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ROLE OF TRANSRECTAL BIOPSY UNDER ULTRASOUND GUIDANCE WITH SHEAR WAVE ELASTOGRAPHY IN DIAGNOSTICS OF THE PROSTATIC DISEASES

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It is commonly known that oncological diseases occupy second place in the structure of causes of death in the adult population after cardiovascular diseases. Prostate cancer is the second most common malignant tumor among men. Thus, timely diagnostics of this disease is of great importance. Despite the large number of screening tests, the development of new visualization techniques and utilization of invasive procedures, such as biopsy, prostate cancer remains difficult for early diagnosis. The shear wave elastography should become an additional method of obtaining images of the prostate, auxiliary to traditional transrectal ultrasound and MRI.

Key words: elastography, prostate.

Introduction. Prostate cancer screening is based on the data obtained during digital rectal examination (DRE) and prostate-specific antigen (PSA) levels. However, elevation of PSA levels is not specific to prostate cancer and can be related to benign prostate hypertrophy, acute and chronic prostatitis and trauma of the prostate (during cystoscopy, resection or biopsy). Moreover, there are clinically significant prostate cancers with PSA level lower than 4 ng/ml.

Prostate cancer can be suspected in patients with elevated PSA levels and if suspicious data is obtained during the DRE. Afterwards, ultrasound investigation and prostate biopsy are to be performed. Prostate biopsy also lets to evaluate the volume of the tumor (quantity and spatial dispersion of positive specimen, length of the tumor in every positive specimen), and its aggressiveness (Gleason score, capsule and neuromuscular bundle invasion) [4].

However, this approach has some limitations. The PSA screening causes significant number of unneeded biopsies in patients without cancer or those with clinically insignificant cancer (cancer that does not require immediate treatment and unlikely leads to death). Many urologists face a dilemma when patients with elevated PSA levels show negative biopsy results: both when biopsy is required and when not.

The transrectal B-mode ultrasound has limited sensibility and specificity within 40–50 % for prostate cancer detection, so application of Doppler ultrasound could improve it insignificantly [10]. Contrast-enhanced ultrasound is still subject of thorough assessment and needs further investigations to confirm its effectiveness [5].

Prostate cancer tissue is usually more dense than normal prostatic tissue, so it can be determined during digital rectal examination [3]. Technique, capable to determine tissue elasticity, can be useful for identification of sites of prostatic gland affected by cancer cells.

Majority of investigations report significant improvement of cancer localization with shear-wave elastography being a useful element for target biopsies [2, 8].

However, there are controversial data showing inability to differentiate prostate cancer from prostatitis [1]. On the other hand, elastography was less accurate than systemic prostate biopsies for detecting prostate cancer [7]. Besides, Porsch et al. in their survey showed that elastography had low diagnostic value for detection of prostate cancer [7]. But in other studies absolute levels of rigidity of benign and malignant tumors varied significantly as well [6].

In this article, we represent our analysis of application of shear-wave elastography, touching upon the following issues:

- application of this technique as screening of the prostate cancer;
- reliability for detection and specification of the prostate cancer;
- practical recommendations for application of this technique in daily routine;
- disadvantages and limitations of this technique.

Materials and methods. Thirty-one patients examined at the Urology clinic of the National Military Medical Clinical Center, Kyiv, were included into the study. Those patients were divided into 4 groups (Table).

Distribution of patients by age and prostate-specific antigen level

Comparison groups	Number of patients	Age, years	PSA total, ng/ml
Control group (conditionally healthy)	3	30 ± 5	0.49 ± 0.33
Patients with benign prostatic hyperplasia	9	63.0 ± 7.3	4.3 ± 0.7
Patients with chronic prostatitis	4	61.0 ± 5.3	3.9 ± 0.3
Patients with prostate cancer	15	69.0 ± 5.8	7.8 ± 2.7

The study was performed on the complex ultrasound diagnostic expert device “RADMIR ULTIMA”. All patients underwent complex transrectal ultrasound examination (TRUS) by endocavitational probe EC 6.5 MHz/10 R with application of the shear-wave ultrasonography.

Elastography ensures evaluation of microscopic properties – such as elasticity. This technique is based on quantitative and qualitative evaluation of elastic properties of the tissue. Term “elastography” (Latin *elasticus*) was used first in 1991 by investigator from Houston (USA) J. Ophir et al. Physical base of elastography is Young’s elastic modulus, which defines the relationship between stress and strain in a tissue during deformation. Depending on the method of calculation of the Young’s elastic modulus, elastography is divided into compression elastography and shear wave elastography.

The compression elastography (real-time elastography – RTE) – is a method of qualitative assessment of elastic properties of tissues based on formula $E = \sigma/\varepsilon$, where E – Young’s elastic modulus, σ – compression value, ε – relative deformation of the tissue column. This method is applied for superficially located organs examination, such as thyroid gland, breast, prostate, uterus. Examination is being performed by linear probe through compression (σ) which is able to deform tissue. Compression is applied by a hand and a probe, or by pulsation, which is applied by special vibro-nozzle. Under such pressure the more dense objects diminish in size more significantly than elastic and soft. Compressive elastography allows to compare elasticity of different areas of the tissue. Elasticity levels ratio is a relative level.

