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Diagnostic significance of multiparameter ultrasound examination in detection and differential diagnosis of ovarian tumor masses

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Abstract
The ultrasound examination is most widely used for differential diagnosis of benign and malignant ovarian lesions. The multiparametric approach, which involves the complete modes' using of the ultrasonic equipment in a logical order, including elastography, allows us to determine the nature of the ovarian tumor masses with high confidence. With this approach, 45 patients with different ovarian masses were examined. In 42 women (93.33%), the pathomorphological diagnosis was compared with the data of a multi-parametric ultrasound study, which clearly demonstrates the sensitivity and specificity of the technique before conventional grey-scale ultrasound examination.

Keywords: Ultrasound diagnostics, elastography, ovarian tumors

Introduction
Due to the ovarian cancer growth rate and an increase in mortality from this pathology, the study of new diagnostic methods is extremely relevant. Ovarian cancer is the seventh in the structure of general cancer diseases, and takes the third place among tumours of female genital organs, after cervical cancer and uterine body.

Ultrasound examination is the most popular in the differential diagnosis of benign and malignant ovarian formations. High informativeness, absence of radiation load, simplicity of conducting, the possibility of multiple repetitions, as well as economical efficiency, determine the priority of ultrasound diagnostics among other visualization methods in identifying the stage of the disease and monitoring in the process of treatment. There are many publications devoted to transvaginal ultrasound examination, using Doppler [1, 3]. However, this is not enough to make a differential diagnosis of the nature of the contents in the formation of the ovary. Purulent, hemorrhagic, serous and mucinous content very often have a similar ultrasound picture, and, in fact, information about the nature of the contents may be final when choosing a treatment method, and as a result – the retention of reproductive health of a woman depends on it. Necessary conditions for choosing the volume of surgical intervention are clear characteristics of localization, size, and content of volumetric ovarian formation [2, 5] A new "trend" in ultrasound diagnostics is the use of a multi-parametric approach to the examination of the pathology of various organs, that is, realization and implementation of technologies and capabilities of ultrasound equipment in the logical sequence. Therefore, ovarian examination in the usual B- and Doppler regimens is insufficient, since very often benign and malignant ovarian tumours cannot be differentiated only on their basis.

In ultrasound diagnostics, a new technique has been introduced that allows to estimate the tissue density in real-time, and it is called sonoelastography. This technique provides a qualitative and quantitative assessment of the elasticity of organs and tissues, which gives a high degree of certainty about their nature, when detecting volumetric ovarian formations.

It is known that various pathological conditions cause significant changes in the structure of tissues, lead to a local change in elasticity, resulting in a decrease in the ability of tissues to deform during compression. At the heart of compression elastography is the principle of manual palpation, when under pressure the deformation of tissues occurs, the assessment of the degree of which provides information about their elasticity. Due to different elasticity of the tissues, its inhomogeneous elements are dyed differently. Therefore, elastography makes it possible to diagnose cancer in the early stages of development [4, 6].

Until recently, ultrasound diagnostics has been the only radiological modality in which contrast media were not used to obtain more diagnostic information.

The breakthrough in contrast-enhanced ultrasound investigations was the use of surfactants, namely, palmitic acid in the structure of microvesicles, which were able to undergo cardio-pulmonary transit. When administered intravenously, the contrast freely passes through the capillaries of the lungs and enters the arterial system. Contrast material easily diffuses through the membranes of the alveoli of the lungs and is excreted with exhaled air for 15 minutes from the beginning of the injection. The most significant benefits of contrast ultrasound are:

- high safety and low frequency of side effects;
- no contraindications for the introduction of contrast;
- no nephrotoxic effect (in distinction from X-ray contrast agents);
- no influence on the thyroid gland function;
- dynamic monitoring of all phases of blood flow in real time mode;
- graphic display of the results.

Materials and methods of research

For the period from September 2017 to September 2018, 45 patients aged 18 to 59, with different ovarian formations, were examined. 36 women were of reproductive age and 9 women – in the postmenopausal period.

The normal sonographic picture of the ovaries was dynamically studied in a control group of patients, which included 22 women. 15 of them were of reproductive age and 7 were postmenopausal women without revealed ovary pathology. Patients of reproductive age were examined in different phases of the menstrual cycle.

