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APPLICATION OF MULTIPARAMETRIC ULTRASOUND INNOVATIVE DIAGNOSTIC METHODS IN FOCAL DISEASES OF THE PROSTATE GLAND

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ABSTRACT: Early and timely detection of prostate cancer (PC) remains one of the actual problems of modern medicine. Today, there is a current focus on developing minimally invasive and accessible methods of diagnosis that are aimed at targeted imaging of the tumor process. One of these techniques is strain elastography - a method of ultrasonic diagnostics (USD) aimed at obtaining a qualitative assessment of color cartogram changes elastic properties of tissues. Research is continuing worldwide to apply strain elastography to early diagnosis of PC.

The aim of this study was to improve the early and differential diagnosis of the foci of the prostate gland by applying modern compression elastography technology

Materials and research methods. The article gives results of transrectal ultrasound (TRUZI) of 146 patients with different foci of prostate gland. The patient's age ranged from 48 to 82 years.

TRUZI was performed on ultrasonic devices of expert class " Mindray DS70", " Mindray DS80", "Logiq S8 XD CLEAR». The research provided for complex ultrasound with the simultaneous application of the gray scale mode, dopplerographic research and strain elastography in real time.

All patients were divided into three groups. The first group consisted of 47 patients with benign prostate disease, the second group consisted of 70 patients with suspected PC, the third group - 29 patients with histologically verified PC.

Based on the carried out TRUZI patients, specific ultrasound diagnostic criteria obtained in grey mode scale, color Doppler mapping and strain elastography, the application of which will allow the detection of PC in the early stages of the disease.

Keywords: prostate cancer, strain elatography, dopplerography, early diagnosis, transrectal ultrasound.

Introduction.

Diseases of the prostate gland represent one of the most important contemporary medical and social problems. Prostate cancer (PCa) is one of the most frequently diagnosed malignant neoplasms in men and occupies a leading position among oncological diseases in developed countries, ranking second after lung cancer as a cause of cancer-related mortality. Mortality during the first year after diagnosis is approximately 25–30%, which indicates extremely low detection rates at the early stages of the disease [1]. Currently, according to various authors, 10–19% of prostate cancers are classified as "non-visualized" forms, meaning they are not detected by transrectal ultrasound scanning [2]. The problem of prostate cancer has become particularly relevant due to the steady increase in incidence and mortality rates, as well as the difficulties associated with timely diagnosis.

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New opportunities in ultrasound diagnostics of prostate cancer are provided by ultrasound elastography, a non-invasive technique that enables assessment of tissue stiffness (elasticity). Ultrasound examinations occupy a leading position in the comprehensive evaluation of patients with prostate pathology. The high diagnostic value of ultrasound allows its use for detecting diseases at preclinical stages. Ultrasound imaging is considered the method of choice at various stages of therapeutic management, after surgical intervention, radiotherapy, and during follow-up for early detection of disease recurrence.

Aim of the study.

To improve early and differential diagnosis of focal lesions of the prostate gland using modern multiparametric ultrasound technology through the application of compression elastography.

Materials and methods.

The study was based on data from 146 (100%) patients referred for advanced ultrasound examination to clarify the nature of nodular lesions of the prostate gland. All patients underwent transrectal ultrasound (TRUS) with the use of compression elastography. The examined patients were divided into three groups. Group 1 included 47 patients with benign prostate diseases; Group 2 consisted of 70 patients with suspected prostate cancer; Group 3 comprised 29 patients with histologically verified prostate cancer.

General characteristics of the study groups

Table 1. Characteristics of the study groups

Parameter	Group 1 (n = 47)	Group 2 (n = 70)	Group 3 (n = 29)
Mean age, years	47.3	62.1	65.2
PSA level, ng/mL	2.26 ± 3.1	18.6 ± 12.8	24.4 ± 19.1
Prostate volume, cm³	49.4 ± 21.8	86.5 ± 35.7	78.9 ± 34.2

The age of patients in this study ranged from 52 to 86 years. Ultrasound examinations were performed using state-of-the-art expert-class ultrasound systems: Mindray DC-70 (China), Mindray DC-80 (China), and Logiq S8 XD Clear (GE Healthcare, USA), equipped with transrectal probes operating in the frequency range of 4–10 MHz. These systems provided real-time grayscale imaging, assessment of intratumoral blood flow using Doppler techniques, and acquisition of compression elastography data.

