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Digital Tomosynthesis in the Diagnosis of Non-Palpable Breast Tumor

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Abstract: Currently, in countries where early breast cancer screening is established, about 20% of breast cancer cases are diagnosed at the preinvasive stage.Comparison of diagnostic efficacy of digital tomosynthesis (DBT) and digital mammography (DM) in non-palpable breast cancer. Fifty-seven patients with histologically confirmed breast cancer were included in the study. A subjective assessment of the advantages of tomosynthesis technology for visualization of pathological signs characteristic of breast cancer (volume formation, focal asymmetry, restructuring of the structure or microcalcinates) is given. The data obtained by performing DM only and taking into account the additional information obtained by performing DBT are evaluated on the BI-RADS scale (force BI-RADS). Methods of preoperative morphological verification are often inaccessible to a wide range of patients, which leads to an increase in the number of diagnostic sectoral resections in proportion to the increase in the number of screening mammograms.

Keywords: dose load, non-palpable formations, image interpretation, mammography, mammary gland, comparative analysis, superposition of tissue structures, microcalcinates.

Relevance. Data on the sensitivity, accuracy and specificity of various methods of preoperative biopsy of non-palpable tumors differ greatly from different authors. Clear recommendations on the choice of the optimal method of verification of non-palpable tumors have not yet been developed. Breast cancer remains one of the main causes of death in women over the age of 40 [1; 2]. As can be seen from Figure 3, 69% of benign formations were classified as BI-RADS II. The BI-RADS III category included 19% of all benign formations and 3% of malignant ones. The positive predictive value (PPZ) of the BI-RADS III category for the diagnosis of breast cancer was 4%. The group of non-palpable tumors belonging to BI-RADS IV turned out to be the most heterogeneous. 72% of malignant neoplasms and foci of proliferative mastopathy and dysplasia and 11% of benign ones belonged to it. The positive predictive value of the BIRADS IV category for the diagnosis of breast cancer was 44%. BI-RADS V accounted for 25% of malignant tumors and nodes of proliferative mastopathy and only 1% of benign ones. Digital tomosynthesis is a new technology in diagnostics... The 47th screening method, which has proven its effectiveness in reducing the mortality rate from breast cancer [3-5]. The sensitivity of screening mammography for breast cancer is 80-90%, but in women with a very dense tissue structure it can be 48% due to the overlay of the image of dense fibroglandular tissue, which significantly reduces the visibility of any neoplasm in the mammary gland. In the DBT system, the X-ray tube moves in an arc during the examination, and performs a certain number of 2D projection images within a limited angle. A three-dimensional (3D) image of the breast is recreated from 2D projection images, which improves the quality of the information contained in each image plane, while the out-of-focus image is blurred. Thus, digital tomosynthesis can provide better visualization of breast tissue by providing a three-dimensional image without

overlapping shadows of various tissue structures. Several studies have shown that tomosynthesis makes it possible to carry out not only a more accurate standard diagnostic, but also suitable for breast cancer screening [15].

In this paper, in the study of 59 histologically verified cases of breast cancer, we compared the diagnostic effectiveness of DM and DBT technologies. It was necessary to determine whether simultaneous interpretation of images obtained during digital mammography and digital tomosynthesis would be a more informative method (including assessment of the features of volumetric formation, focal asymmetry, violations of architectonics and microcalcifications) for the diagnosis (according to the BI-RADS scale) of breast cancer.