The examination was performed on a Hitachi Aloca Arietta 60 ultrasound scanner using a 3.5 mHz sector detector (for transabdominal examination) and a vaginal transducer with a frequency of 8 mHz (for transvaginal examination). The system support of the ultrasound apparatus allows to conduct a multiparameter examination of the pelvic organs. Such research allows identifying and conducting differential diagnostics of volumetric ovarian formations more accurately, which later is confirmed pathomorphologically.

First of all, all women had a standard transvaginal ultrasound investigation in the B-mode using Doppler techniques: colour, energy, and pulse doppler. After this, compression elastography was performed to determine the density of the detected neoplasms. The investigation was conducted in real time. The area of interest was denoted as ROI (region of interest), the parameters of sonoelastography were optimized: intensity, mechanical index, and with the help of scale or graph on the monitor screen the optimal parameters of compression on the studied area were controlled. Also, for proper elastography, in the region of interest at least ¾ of reference unmodified tissue was included, since the definition of rigidity index is based on a comparative analysis of the density of normal and pathologically altered tissue. The elastographic image of the affected ovary was compared with the elastographic image of the contralateral part of the ovary. All received results in the form of static images were stored, which made it possible to interpret them later.

The qualitative estimation of the density of neoplasms was carried out by means of classification of elastotypes on the scale UENO (fig.1). That is, all images that can be attributed to 0.1 and 2 elastotypes correspond to benign formations. Those belonging to 3 elastotype are referred to conditionally benign, and the image with 4 and 5 elastotype is characteristic for malignant neoplasms.

At the same time, assessing the qualitative characteristics of the focus of interest, it was assessed quantitatively, that is, the coefficient of tissue deformation – Strain Ratio was determined. This coefficient was determined by the ratio of the density of the ovarian formation and the density of the surrounding unchanged tissues. EFSUMB (European Association of Ultrasound Specialists) does not yet have theoretical and practical recommendations for assessing the norms of this indicator. Therefore, in the process of preparing the scientific dissertation, it is planned to develop our own indicators of this coefficient for ovarian neoplasms.

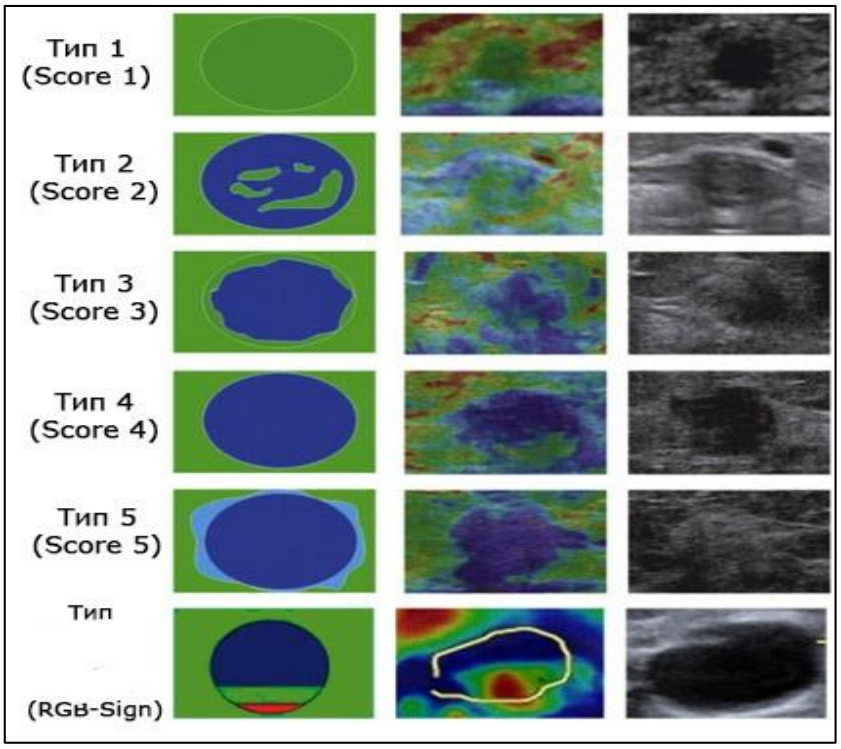

Fig 1: Scale of UENO elastotypes.

The results of the multiparameter ultrasound investigation were compared with the results of the pathomorphological study, as well as with ultrasound investigation in the dynamics.

Research results

Results of the study of the control group.

The normal ultrasound and elastography of the ovary was studied in the control group of women in the reproductive and postmenopausal period without gynecological pathology.

