinguished from periprostatic tissue, including the rectum, neurovascular bundles, and adipose tissue, by TRUS.

Classically, a hypoechoic lesion in the peripheral zone may indicate a malignant process, but PCa may have less isoechoic or hyperechoic features.

Prostate cancer. Transverse gray-scale TRUS image shows a poorly defined, slightly hypoechoic mass in the subcapsular zone (arrow) of the left lobe, confirmed histologically as an adenocarcinoma.

(A) Transverse gray-scale TRUS image with no obvious lesion in the peripheral zone. (B) Transverse color Doppler TRUS image from the same patient shows an area of vascular enhancement in the right peripheral zone (arrow), which was the only feature of adenocarcinoma identified histopathologically. The tumor was invisible on gray-scale TRUS due to its isoechoic nature.

Currently, the use of other less specific features is required for the diagnosis of prostate cancer, as a significant proportion of detected prostate cancers are isoechoic. In this context, the following features may be useful: asymmetry, echotexture or glandular edge. Accordingly, a nonspecific irregular echo or a bulging or discontinuous capsule contour may indicate the presence of PCa. However, approximately half of PCa lesions are not visible on grayscale ultrasound. In addition, some types of pathology, for example: BPH, prostatitis, atrophy, hematoma, ductal ectasia and intraepithelial neoplasia can mimic the image of prostate cancer on gray ultrasound. Another challenge for evaluating PCa is that it is predominantly multifocal; a single circular formation may also occur, but this pattern is less common. Morphologically, only 30% of PCa may present as a solitary nodule, a lesion accompanied by an infiltrative component occurs in approximately 50% of patients, and the infiltrative pattern predominates. the remaining 20%. Ultrasonography shows advanced prostate cancer with diffuse hypoechoic and heterogeneous peripheral echotexture, which is isoechoic or hyperechoic compared to normal prostate tissue.

ULTRASONOGRAPHY OF THE PROSTATE:

Prostate cancer. (A) Transverse grayscale TRUS image shows a round, hypoechoic mass located in the right peripheral zone (arrow). Neither color (B) nor power (C) Doppler TRUS revealed a significant increase in blood flow, which predicts the neovascularization characteristic of PCa. (D) Transverse TRUS image illustrates the trajectory of the needle used to obtain a biopsy specimen from the lesion noted above.

Prostate cancer. (A, B) Transverse and longitudinal gray-scale TRUS images depicting a localized nodule in the right peripheral zone (arrows in A and B). (C, D) Transverse and longitudinal power Doppler TRUS images (arrows C and D) revealed vascular enhancement in the lesion.

Prostate cancer. (A) Transverse gray-scale TRUS image shows diffuse heterogeneous parenchymal echotexture with irregular capsular contour and prominent posterior extracapsular extension. The lesion has a significant protrusion and is located close to the rectal wall, indicating infiltration of cancer tissue. Transverse color (B) and power (C) Doppler TRUS images show increased blood supply to the affected area. (D) Whole-body scintigraphy of the same patient shows multiple areas of increased growth in the axial skeleton, representing abnormal osteoblastic activity and consistent with a metastatic lesion.

Small cancers usually have a hypoechoic appearance, while tumor extension may result in an isoechoic lesion or a heterogeneous echogenic lesion. There are no specific ultrasound features for cancer of the transition zone, but they differ from cancer of the peripheral zone in that they are clinically less aggressive. Therefore, a routine biopsy is the only way to detect transition zone cancer. The presence of concomitant BPH may be a limiting factor in TRUS evaluation of the prostate gland, as its mixed signal reflection or peripheral compression effect may mask prostate cancer.

In addition to adenocarcinoma, the most common histological type of prostate cancer, ultrasound features of rare prostate tumors have also been described. An adenomatous cyst of the prostate gland can appear with several identical small cysts. Comedocarcinoma, the most dangerous form of PC, appears sonographically as a cancerous hypoechoic zone interspersed with numerous heterogeneous small hyperechoic foci. Lymphoma, on the other hand, has an ultrasound appearance of large hypoechoic masses in the transitional and peripheral zones. In summary, soft tissue masses that invade the bladder and prostate can present as rhabdomyosarcoma, which develops during childhood.