Materials and methods: This study included patients with histologically confirmed breast cancer who underwent both DM and DBT studies in the period from January 2022 to November 2023. Data from mammographic and histopathological studies. The mammography results contained information on the density of the breast structure, the type of malignancy sign (features of volumetric formation, focal asymmetry, violations of architectonics and microcalcinates), study protocols and BI-RADS score data. Tumors were located in the right gland in 53.6% of cases, in the left in 46.4%. If the results were of a heterogeneous nature, we recorded the most obvious ones. In cases where there was more than one neoplasm, a separate map was created for each formation. Getting images. Performing the study in 2 projections — direct (cranio-caudal) and oblique (media-lateral) in a combined mode ("combo-mode"), for simultaneous imaging of traditional digital mammography and tomosynthesis in one study procedure with the same breast compression. The system uses a tube with a tungsten anode (W) and a selenium detector (Se), a rhodium (Rh) filter, a silver (Ag) filter for two-dimensional (2D) images and an aluminum (Al) filter for imaging with tomosynthesis technology. During a low-dose irradiation study by continuous exposure with parameters of 29 kV peak and 44 WT along an arc with a scanning angle of 15 °, 15 projection images are obtained. Then the initial data of the projection images are used to reconstruct and obtain a general image with a thickness of 1 mm in a plane parallel to the plane of the detector, containing a total of 30-80 projection images using tomosynthesis technology, depending on the thickness of the compressed breast. The pixel size of the reconstructed image is 110-120 microns. The total scan time of one breast in the tomosynthesis mode is approximately 3 seconds. The radiation dose affecting one mammary gland is about 1.45 mGr Evaluation of the images obtained. The selection of cases for the study was carried out by a specialist radiologist, who knew in all cases about the diagnosis and, in particular, about the pathological sign, from the relevant medical records. The main task was to give a subjective assessment of the effectiveness of a combined study (digital mammography with tomosynthesis) compared with a separate digital mammography. A scale from 0 to 2 was used for evaluation, where "0" indicates that DM plus DBT images are equivalent or comparable to DM images; "1" — DM plus DBT is somewhat better for diagnostics; "2" — DM plus DBT images are definitely better for diagnostics than DM-only images. After interpretation of the data, a category was set according to the BI-RADS scale (1-5) for each malignant sign obtained by reading only the DM image and additional data obtained using DBT. Definitions. Based on the ACR recommendation (Criteria of the American College of Radiology) [17], there are 4 types (1-4) of mammary gland structure and density: the structure is represented by a predominant fat component, the presence of foci of fibroglandular tissue, mammary glands with heterogeneous density type, very dense mammary glands (respectively). Focal asymmetric density in the mammary gland is defined as "asymmetry of tissue density in both projections without the presence of certain boundaries, which does not have all the criteria for volumetric formation." Violation of architectonics — the term is used when describing a section of breast tissue with a violation of the normal anatomical structure without detecting a volumetric formation. These may be strands radiating radially from one point, the so-called "spicules", focal retraction or a violation of the structure along the edge of the parenchyma. Violation of architectonics can also be an additional feature. As for microcalcinates, amorphous or coarse heterogeneous microcalcinates are suspicious of the presence of a malignant process, and

pleomorphic, linear or linear branching calcinates have a high probability of having a malignant process. Grouped calcinates (clusters), as well as linear or segmental distribution of microcalcinates are suspicious signs of the presence of a malignant process. Data analysis. We determined the average age of 57 patients. Then the frequency analysis and calculation of the ratio of patient characteristics, subjective assessments, conclusions on the definition of categories on the BI-RADS scale were carried out. For this purpose, subjective scores 1 and 2 were combined. The interdependence of the category on the BI-RADS scale and the radiological manifestations of breast cancer was determined using the Chi-square test.

Results. Fifty-seven patients (average age 54.5 years, range from 25 to 87 years) with histologically verified breast cancer participated in this study. All patients underwent a combined study with digital tomosynthesis (DBT) for screening and diagnosis. Two patients had a second malignant neoplasm in the same mammary gland. Thus, a total of 59 cases of breast cancer were examined in this study. 31 neoplasms were determined on the right, 28 on the left. According to the type of breast structure (ACR type), the majority (up to 79%) of patients had a dense type of structure (type 3 or 4), type 1 in two (3.5%) patients, type 2 in 10 (17.5%) patients, type 3 in 27 (47.3%) patients and type 4 — in 18 (31.6%) patients. Radiological manifestations of non—palpable breast cancer in 59 patients were presented as follows: 17 (28.8%) — volume formations, 12 (20.3%) - focal asymmetry/density, 6 (10.2%) — violation of architectonics and 23 (39.0%) — microcalcinates. One intracystic neoplasm (1.7%), which was palpated and diagnosed on ultrasound, showed no signs of malignancy in the images of digital mammography and digital tomosynthesis and, therefore, could actually be considered as a false negative result. Fifty-seven patients were initially divided into categories of the BI—RADS scale as follows: category 0 — in 20 cases (35%), 4A — in 8 (14%), 4B — in 9 (15.8%), 4C - 7 (12%), and category 5 — in 13 cases (22.8%), respectively; by clinical stages: ductal carcinoma in situ (DCIS) occurred in 16 cases (28.1%), tumors of stage 1 — in 17 cases (29.8%), tumors of stage T1N1 and higher — in 24 cases (42.1%)In general, when interpreting images of 59 neoplasms, the combined study with DBT was subjectively perceived as more informative for diagnosis in 48% of cases. When assessing malignant manifestations, there was an improvement in visualization: in 30 out of 51 (58.8%) cases with volumetric formations, in 30 out of 36 (83.3%) cases with asymmetry/density, in 17 out of 18 (94.4%) cases with violation of architectonics and only in 8 out of 69 (11.6%) cases — with Microcalcinates were further evaluated according to the BI-RADS scale of 57 patients with breast cancer (indicator — 171): 64 (37.4%) and 33 (19.3%) images with DM were assigned to category 0 and 4A, 10 (5.8%) and 29 (16.9%) images in a combined study with tomosynthesis, respectively. Out of 64 DM images with category 0 on the BI-RADS scale, 10 (15.6%) did not change the category during tomosynthesis, increased the category to 4A — 4 (6.3%), to 4B — 22 (34.4%), to 4C — 17 (26.6%), and to category 5 — 11 (17.2%). At the same time, out of 33 digital mammography images of category 4A on the BI-RADS scale, 24 (72.7%) were assigned to the same category, 5 (15.2%) increased the category to 4B, 4 (12.1%) — to category 4C, respectively, after obtaining a three-dimensional image during tomosynthesis. Calcification was the dominant pathological sign in 31 (93.9%) of 33 patients from the category 4A group. Generalized image evaluation data for digital mammography and tomosynthesis on the BI-RADS (forced) scale are listed in Table. 3. Despite minor improvements in the diagnosis of calcifications during DBT, these studies show a noticeable improvement in the diagnosis of such pathological signs as asymmetry/density, violation of architectonics and volumetric formations.