On the 5^{th} –10^{th} days of the menstrual cycle, the stroma and ovary were mapped mainly in green with the inclusion of blue colour, and the capsule was red. On the 10^{th} – 16^{th} days of the menstrual cycle, 0 elastotype was detected, which corresponded to the dominant follicle. From the 14^{th} – 16^{th} days of the menstrual cycle, a yellow body appeared which was mapped mainly in blue and corresponded to 3 elastotype and, accordingly, until the end of the menstrual cycle, this area was decreasing.

Somewhat different was the sonomalastographic picture of women in the postmenopausal period. The ovary was mapped in blue-green, and on the periphery it was red.

Results of the research and their discussion.

On the basis of the conducted dynamic observations and the pathomorphological study, follicular cysts were determined in 18 women (40%), yellow body cysts – in 10 (22.22%), endometrioid – 4 (8.9%), serous cystadenomas – 3 (6.67 %), papillary cystadenomas – 2 (4.44%), fibroma – 1 (2.22%), teratoma – 3 (6.67%), ovarian cancer – 4 (8.9%).

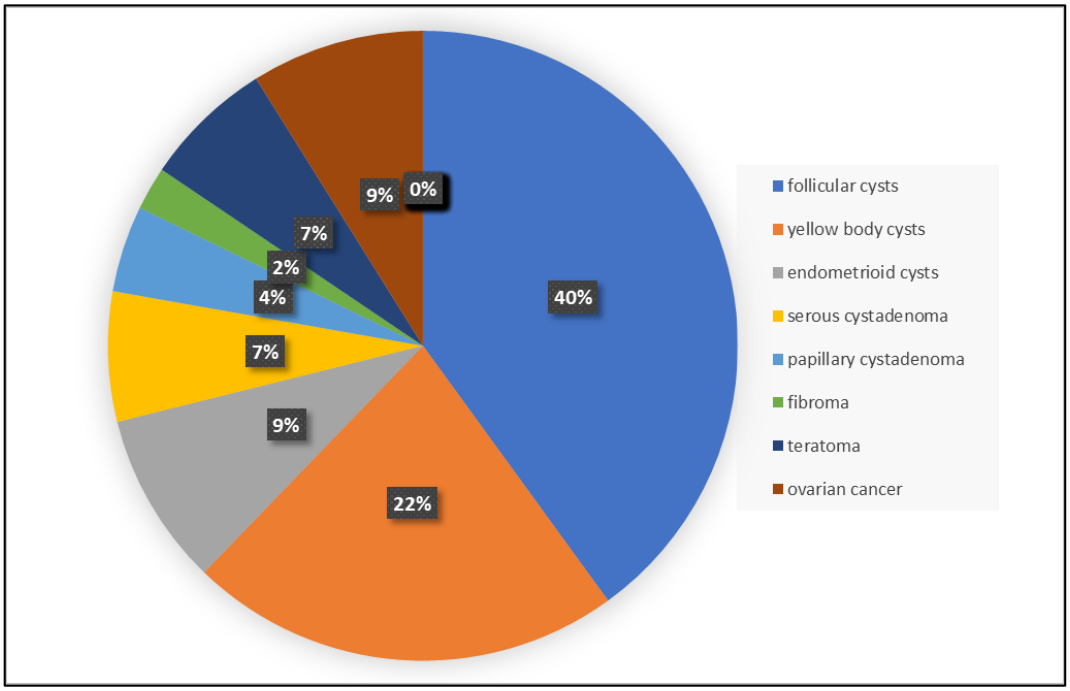

Fig 2: Distribution of the revealed ovarian pathology

In 42 women (93.33%), the pathomorphological diagnosis was compared with the data of a multiparameter ultrasound study, which greatly increases the sensitivity and specificity of the technique in comparison with conventional greyscale ultrasound examination.

Taking into account the relevance of this topic, the incidence of morbidity, the purpose of our study is to increase the accuracy of ultrasound diagnosis of volumetric ovarian formations by conducting a multi-parametric ultrasound examination.

In the course of this work, the main indicators in the B-mode, Doppler mode and sonoelastography are studied.