Although the use of TRUS in the diagnosis of PCa is limited, some TRUS findings can detect extracapsular extension. These findings include local protrusion or irregularity of the prostatic capsule and hypoechoic lines in the plane of the periprostatic adipose tissue. However, TRUS cannot detect the extracapsular spread of small microscopic clusters of tumor cells.

COLOR DOPPLEROGRAPHY

Doppler ultrasound is a tool for assessing local blood flow, which is closely related to tissue function and vitality. In color Doppler, the color palette is related to the direction of blood flow and the direction of the sensor when receiving the signal, where the flow to the sensor is depicted in red and the flow from the sensor is depicted in blue. On the other hand, with the accelerated growth rate, the increase in blood supply demand of cancer tissue is more obvious than that of normal tissue, which can cause significant changes in local hemodynamics. As a result, this affects the ability to see and detect cancer using color Doppler ultrasound. An increase in the number of dilated and atypical blood vessels, reflecting angiogenesis and increased blood flow in tumor tissue, can be detected using color Doppler ultrasound. Technically, increased blood flow can be demonstrated by spectral analysis using pulsed-wave Doppler, which detects waves representing frequency or velocity shifts, or color Doppler, which depicts a spectrum of colors representing the average range of frequency or velocity shifts. red blood cells in the bloodstream.

Previously, it was believed that color Doppler sonography provides the best diagnosis of prostate cancer, because it allowed to determine the diffuse, local and surrounding nature of blood flow. It was later determined that the technique had low specificity for appropriate evaluation. Furthermore, hypoechoic lesion and hypervascularity suggestive of PCa are not correlated. However, the color Doppler signal has been shown to correlate well with the stage and type of PCa, as well as the risk of recurrence after treatment, which is key to determine the behavior and aggressiveness of PCa. Accordingly, color Doppler ultrasonography has been useful in distinguishing low-risk hypovascular tumors from high-risk hypervascular tumors, since the latter group is associated with hypervascularization and represents a higher stage of Gleason tumor, which is an extraprostatic tumor. 'implies a high risk of simta enlargement. Targeted biopsy relies only on high-frequency color or power Doppler imaging, because theoretically there is a risk of missing a significant number of tumors. In addition to quantifying blood flow, color Doppler ultrasound can calculate microvascular density (distribution of microvessels), which may be useful for assessing blood flow in the prostate gland. Naturally, the density of microvessels was higher in metastatic tumors, which is typical for PCa. Because core biopsy underestimates Gleason histology, microvessel density can be used as an indicator of disease prognosis. Technical limitations of color Doppler imaging for prostate evaluation include angular dependence of Doppler flow, intraprostatic noise that mimics flow enhancement, and inadequate detection techniques at low flow rates.

POWER DOPPLEROGRAPHY

Power Doppler has less angular dependence than color Doppler and provides information on the presence and intensity of flow signals. The advantage of the technique is to detect slow flow in small tumor vessels and even subtle changes in blood flow. However, it is not possible to predict the flow direction using this method. Power Doppler ultrasound, which has 3-4 times the sensitivity to detect prostate cancer, also helps in the differential diagnosis of BPH and prostate cancer. However, this technique has rarely been reported to be superior to color Doppler in the detection of PCa. Although power Doppler can help determine a suitable site for prostate biopsy by identifying areas of local hypervascularization, it is not considered superior to color Doppler and is only useful for targeted biopsy if the number of biopsies through the prostate is limited. Combined grayscale sonography and color Doppler TRUS-guided biopsy are not sensitive enough to obviate the need for routine biopsy. A recent study has shown that spectral waveform measurement of prostatic capsular and urethral arteries using power Doppler ultrasound may be useful in distinguishing prostate cancer from benign hypertrophy. The researchers also hypothesized that increasing the number of biopsies limited to abnormal spectral Doppler index values would increase the diagnostic efficiency in detecting PCa.

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