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POTENTIALITY OF THE MODERN ULTRASOUND TECHNOLOGIES IN THE DIAGNOSIS OF BREAST NODULAR TUMORS

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Abstract
The article analyzed the results of multiparametric ultrasound examination of 420 patients with various focal formations of the mammary gland (MG) aged of 15-75 years. Comparative data on diagnostic efficiency of modern technologies of ultrasonic method of palpated and non-palpated MG formations are presented.

Keywords: breast cancer, multiparametric ultrasound examination, focal breast formations, dopplerography, sonoelastography.

INTRODUCTION

The aspects of early detection of breast tumors remain to be relevant due to the high morbidity and mortality of the female population [5]. Among medical mammological imaging systems, X-r ay and ultrasound technology play a leading role. Magnetic resonance imaging (MRI) contributes significantly to more specific diagnosis of nodal formations [5]. However, for all the benefits of this research method, it is still not available for a wide network of health care facilities. Therefore, regarding the availability of X-ray mammography and ultrasound diagnosis, they are widely used in clinical practice [2]. Nowadays, ultrasound examination of mammary glands is increasingly attracting the attention of researchers in connection with availability, absence of undesirable biological action on organism, introduction of high-resolution innovative technologies [2,3]. Breast cancer (MGC), in terms of mortality and morbidity, is ranked in the leading position among all malignancies in women. Every year, 10 million of malignant tumors of various localizations are detected in the world, while breast cancer accounts for 10% [4]. In the Republic of Uzbekistan breast cancer stably occupies the first place (24.6%) in the structure of women's oncological diseases.

Early and differential diagnosis of benign and malignant processes, assessment of the severity and prevalence of tumor lesion is one of the current problems in oncology. In this regard, the attention of researchers is focused on finding ways to prevent early diagnosis of MG neoplasms, providing survival results, and returning to an active social environment.

Diagnostic opportunities of this method extended thanks to introduction in clinical practice of such perspective technologies as: an ultrasonic angiography, the color Doppler mapping (CDM), power mapping (PM), 3D-reconstruction of vessels, technique of contrastless microangiography - SMI mode (supermicro-vascular imaging), technique of artificial vascular contrasting, 3D and panorama echography, elastography, technique of microcalcinate visualization (MicroPURE) improvement. At the same time during determination of the role and significance of the current techniques of the ultrasound mammography the opinions of researchers are discutable. In particular, issues of ultrasonic differential diagnosis of nodular formations of minimum size (5-20 mm) are discutable and often they are associated with the patient's age and hormonal status of the body [3].

The aim of the study is to determine the potential of modern technologies in ultrasound multiparametric diagnosis of benign and malignant neoplasms of the mammary gland.

MATERIALS AND METHODS

Under supervision there were 420 patients aged of 15-75 years with various nodal pathology of mammary gland. Research was carried out on premium devices of class Applio a 550, Aloka Arrieta 850, (Japan) using linear sensors at a frequency of 7.5 - 18.0 MHz. Ultrasound examination was carried out using standard technology: in the mode of grey scale, color, energy, pulse-wave dopplerography, in the mode of contrastless amplification of microblood flow imaging, SMI (supermicro-vascular imaging). Compression elastography was combined with shear wave elastography (2DSWE), with technology to improve the visualization of microcalcinates (MicroPURE).

When studying neoplasms, MG (mammography) was carried out according to a standard protocol. The following parameters of formations were determined: location, dimensions, shape, contours, echogenicity, structure, orientation, state of surrounding tissues, type of vascularization, quantitative characteristics of blood flow of neoplasms. Compression elastography was performed using a standard procedure [1,8,10,11]. Qualitative and quantitative criteria were evaluated. During qualitative analysis, the type of elastogram was determined on the Tsukuba scale [9, 11]. In quantitative analysis the stiffness coefficient (Strain Ratio) [6, 7] was determined. At elastography with shear wave in the mode, the method of elastography (2D-SWE) was applied, which is a quantitative analysis of elasticity - according to the Young's modulus in kPa and the speed of shear wave propagation (SWE) in m/s. From all calculated parameters, we used values of Young's modulus (Emax) in the areas with maximal stiffness, corresponding to the pathological changes in the mode of grey scale. The results of investigations were compared with data of digital roentgen mammography and morphological researches of bioptate.

The results of the studies are compared with digital X-ray mammography and morphological studies of the bioptate.

RESULTS

A multiparametric ultrasound evaluation of focal breast formations of 420 women in 120 observations (28.5%), based on clinical-radiological ultrasound and morphological

biopsy studies (COR biopsy), showed breast cancer. The benign MG formations were found in 300 (71,4%) women. Among 300 patients with benign MG formations, in 194 (64.6%) women there were diagnosed cysts, 69 (23%) had fibroadenomas, and 37 (12.3%) had lipomas.

The multiple and single cysts of various sizes were identified in 194 women. In 120 (61.8%) observations patients showed simple cysts. In the grey scale mode, they were characterized by clear, smooth contours, homogenous unechogenic contents, and by the presence of a distal reinforcement effect. In CDK mode SMI are avascular. In compression elastography mode they corresponded to a three-layer elastotype (blue-green-red) (Fig. 1).

Atypical cysts having heterogeneous structure were identified in 74 (38.1%) cases. Among this group, cysts with signs of inflammation were detected in 21 (28.3%) patients, seborrheic cysts in 9 (12.1%), post-traumatic cysts - in 9 (12.1%) cases, galactocele - in 6 (8.1%), intracystic vegetations - in 29 (39.1%) cases. Cysts with signs of inflammation had thickened walls, heterogeneous internal contents. In the CDK mode, locally enhanced vascularization was detected along the periphery of the cavity formation. In the mode of compression elastography, they corresponded to a three-layer elastotype (Fig. 2).