Women with follicular cysts have the following sonographic signs:

- B-mode: anechoic formations with a clear, equal contour, homogeneous structure, 29 to 51 mm in size;
- Doppler regimens: typical extranodular blood flow type, at a rate Vmax = 9.6-52.1 cm / s, SD – 2.05-3.95, RI – 0.5-0.89;
- Mode of sonoelastography: restrictions for this type of study were large anechoic formations, the size of which exceeded 40 mm, since such formations are not mapped at all, or only in the upper third of the formation. Those cysts which size is smaller are mapped in blue-green-red colour corresponding to 0 elastotype. The rigidity index ranges from 0.219 to 1.23 (Fig. 3).

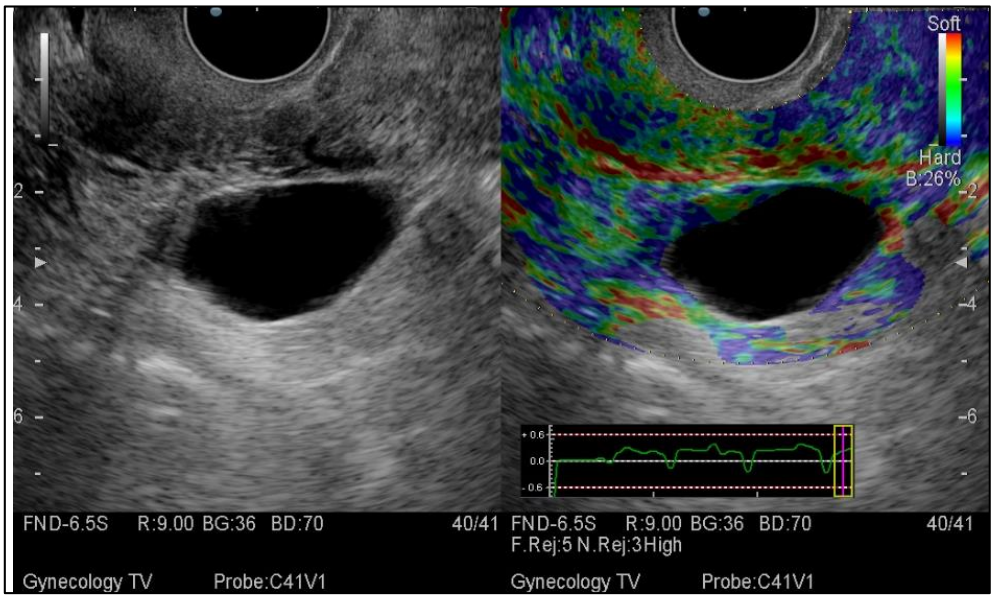

Fig 3: Sonoelastogram of follicular ovary cyst

When the cyst of the yellow body was detected, the following sonographic characteristics were revealed:

- **B-mode:** Heterogeneous formations with a clear, equal contour, heterogeneous structure;
- **Doppler regimens:** Characteristic extranodular blood flow type, at a rate Vmax = 13.5-32 cm / s, SD – 1.94-2.26, RI – 0.48-0.557;
- **Sonography mode:** In 8 women, the neoplasms are mapped in blue with green elements, which is typical for 3 elastotype, and in 2 women the neoplasms are mapped mainly in green, that is 2 elastotype. The rigidity index (Strain Ratio) is from 0.98 to 3.08 (Fig. 4).

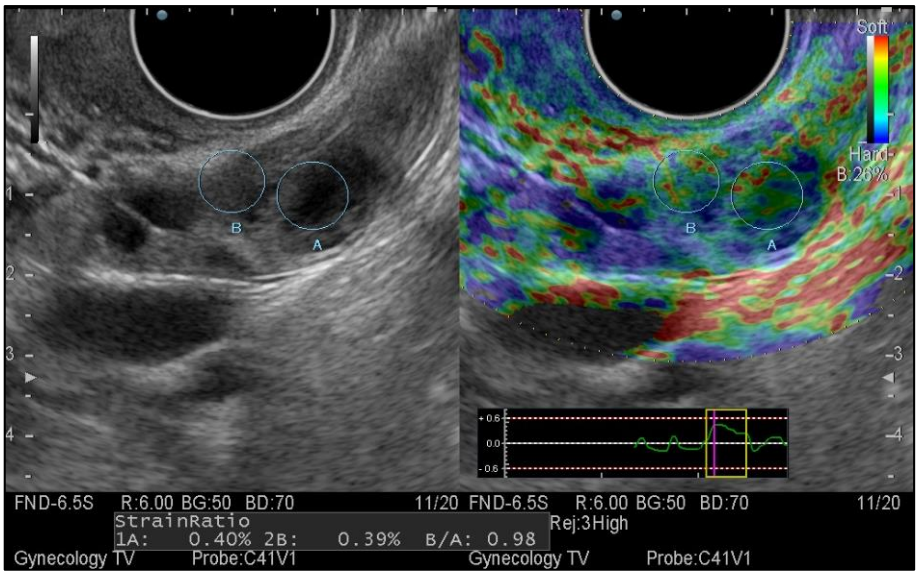

Fig 4: Sonoelastogram of the the ovarian yellow body cyst.