Compression elastography provides only qualitative assessment of rigidity distribution inside tissues, because it is very difficult to measure level of compression (in kPa) in real circumstances in the area of interest. In addition, tension, which is calculated as ratio of level of deformation of the tissue column to its initial height, is a dimensionless value, and data received contain only information about deformation of the tissue. The only one quantitative (relative) value is a ratio of elasticity of two different areas of tissues. Assessment of elasticity by determination of relative value is called semiquantitative analysis. In ultrasound systems tension assessment is implemented by degree of tissue’s displacement. In compression elastography information can be presented by graphical way, or by color mapping where elasticity zones are marked by different colors. Elastography is the most informative tool/method to examine superficial organs and tissues, located maximum 5 cm deep (optimally 3–4 cm). It is of high importance to have the level of local deformation not exceeding 1–2 %, because the accuracy of assessment decreases in high values of deformation.

When performing shear wave elastography the force of pressure of powerful impulse ultrasound beam is used. This pressure has a maximum value in the focal area, which becomes a point source of shear waves spreading from the focal area in the perpendicular direction.

Physical wave is an elastic transverse wave unlike longitudinal ultrasound wave. The technique is based on measurement of speed of shear waves inside the tissues. According to the equation $E = 3 \rho C^2$ speed C is directly proportional to tissue's elasticity E . Thereby, the higher the speed, the higher the elasticity. This is the only approach capable to obtain quantitative information about rigidity levels, measured in kPa. However, dimensional capability of shear wave elastograms cedes to compressional technique.

Color carting assessment and measurement of the tissue's rigidity at the symmetrical parts of the peripheral, central and transitional zones of the prostate was performed during shear wave elastography. Standard range of rigidity color scale – from dark-blue (0 kPa) till bright-red (300 kPa) was used in all examinations. Mean values (E mean) was used during elastometry.

Transducer was kept in steady position for 2–4 seconds until signal stabilization for every area. High-rigidity tissues were mapped by red color, while soft tissues were mapped in blue color.

Transrectal multifocal prostate biopsy was performed to the patients representing Groups 2, 3, and 4. Biopsy was performed according to standard 12-points scheme. Moreover, patience underwent additional biopsy of suspicious areas according to shear wave elastography.

In young patients without prostate diseases (conditionally healthy), whole prostate was mapped at the elastograms evenly with soft elasticity and colored by dark-blue color with values less than 29 kPa (Fig. 1).

Patients with benign prostatic hypertrophy have soft peripheral area even when central and transitional area become heterogenous with elevated levels of rigidity (especially in the presence of calcinates). Picture 2 shows typical peripheral areas of the benign prostatic hypertrophy with 30–39 kPa. e

We have noticed significant polymorphism of results in patients with chronic prostatitis. This is associated with different forms of prostatitis (diffuse and focal), and presence of calcinates. Mean levels of elasticity for these patients fluctuated within 40–69 kPa (Fig. 3).

We observed significant increase of tissue elasticity in patients with prostate cancer ≥ 70 kPa, which was mapped on elastograms as red color (Fig. 4).

Results. Shear wave elastography provides useful additional information for prostate cancer localization. At first, suspicious areas match to those detected during other examinations like ultrasound in standard gray scale mode, Color Doppler and MRI.

Secondly, some areas detected by shear wave elastography were not observed during any other technique.

Thirdly, application of shear wave elastography for navigation during prostate biopsy allows to perform ongoing scanning of the prostate from basis to apex in order to detect areas with heightened elasticity. Obtaining quantitative information about tissue's elasticity, finding of elasticity ratio between neighboring tissues of the prostatic gland.

Discussion. Shear wave elastography has been performed for complete, high-quality transrectal ultrasound examination of the prostate in transverse and sagittal planes in order to measure prostate volume, to detect suspicious hypo- and hyperechoic areas, and to analyze periprostatic space (including seminal vesicles).

Shear wave elastography has some weaknesses, including: minimal pressure to transducer (the tip of the transducer requires minimal pressure on the prostate for obtaining of the image of the prostate), slow frame rate (one image per second), and limited size (elasticity can be measured only on the certain part of the prostate). Stabilization delay for every new part of the prostate and attenuation of the signal inside large volume prostates has been observed. Information about elasticity should be considered in combination with results of transrectal ultrasound and other visualization techniques, such as MRI.