Intracystic papillomas were characterized by clear, smooth contours, the presence of parietal intracystic vegetations, by absence of vascularization both along the periphery of the cysts and the tissue component in the modes of CDK, ED, SMI. In compression elastography, the tissue component corresponded to the second or to the third elastotypes, and the liquid component of the cyst corresponded to the tricolor elastotype (Fig. 3).

Fibroadenomas of various sizes were diagnosed in 69 women. In the grey scale mode, fibroadenomas up to 2 cm in size had clear and smooth contours, uniform structure, horizontal orientation, reduced or average echogenicity (Fig. 4).

In 12 observations fibroadenomas larger than 2 cm had clear, sometimes uneven contours, horizontal orientation. The structure of nodes in 8 patients was heterogeneous due to areas of reduced and increased echogenicity represented by fibrosis zones. Peripheral type of vascularization was detected in CDK-arrival mode. A mixed intra-node type of vascularization was detected in 14% of cases. In pulse wave Doppler mode, the mean value of maximum systolic bloodflow velocity (Vmax.) was 8.3±3,7 cm/s. At resistance index (RI) 0,50±0.08 compression elastography revealed elastotype 1 and 2 in 43 of 69 patients, in 21 patients – elastotype 3. The 4th elastotype was noted in 5 women over the age of 50 years. The higher stiffness of the nodes appears to be due to pronounced fibrosis of the tissue, as well as the presence of calcinates in the structure of the nodes. In the measurement of Strain-Ratio, the mean stiffness of the formations averaged 2.7±1,1. In the shear wave elastography mode, the maximum values of the Young's modulus (Emax) were 12.5-36.3 kPa (SWE1,56-3.48 m/s).

Breast lipomas were identified in 37 observations. In ultrasonic examination, they were characterized by the presence in the thickness of glandular tissue of a section of increased or medium echogenicity, by oval or rounded shape, with clear smooth contours, homogenous structure, and horizontal orientation. In CDK mode, they were avascular. With compression elastography, they had the 1st elastotype. In elastography mode, when evaluating quantitative stiffness indicators (Strain- Ratio), the average stiffness of the formations accounted, on average, for 0.93± 0,6. The results of shear wave elastography represented the maximum values of the Young modulus (Emax) in the range of 9.8-17.7 kPa, and the velocity (SWE1,52-2.06 m/s) (Fig. 5).

During observation of the 120 patients with breast cancer, the first stage was established in 77 (64.1%) patients. A tumor measuring 0.1-0.5 cm in the largest dimension was detected in 5 patients (4.16%); in 32 patients (26.6%) 0.5 to 1.0 cm; from 1 to 2 cm in the largest dimension - found in 40 patients (33.3%). The second stage (tumor 2-5 cm) was detected in 31 (25.8%) patients. Stage three (tumor greater than 5 cm) in 10 patients (8.33%), and stage 4 is a tumor of any size with direct spread to the chest wall or skin) in 2 patients (1.66%).

Studies have shown that malignant MG tumors with sizes up to 0.5 cm in grey scale mode were visualized in the form of hypoechogenic structures, with uneven contours, homogenous structure, and uncertain orientation. In the mode of color Doppler mapping (CDK), changes in blood flow were not detected. In the energy mapping mode inside the tumor node, blood flow was visualized in 20% of cases, and in the SMI mode it increased to 40%. In pulse wave Doppler mode, low-speed blood flow prevailed, with relatively high peripheral resistance. The mean value of the maximum systolic blood flow velocity (Vmax.) was 5.32±1,29 cm/s. The resistance index (RI) was within 0,60±0.08. In the mode of compression elastography, 3 out of 5 patients showed 4 elastotype, and in two patients - 5 elastotype. When evaluating the quantitative stiffness of compression elastography (Strain-Ratio), the formation stiffness value was 2.9 -13.3 (average 8.6). In shear wave elastography, the maximum values of Young's modulus (Emax) were 86.7 - 98.5 kPa, and the shear wave velocity (SWE 4.8- 5.46 m/s). The application of the technology for improving the visualization of microcalcinates (MicroPURE) contributed to their detection in 20% of cases (Fig. 6).

The malignancies up to 1 cm in size were detected in the chest of 32 patients. In these cases, in the grey scale mode, they were characterized by fuzzy, uneven contours, uniform structure, vertical orientation visualized by the presence of distal acoustic shadows. In CDK mode and energy mapping, blood flow in the tumor was detected in all patients. Indicators in SMI mode reached 78.1%. Pulsed wave dopplerography showed an increase in maximum systolic blood flow velocity, and (Vmax.) was 12.8±5,1 cm/s ($p < 0.5$) and ranged from 0, 66 ± 0,05. Compression elastography revealed 4 elastotype in 20 patients, and 5 elastotype in 12 patients. When measuring the strain coefficient, the average stiffness of the neoplasms was on average 8.6±3,4. In the shear wave elastography mode, the maximum values of the Young's modulus (Emax) reached 89-135 kPa (SWE 5,3-7,0 m/s). In Micro PURE mode, 10 patients showed microcalcinates, which is 11.2% higher than observed in 1 subgroup (Fig. 7).