Four women with endometrioid ovarian cysts have the following symptoms:

- **B-mode:** Anechoic formations with a clear, equal contour, content – fine-grained, with the size from 18 to 80 mm;
- **Doppler regimens:** Typical extranodular blood flow type, at a rate Vmax = 6.6-32.1 cm / s, SD = 1.85-2.63, RI = 0.5-0.74;
- **Sonoelastography mode:** All formations are mapped in blue-green-red, corresponding to 0 elastotype. The rigidity index ranges from 0.819 to 3.23 (Fig. 5)

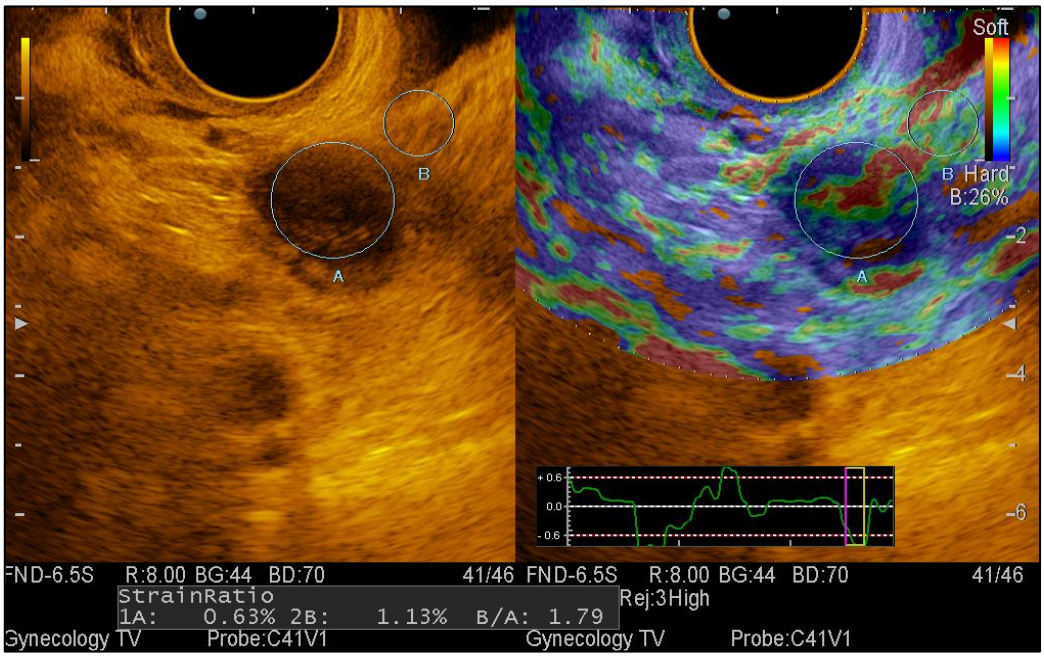

Fig 5: Sonoelastogram of the endometriotic ovary cyst.

Among the 5 detected serous and papillary cystadenomas there were the following sonographic signs:

- **B-mode:** Anechoic formations with a clear, equal contour; in the structure there are small hyperhymic linear structures (partitions) with parietal papillary enlargement, the sizes of these formations fluctuated from 32 to 84 mm;
- **Doppler regimens:** Typical extranodular blood flow type, at a rate Vmax = 9.6-52.1 cm / s, SD – 2.63-4.44, RI – 0.62-0.77; in the papillary inclusions there was a low-level blood flow – RI 0.42-0.53.
- **Sonoelastography mode:** All formations are mapped in blue-green-red, corresponding to 0 elastotype, and papillary enlargements were mapped in blue-green color, which corresponded to 3 elastotype. The index of rigidity of the tissue component is from 0.5 to 2.9 (Fig. 6).