Comprehensive ultrasound examinations were conducted by two highly qualified physicians. TRUS was performed according to the standard protocol, including grayscale imaging, color and power Doppler mapping (CDM, PDM, spectral Dopplerography), as well as compression elastography, which was used to assess the stiffness of focal prostate lesions.

For interpretation of elastographic findings, the following classification scale of elastograms was applied:

Type 1 – homogeneous mapping with green color;

Type 2 – combination of green and red color fragments;

Type 3 – heterogeneous staining with green and blue colors;

Type 4 – homogeneous mapping with shades of blue.

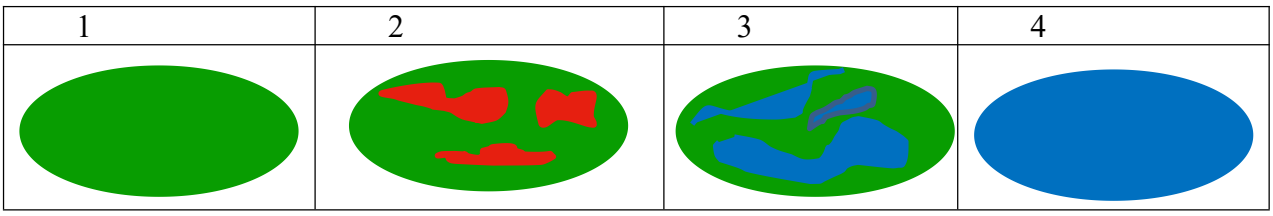

Fig. 1. Scale for typing elastographic cartograms.

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…patients examined using high-resolution scanners with a field strength of 1.5 T.

Results of the study and discussion.

Based on the grayscale imaging results, changes in the size of the prostate gland were recorded in 137 out of 146 patients (94.1%). Irregularity and blurring of the prostate contours were observed in 112 patients (76.7%), while heterogeneous echogenicity was detected in 132 patients (90.4%). An increase in prostate volume was identified in 143 patients (98.2%). Additional inclusions, such as fibrotic changes and calcifications, were visualized in 65 patients (44.5%).

Table. Grayscale ultrasound characteristics of the prostate gland in the study groups

Characteristic	Group 1 (n = 47)	Group 2 (n = 70)	Group 3 (n = 29)
Increase in prostate volume, cm³	54 ± 21.6	47 ± 15.1	49 ± 18.2
Irregular and indistinct prostate contours	32 (68%)	56 (80%)	24 (82.7%)
Heterogeneous echogenicity	43 (91.4%)	62 (88.5%)	27 (93.1%)
Additional inclusions	21 (44.6%)	29 (41.4%)	15 (51.7%)

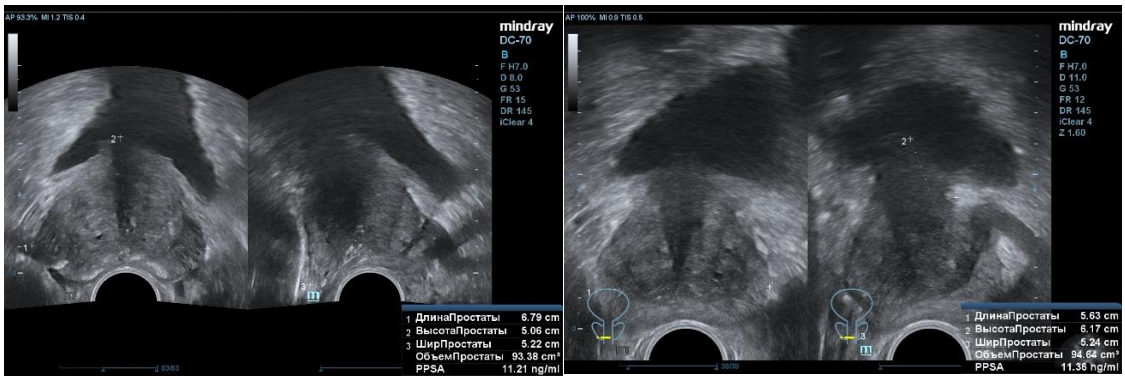

Figure 2. Benign prostatic hyperplasia (BPH). Transrectal ultrasound (TRUS) in grayscale mode.