Echographic features in patients with tumor sizes up to 2 cm in grey scale mode were displayed as a node with fuzzy, uneven contours, mainly heterogeneous structure, vertical orientation. Blood flow in CDK was detected in 29 (72.5%) of 40 patients, in the energy mapping mode it increased to 80%, in the SMI mode the value was 90%. The response of the Doppler impulse wave was dominated by high-speed blood flow, with increased peripheral resistance: Vmax. and accounted 19.5 ± 4,3cm/s, with, RI 0,71±0.06. Compression

elastography showed 55% with 4 elastotypes, 45% - 5 elastotypes. The average stiffness of the formations with a Strain Ratio was 11.8 ± 6.4. For the SWE shear wave, the maximum values of the Young's modulus (Emax) were 98.5±154 kPa, and the propagation rate SWE 5,46 - 7.19 m/s). The presence of microcalcinates was detected in 37.5% of the observations (Fig. 8).

In mammary gland cancer with a 2-4 stage in the grey scale mode, the tumor reliably had fuzzy, uneven contours, mainly a heterogeneous structure, vertical orientation, and the presence of a thick echogenic "ring" around the formation. CDK detected blood flow in 90% of patients and was predominantly of mixed type. Pulse wave dopplerography showed high-speed blood flow with high peripheral resistance. In these cases, Vmax. accounted for 35±5.6 cm/s, RI 0,87± 0.04. Compression elastography at sizes up to 3 cm revealed elastotype 5 in most of cases. The application of Strain-Ratio technology indicated an increase in the average stiffness of the formations by 38±12. In the presence of a tumor of more than 3 cm, the quantitative and qualitative indicators of the elastogram were not informative, due to the large size of the formations, the lack of a reference zone to obtain stiffness indicators. The values of Young's Modulus in formations up to 3 cm. accounted for 162-169 kPa: SWEmore than 7.3 m/s. In these cases, qualitative and quantitative analysis was difficult. The presence of microcalcinates was detected in 39% of cases. (Fig. 9,10). At stage 2-3 of disease, as the size of the neoplasm increased, an increase in axillary, parasternal, supraclavicular and subclavian lymph nodes characteristic of metastasis lesion was detected. In stage 4 breast cancer, metastases to the liver (3 observations) and to the spine (2 observations) were detected.

CONCLUSIONS

The research shows that the step-by-step approach from basic grey scale echography to new technologies improves differential diagnostics of focal MV formations, opens up fundamentally new possibilities in ultrasound diagnosis of RV in the early stages. As our studies have shown, one of the signs requiring close attention in nodal formations is the appearance of a color pattern both in nodal pathological sites and around the formation. As malignancy grows, it is noted that ultrasonic angiography in the SMI mode is an effective addition to CDK and ED, improving the imaging of microstreams with a minimum (up to 0.5 cm) RMG.

A potential sign of malignancy is the high stiffness of formation determined in compression elastography and elastography by shear wave. Indicators of two methods of breast elastography indicate that there are reliable differences between the rigidity of benign and malignant neoplasms. These elastographs, combined with basic methods, serve as an important additional criterion in assessing the focal formations of MG, thereby allowing differentiating malignant and benign tissues, solid and liquid structures among themselves.

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ECHOGRAMS

Fig. 1. Echograms of a simple breast cyst: a- B mode, b -elastogram tricolor elastotype.

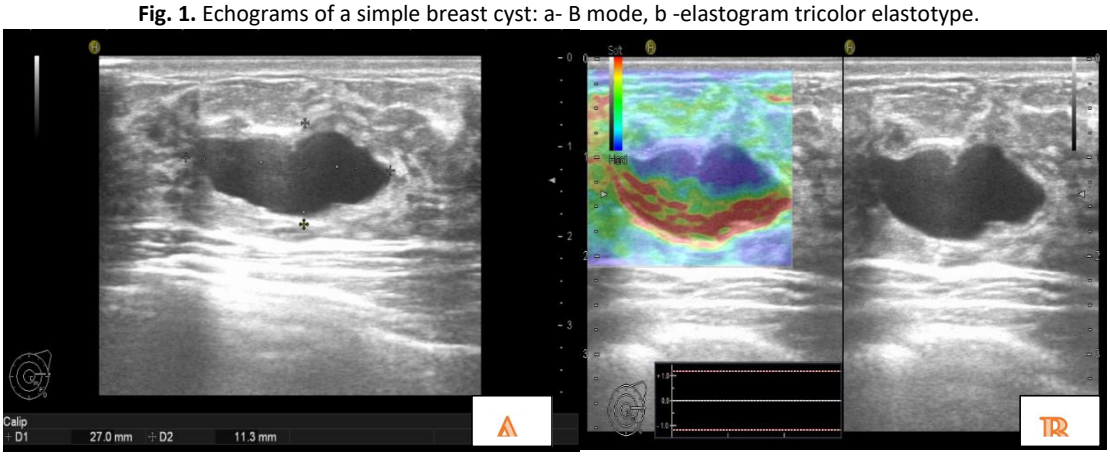


Fig.2. Echograms of an inflamed breast cyst: a- B mode, b – elastogram tricolor elastotype.