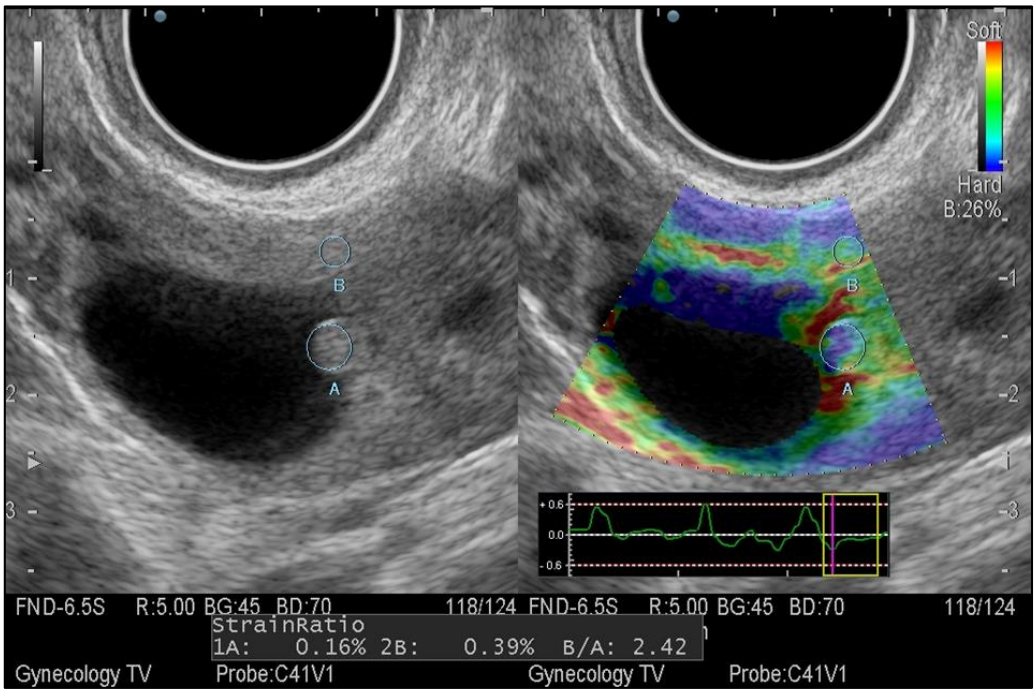

Fig 6: Sonoelastogram of papillary cystadenoma.

Three women were diagnosed with benign teratomas of the ovaries with the following sonographic signs:

- **B-mode:** Hypoechoic formations with a clear, equal contour, heterogeneous structure, the size from 32 to 37 mm;
- **Doppler regimens:** A characteristic extranodular type of blood flow, at a rate Vmax = 20.6-22.1 cm / s, SD – 2.03-2.43, RI – 0.46-0.589.
- **Sonoelastography mode:** All formations are mapped mainly in blue, which corresponds to 4-5 elastotype. The rigidity index ranges from 38 to 43.33 (Fig. 7).