According to color Doppler mapping, hypervascularization of the focal lesion was detected in 82 patients (56.1%). Among them, it was registered in 17 patients (36.1%) in the first group, in 44 patients (62.8%) in the second group, and in 21 patients (72.4%) in the third group.

According to compression elastography in patients with benign prostatic hyperplasia (BPH) (n = 47), types 1 and 2 elastograms were obtained significantly more often, accounting for 41 cases (87.2%). In patients of the second group, compression elastography revealed type 1 and type 2 elastograms in 27 patients (45.7%), type 3 in 25 patients (35.7%), and type 4 color patterns in 18 patients (25.7%).

In patients with histologically verified prostate cancer (PCa) (n = 29), type 3 elastograms were obtained in 11 cases (37.9%) and type 4 elastograms in 18 cases (62.0%), which corresponded to increased tissue stiffness of the prostate gland ($p < 0.05$).

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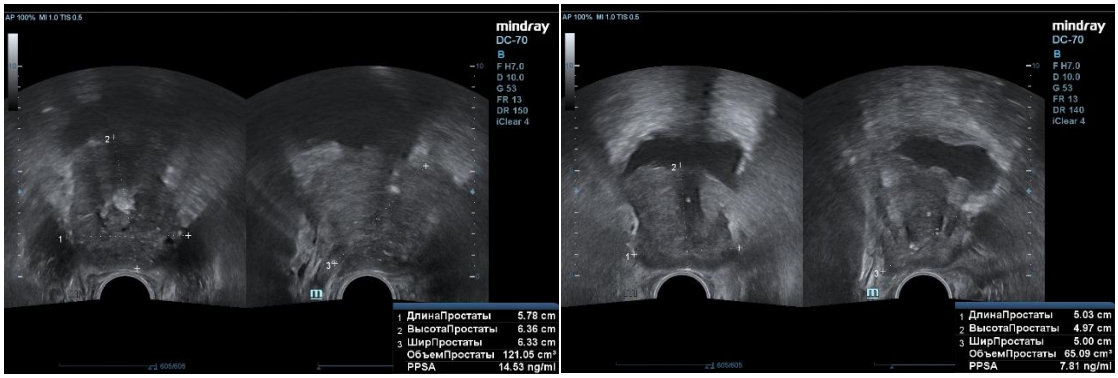

Figure 3. Prostate cancer (PCa). Transrectal ultrasound (TRUS) in grayscale mode.

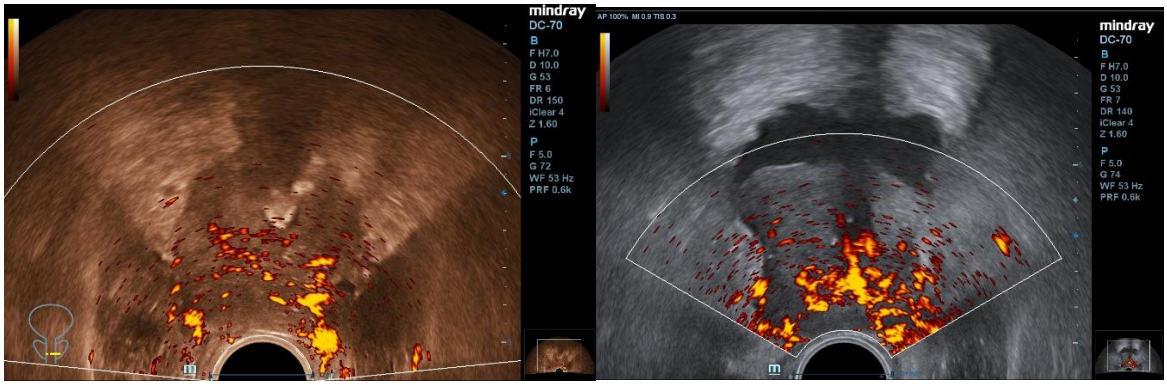

Figure 4. Prostate cancer (PCa). Transrectal ultrasound (TRUS) in the power Doppler imaging mode.