Conclusions. 1. Shear wave elastography is a valuable ultrasound diagnostic method which increases information content of prostate diseases diagnostics. 2. Mean value of elasticity of normal prostatic tissue was within the limits of 10 and 29 kPa. Main elastographic feature of benign prostatic hyperplasia was mean value of elasticity

Fig. 1

Fig. 2

Fig. 1

Fig. 4

Fig. 1. Patient C., 56 years old. PSA level 3,1 ng/ml. No pathology was identified at digital rectal examination. Prostate size at the ultrasound examination $41,7 \times 33,6 \times 43$ mm, even. Flat, well defined contour. At the shear wave elastography mean value of elasticity of this area is 16,3 kPa

Fig. 2. Patient L., 65 years old. PSA level elevated to 7,76 ng/ml. At the digital rectal examination prostatic gland is soft-elastic, flat, has well-defined contour, additional tumors not palpable. Mucous membrane of the rectum is mobile, interlobar furrow is not smoothed. Ultrasound examination reveals $50,5 \times 39,7 \times 36,2$ mm prostate, heterogenous due to fibrotic areas in the peripheral zone. Hyperechoic area ($13 \times 7,7 \times 12,4$ mm) identified in the right lobe of the prostate at the border with periuterthral zone. At the shear wave elastography mean value of elasticity of this area was 32.88 kPa. Subsequent biopsy of this area showed adenomatous-stromal hyperplasia of the prostate. Correlation between elastographic and histological data was observed

Fig. 3. Patient G., 42 years old. Psa level elevated to 11.86 ng/ml. Digital rectal examination shows flat soft-elastic prostatic gland with well-defined contour, additional tumors not palpable. Mucous membrane of the rectum is mobile, interlobar furrow is not smoothed. The ultrasound examination shows $64,5 \times 62,7 \times 64,2$ mm prostate, heterogenous due to calcinates in central area, hyperechoic area $23 \times 9,7 \times 16,4$ mm (volume $1,9 \text{ cm}^3$) was defined. At the MRI prostate size was $41 \times 48 \times 58$ mm, enlarged due to middle lobe, with its intravesical protrusion. Right lobe is heterogenous. No signs of metastatic lesion of regional lymphatic nodes. At the shear wave elastography mean value of elasticity of this area 56.4 kPa. Subsequent biopsy of the prostate showed significant diffuse and focal lymphatic infiltration of the prostate. Summary: chronic prostatitis. We observed correlation between elastographic and histological data

Fig. 4. Patient N., 69 years old. PSA elevated to 109,4 ng/ml. At the digital rectal examination, prostatic gland is rigid, uneven, indistinct contour. Limited mobility of mucous membrane of the rectum. Ultrasound examination shows $56 \times 49 \times 54$ mm prostate with consolidation areas. Oval hyperechoic area $17,7 \times 19,3 \times 15,3$ mm is detected. At the shear wave elastography mean value of elasticity of this area 129.38 kPa. Biopsy of this area shown adenocarcinoma of the prostate, Gleason score $2 + 3 = 5$

within the limits of 30 and 39 kPa, chronic prostatitis within the limits of 40–69 kPa, prostate cancer more than 70 kPa. 3. Elastography provides more information for suspected prostate cancer localization and serves as additional guide for targeted biopsy. Early detection of the prostate cancer ensures improved treatment results and consequently influences patient's quality of life.

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РОЛЬ ЕЛАСТОГРАФІЇ ЗСУВНОЇ ХВИЛІ В ДІАГНОСТИЦІ ЗАХВОРЮВАНЬ ПЕРЕДМІХУРОВОЇ ЗАЛОЗИ

Ф. З. Гайсенюк, С. В. Головко, Б. В. Джуран, В. В. Козут, О. Ф. Савицький,
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Як відомо, онкологічні захворювання посідають друге місце в структурі причин смерті дорослого населення після серцево-судинних захворювань. У чоловіків рак передміхурової залози – друга за поширеністю злоякісна пухлина, отже, питання своєчасної діагностики цього захворювання є актуальним. Незважаючи на велику кількість скринінгових обстежень, розробку нових методів візуалізації і використання інвазивних процедур, таких як біопсія, рак передміхурової залози залишається складним для ранньої діагностики. Еластографія зсувної хвилі повинна стати додатковим методом отримання зображень передміхурової залози, що доповнює традиційне трансректальне ультразвукове дослідження і МРТ.

Ключові слова: еластографія, передміхурова залоза.

РОЛЬ ЭЛАСТОГРАФИИ СДВИГОВОЙ ВОЛНЫ В ДИАГНОСТИКЕ ЗАБОЛЕВАНИЙ ПРЕДСТАТЕЛЬНОЙ ЖЕЛЕЗЫ

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Как известно, онкологические заболевания занимают второе место в структуре причин смерти взрослого населения после сердечно-сосудистых заболеваний. У мужчин рак предстательной железы – вторая по распространённости злокачественная опухоль, поэтому вопрос своевременной диагностики данного заболевания очень актуальный. Несмотря на большое количество скрининговых обследований, разработку новых методов визуализации и использования инвазивных процедур, таких как биопсия, рак предстательной железы остаётся сложным для ранней диагностики. Эластография сдвиговой волны должна стать дополнительным методом получения изображений предстательной железы, которая дополняет традиционное трансректальное ультразвуковое исследование и МРТ.

Ключевые слова: эластография, предстательная железа.