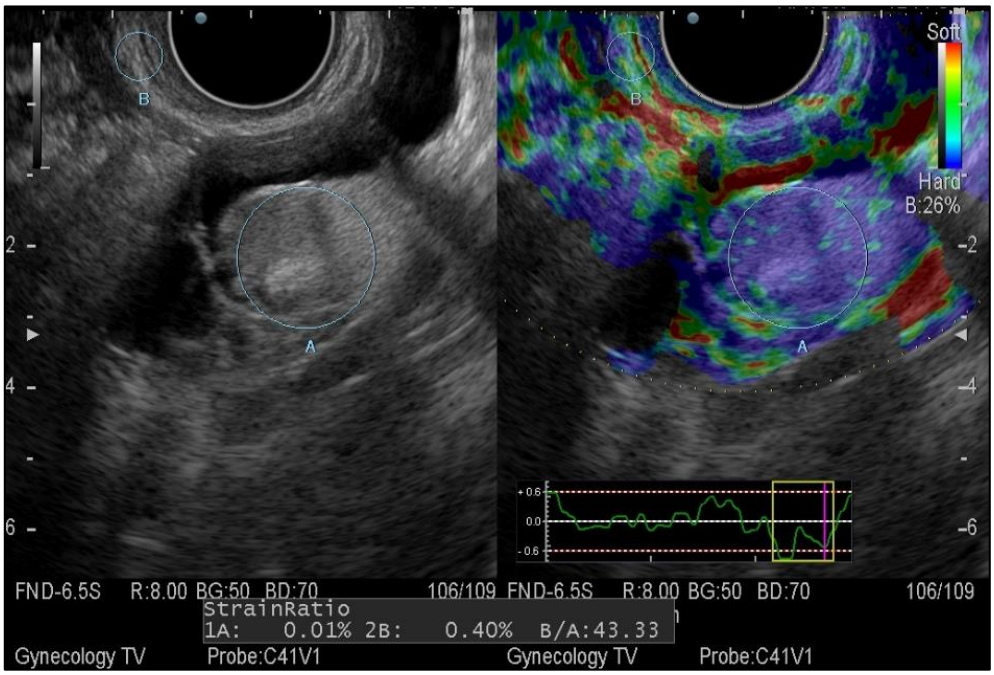

Fig 7: Sonoelastogram of mature ovarian teratoma.

In a patient with fibroma, ovarian cancer was detected based on ultrasound diagnosis, but the pathomorphological diagnosis denied this assertion. Therefore, there are not enough sonographic signs for this type of volumetric ovarian formations.

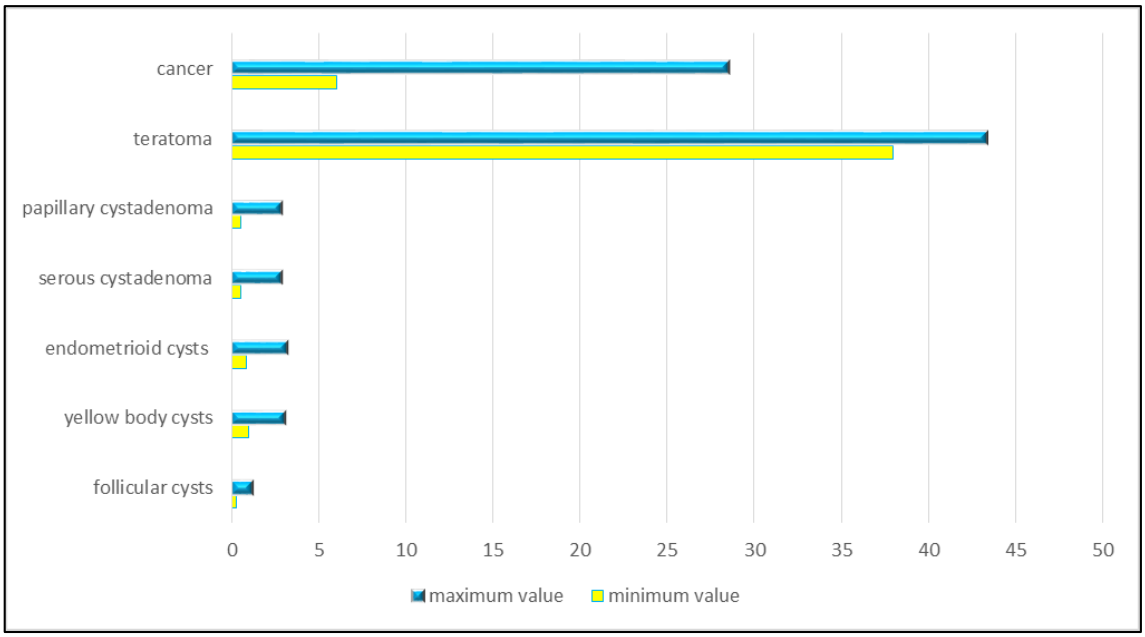

Fig 8: Minimum and maximum values of the rigidity index (Strain Ratio) of the revealed neoplasms

Four women were pathomorphologically diagnosed with ovarian cancer, but the ultrasound diagnosis coincided in three cases, and those neoplasms had the following ultrasound signs:

- **B-mode:** Hypoechoic formations with a fuzzy, unequal contour, heterogeneous structure;
- **Doppler regimens:** In all formations there were multiple blood supply locuses, with high-speed and low-resistance blood flow: Vmax = 26.6-62.1 cm / s, RI – 0.23-0.32.
- **Sonoelastography mode:** All formations are mapped in blue, which corresponds to 4-5 elastotype. The rigidity index ranges from 6.0 to 28.54 (Fig. 9).