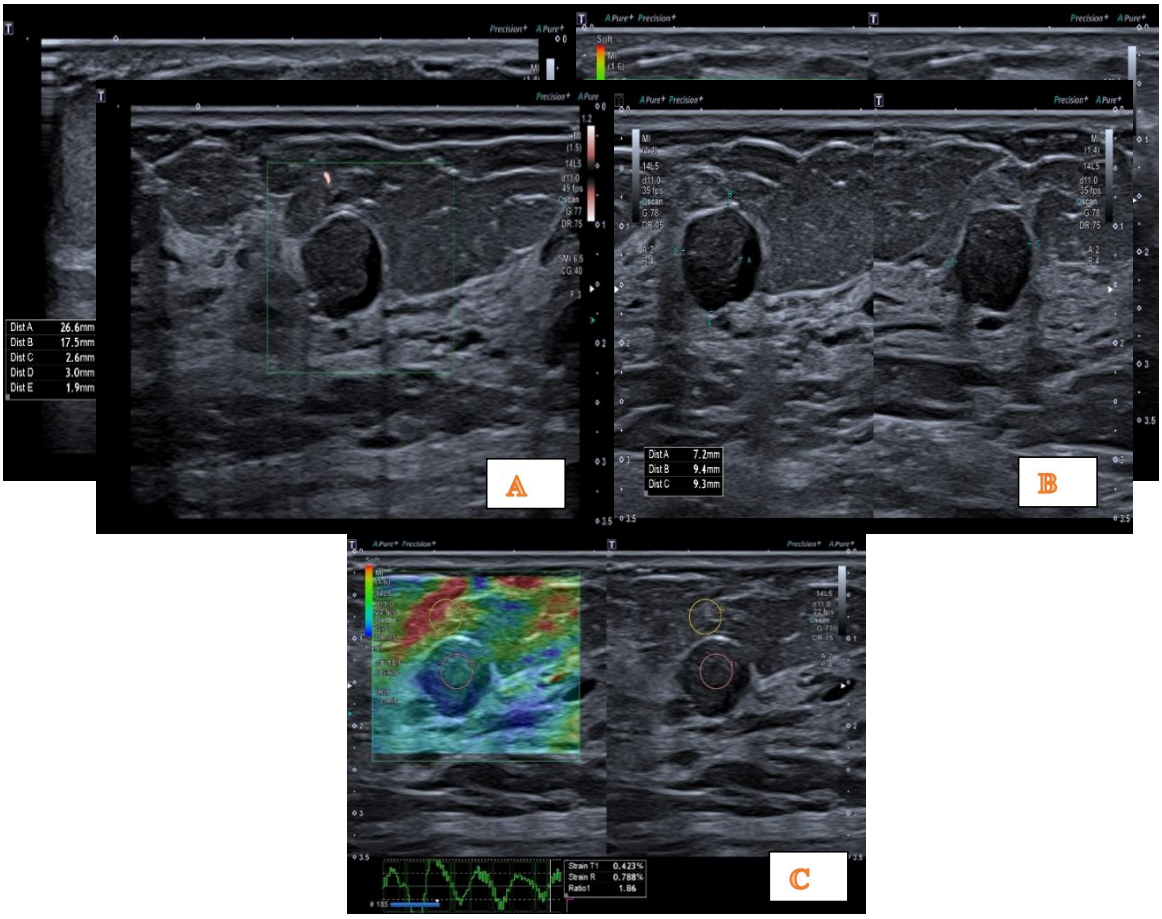


Fig. 3. Intracystic papilloma echograms: a-B mode b - SMI c-elastogram mode, 2 elastotype, Strain-Ratio