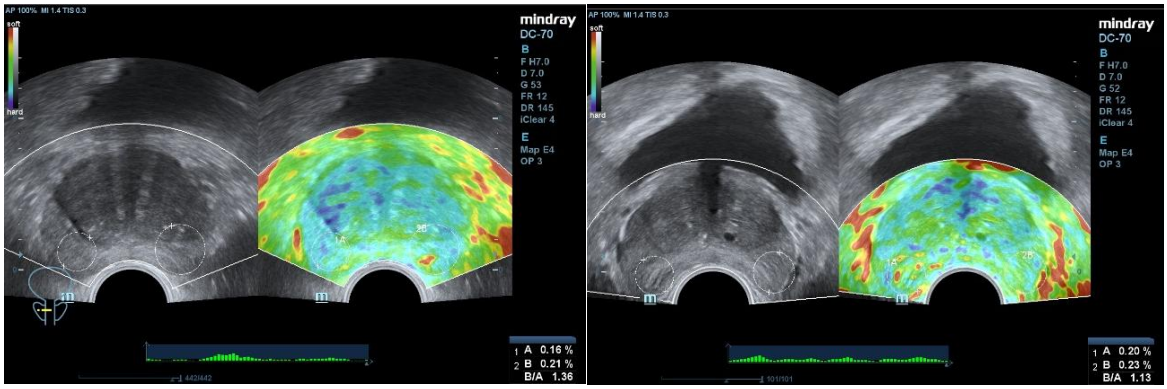

Figure 5. Benign prostatic hyperplasia (BPH). Transrectal ultrasound (TRUS) in the compression elastography mode.

Figure 6. Prostate cancer (PCa). Transrectal ultrasound (TRUS) in the compression elastography mode.

Results

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Based on the results of comprehensive ultrasound examination, a number of specific features were identified that reliably and accurately characterize the malignant nature of the investigated process: asymmetry of the peripheral zone thickness, asymmetric hyperplasia of the transitional zones, areas of microcalcification accumulation, deformation of the prostatic "surgical capsule," local deformation of the vascular pattern within the gland, as well as local deformation of the capsule and the prostatic "border layer."

During the analysis of the obtained data, the findings detected by transrectal ultrasound (TRUS) were compared with the reference diagnostic method. As a result, the sensitivity of the method was 93.1%, specificity was 87.2%, and overall diagnostic accuracy reached 90.6%.

Conclusions

Thus, the TRUS technique using the innovative modern technology of compression elastography makes it possible to detect areas with a high stiffness coefficient, perform differential diagnosis of prostate cancer, and select patients for targeted multifocal needle biopsy. Compression elastography enables both qualitative and quantitative assessment of tissue stiffness in prostate cancer lesions (B/A > 4 conventional units).

Indirect signs of prostate cancer were identified and systematized. Among them, the most frequent accompanying features of early-stage prostate cancer include asymmetry of the peripheral zone thickness, asymmetric hyperplasia of the transitional zones, areas of microcalcification accumulation, deformation of the prostatic "surgical capsule," local deformation of the vascular pattern in the power Doppler imaging mode in the projection of hypo- and even isoechoic lesions within the gland, as well as local deformation of the capsule and the "border layer."

Modern comprehensive TRUS, including B-mode imaging, power Doppler imaging, color Doppler imaging, Doppler velocimetry, and compression elastography, is a highly informative diagnostic method for the early detection of prostate cancer. Elastography is a modern technique that can significantly improve the results of ultrasound diagnostics of malignant transformation of nodular formations of the prostate.

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Conflict of Interest

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Mamadaliyeva Y.M. — development of the conceptual framework of the study, manuscript writing, and article editing.
Khushnazarov K.K. — collection and analysis of literature sources, manuscript writing.
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