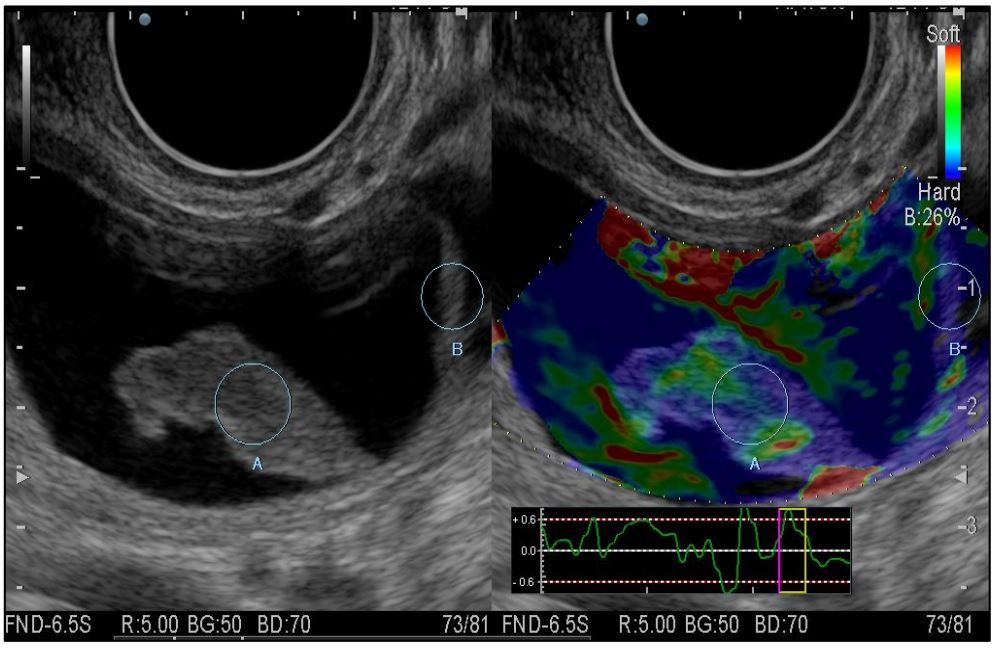

Fig 9: Sonealastogram of ovarian cancer

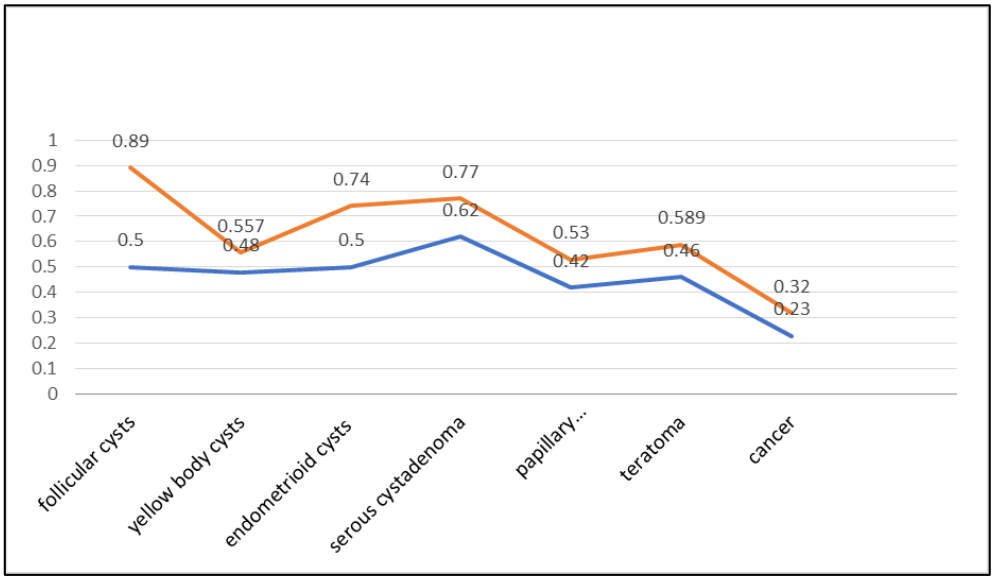

Fig 10: Minimum and maximum values for resistance index of the revealed neoplasms.

On the basis of the performed part of the work, it can be concluded that the multi-parametric approach, which includes the analysis of ultrasound data in the
B-, Doppler regimes and the elastography regime, greatly increases the diagnostic value of the method in detecting and differential diagnostics of volumetric ovarian formations.

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