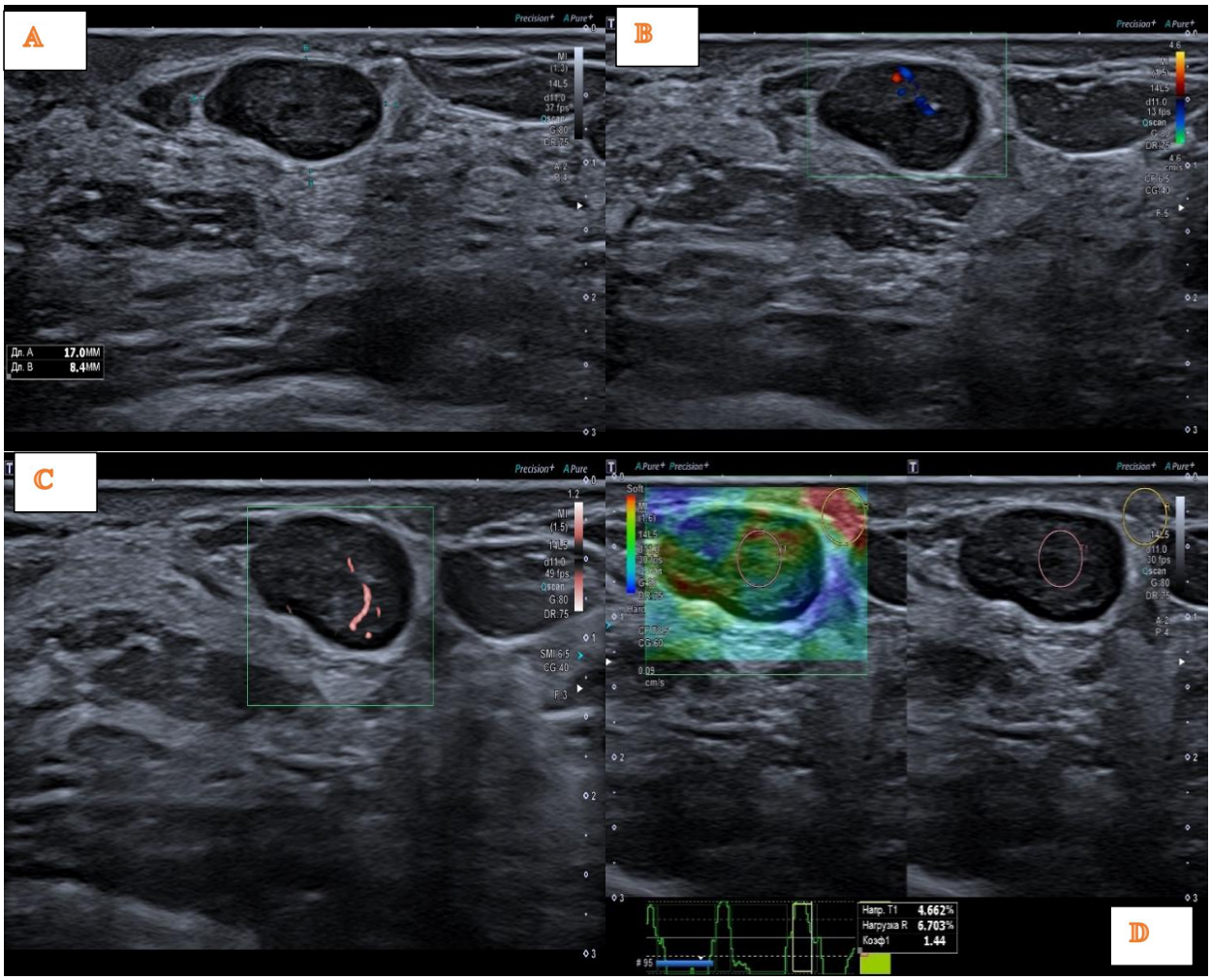


Fig. 4. Breast fibroadenoma echograms: a) B mode b) CDK mode c) -SMI mode d) elastogram 1elastotype, Strain-Ratio 1.44

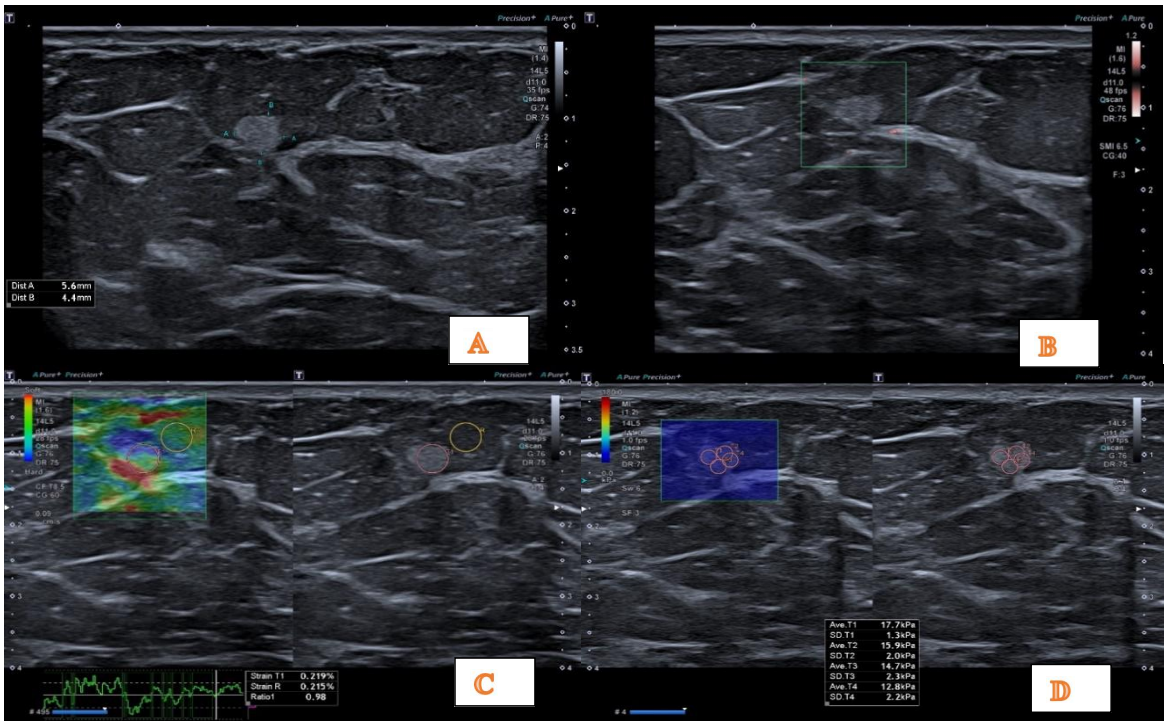


Fig. 5. Echograms with lipoma: a) B-mode b) SMI- mode c) Elastogram 1 elastotype, Strain-Ratio determination. d) shear wave elastography