Discussion. Signs of malignancy in breast cancer can be classified as volumetric formation, focal asymmetry, violation of architectonics and microcalcinates. A clearer image of the boundaries and edges of the formation helps to interpret the result of the study more definitely. In previous studies, it was concluded that the shape and edges of the volumetric formation were visualized better during tomosynthesis than with DM. Thus, if the volume formation has slightly undulating or poorly defined outlines, during tomosynthesis, their image does not overlap with normal breast tissue and can be clearly visible on a thin slice. Our study confirmed that 58.8% of images

of such a pathological sign as volumetric formation received a higher score during tomosynthesis than when performing digital mammography alone. Focal asymmetric density was detected on approximately 3% of mammograms. A review of the literature showed that malignant tumors can be detected in 0-14% of cases by biopsy of areas of breast asymmetry, and any signs of possible malignancy or clinically palpable volumetric formation requires examination of breast tissue. Nevertheless, in the presence of such a sign as focal asymmetric breast density, it is not always possible to determine its boundaries well on a 2D mammogram, which makes the diagnosis of a malignant tumor difficult. And although the focal density asymmetry on DBT is represented as an implicit formation, its boundaries and dimensions are definable. Due to this, it can be easily distinguished from a section of normal breast tissue. In other words, a 5 mm formation can be detected on five slices of adjacent tissue sections with a thickness of 1 mm, even if it is represented as a focal asymmetry. In our study, when interpreting 83.3% of the DBT images with focal density were evaluated as improved compared to DM images, and 85.2% of the images changed the category on the BI-RADS scale from 0 to 4 or 5. On mammograms, the mammary gland looks like a textured image due to the presence of linear structures such as ligaments, ducts and vessels. A tumor, inflammation, injury, or surgery can change the normal architectonics of tissues. In addition, overlaying images of dense fibroglandular breast tissue can significantly reduce the visualization of suspicious changes. It is known that in 12-45% of cases with breast cancer, such a sign as a violation of architectonics is not determined or is incorrectly interpreted during screening mammography and was the main pathological sign that gives a false negative result. Since the false negative result in violation of architectonics is mainly associated with the layering of tissue images, DBT has proved to be an encouraging method to solve this problem. In our study, when interpreting 94.4% of DBT images with a violation of architectonics, they were rated as improved compared to DM images, all images changed the category on the BI-RADS scale from 0 to 4 or 5. Our study also showed that the accuracy of the diagnosis of uncalcified formations on mammograms with tomosynthesis has significantly improved, 78.2% of the images of the original 0 category on the BI-RADS scale (with DM) remained the same or increased to 4B and higher.The reason is that in patients of this group, microcalcifications were mainly a pathological sign (93.9%). The clinical advantages of tomosynthesis in the presence of calcified formations can be further discussed due to the fact that they are not clearly visualized. However, as the thickness of the slice increases, the ability to perceive the three-dimensional (3D) configuration of calcinates will increase, and the area of microcalcinate distribution will be better displayed on a DBT than on a two-dimensional mammogram. Nevertheless, the values of diagnostic efficiency values (as measured area under the curve using the BI-RADS scale) did not differ significantly. Other studies have also supported the diagnostic effectiveness of digital tomosynthesis — both in combination with full-format digital mammography and without it.

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