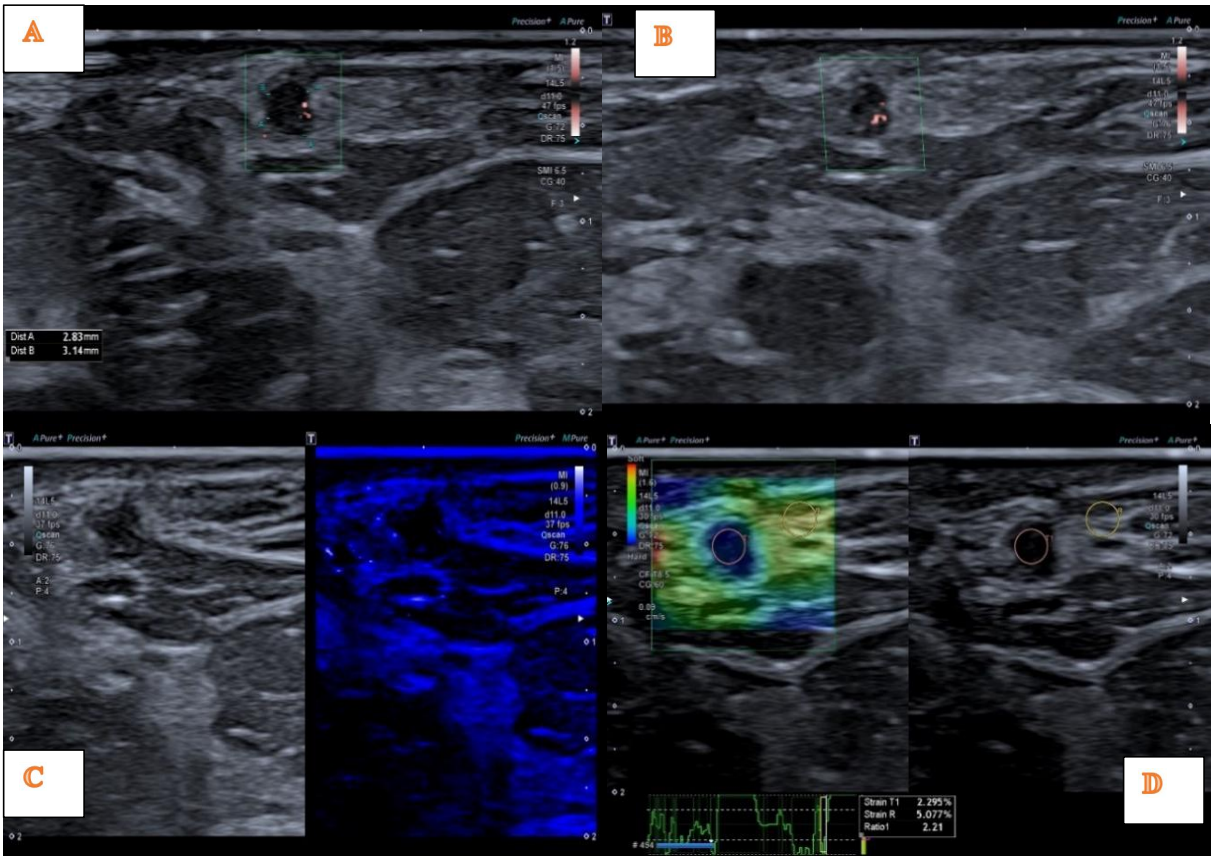
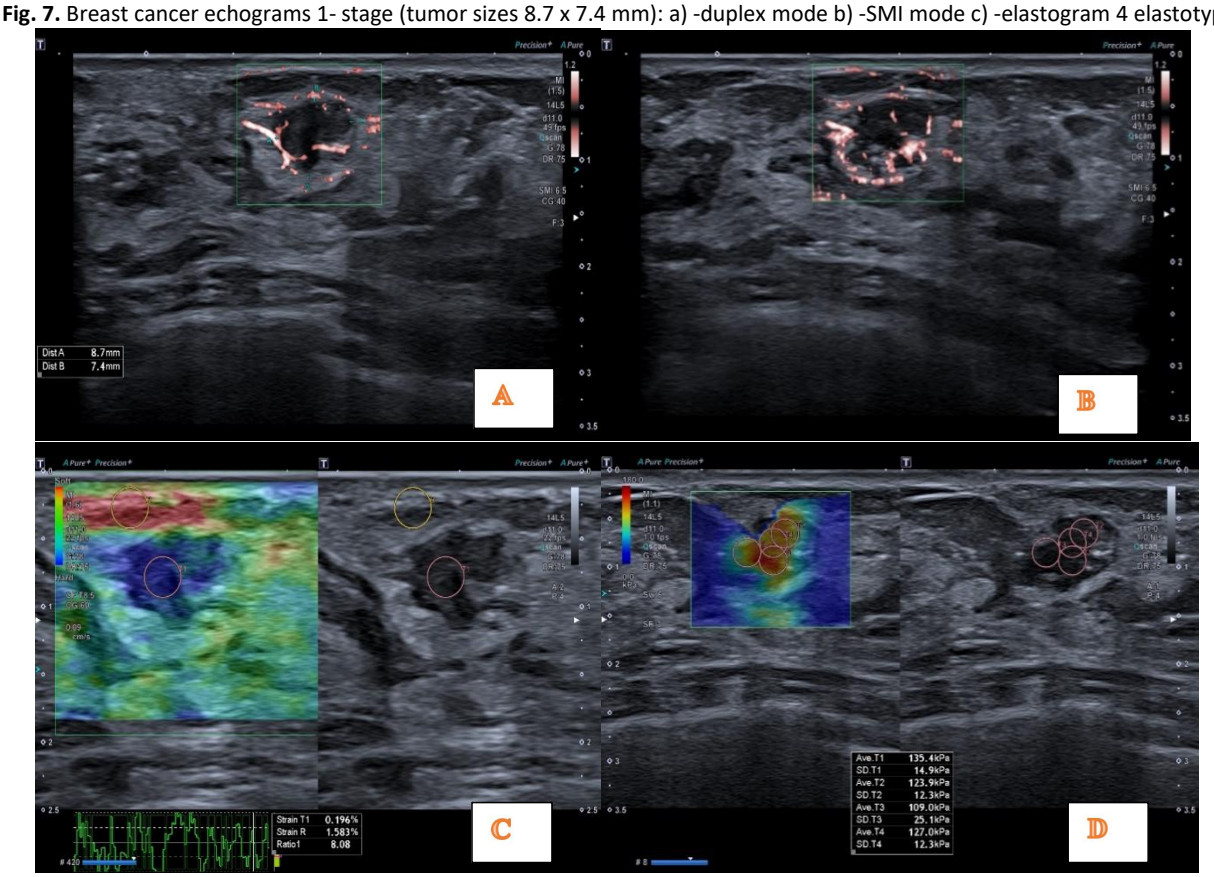


Fig. 6. Breast cancer echograms 1- stage (tumor sizes 2.83 x 3.14 mm) : a) - duplex mode b) -SMI mode c) elastogram 4 elastotype, strain coefficient (Strain-Ratio) .d) MicroPURE - mode , calcinates in the tumor

Fig. 7. Breast cancer echograms 1- stage (tumor sizes 8.7 x 7.4 mm): a) -duplex mode b) -SMI mode c) -elastogram 4 elastotype, definition of Strain-Ratio d) -shear wave elastography mode



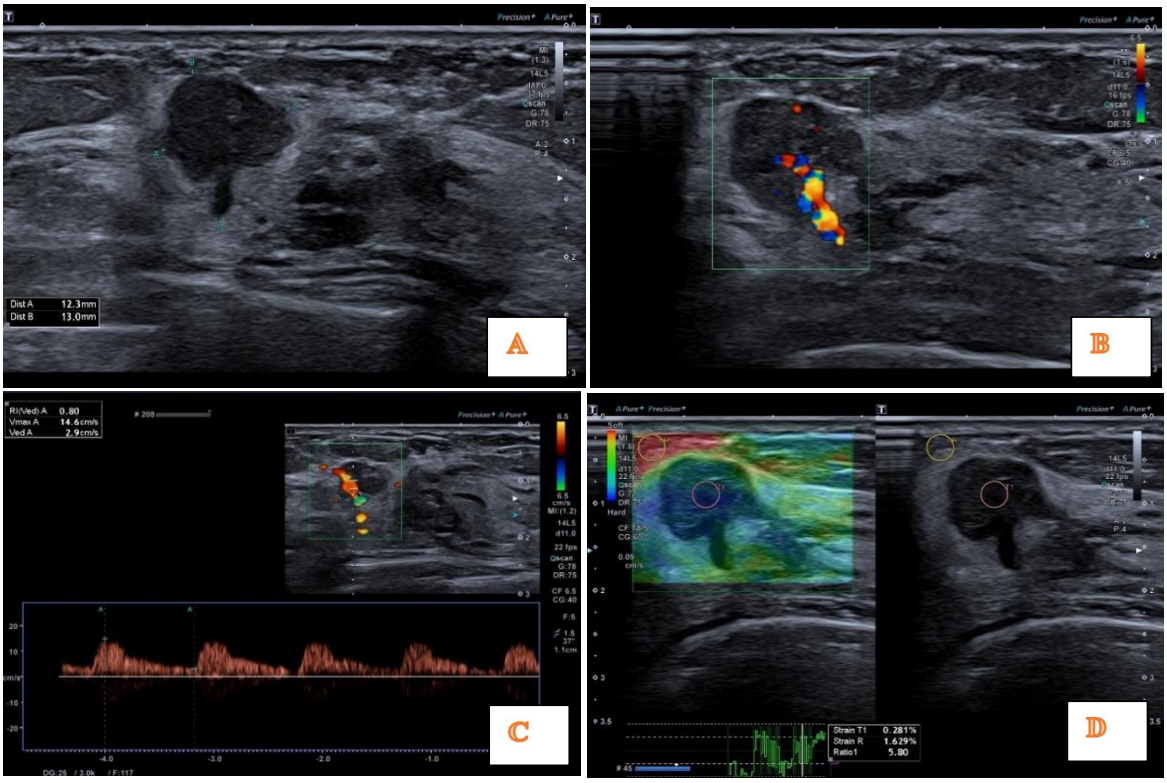


Fig. 8. Breast cancer echograms 1- stage, (tumor sizes 12.3 x13 mm: a) - B mode b) CDK mode c) - the mode of pulse dopplerography d) an elastogram 4 elastotype, definition of Strain-Ratio.

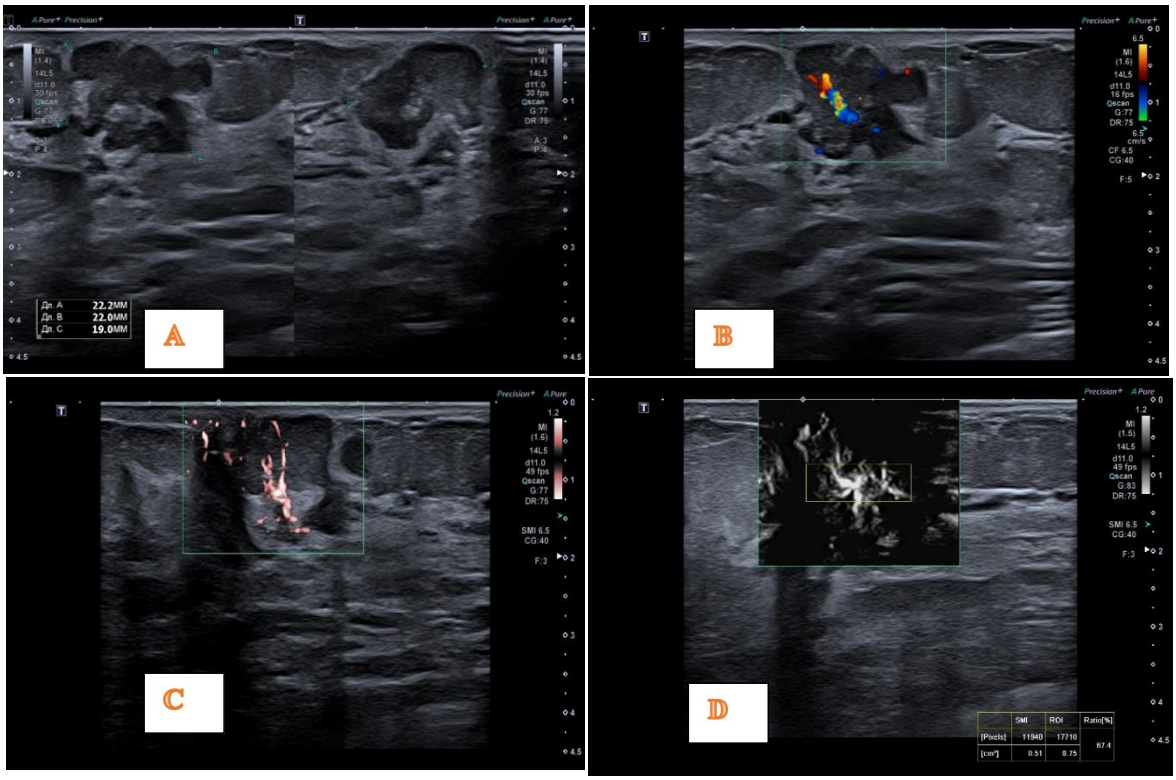


Fig. 9. Breast cancer echograms with germination into subcutaneous fiber: a) -B mode b) - CDK mode c, d) -SMI mode

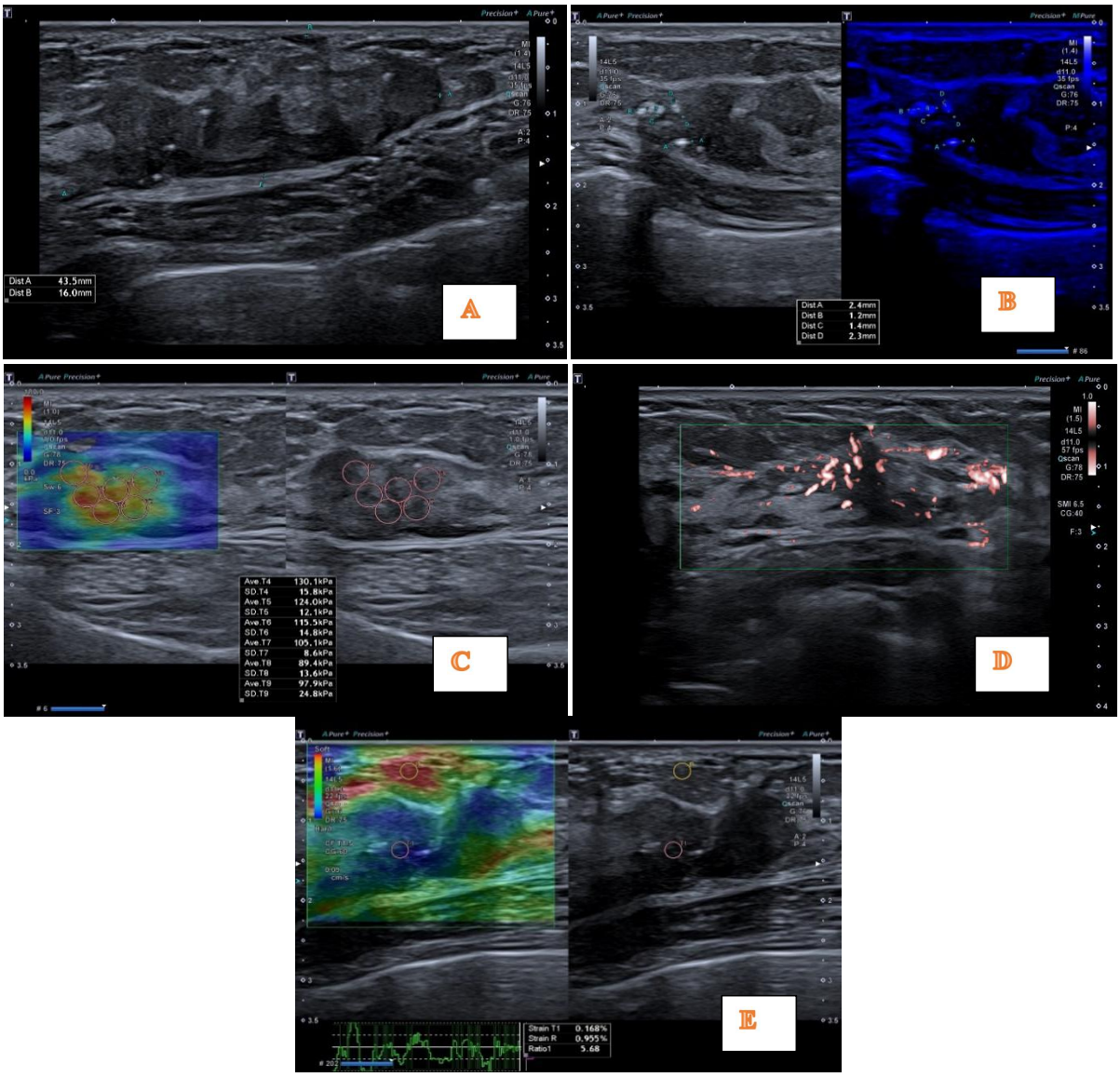


Fig. 10. Breast cancer echograms with dimensions 43.5 x 16 mm: a) -B mode b) -SMI mode c) - mode MicroPURE d) Elastogram, definition of Strain-Ratio e) Elastography by shear wave.