AI AND DIGITALIZATION IN HISTOPATHOLOGICAL DIAGNOSTICS OF BREAST CANCER: MODERN APPROACHES AND PROSPECTS

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Introduction : *Breast cancer is one of the most common and dangerous oncological diseases in women worldwide. Early and accurate diagnosis (usually biopsy or surgical material) is the key to successful treatment and improved prognosis. Histopathological examination of tissues remains the "gold standard" for confirming the diagnosis and determining prognostic factors. In recent years, digital technologies and artificial intelligence (AI) have been actively introduced into this area, opening up new opportunities to improve the accuracy and speed of diagnosis.*

Briefly about the disease itself :

Breast cancer is a malignant neoplasm that develops from the epithelial cells of the ducts or lobules of the mammary gland. Histopathology allows us to accurately determine the type of tumor, its degree of malignancy, prognostic markers (e.g. hormone receptors and HER2/ neu), the level of invasion and other key parameters that affect treatment and prognosis.

Materials and methods

Modern laboratories increasingly use high-precision scanners to digitize histological sections, which allows for the creation of digital archives and remote consultations. Neural networks are trained on large databases of labeled images, which makes it possible to automatically recognize tumor cells, assess their prevalence and other important indicators, such as the degree of differentiation and the presence of receptors.

Using digital scanners to obtain high-quality images of microscopic specimens (Whole Slide Imaging).

Training and application of neural network models for automatic recognition of pathological structures - tumor cells, invasive foci, assessment of the degree of differentiation.

Analysis of prognostic markers (e.g. estrogen receptors, progesterone receptors, HER2) using digital immunostaining and AI.

Comparison of the results of automatic analysis with the conclusions of experienced pathologists .

How is a tumor examined?

1. Source material

Objects of study : biopsy and surgical material from patients with confirmed or suspected diagnosis of breast cancer.

Histological preparations : stained with the standard hematoxylin and eosin (H&E) method; for some - immunohistochemical markers (ER, PR, HER2, Ki-67).

Storage format : glass and/or digital images in WSI (Whole Slide Imaging).

2. Digitization of micropreparations

High resolution scanners are used (eg Leica , 3DHISTECH, Hamamatsu).

The resulting images are saved in digital format, allowing them to be viewed on a computer, scaled and analyzed automatically.

3. Application of artificial intelligence

Algorithms used : convolutional neural networks (CNN) trained on labeled datasets .

Programs and platforms : Google AutoML , Aiforia , PathAI , QuPath (open platform), IBM Watson Pathology and others.

AI functions :

Isolation of tumor cells and normal tissue,

Recognition of structures (tubules , mitoses, nuclear polymorphism),

Ki-67 count, HER2 assessment.

4. Comparison and validation

Comparison of AI results with pathologist's assessment :

A "blind" evaluation of the same drugs is carried out.

Analysis of accuracy, sensitivity and specificity (AUC, accuracy in %).

Statistical methods : t-test, ROC analysis, agreement coefficient (κ-Kappa).

Results and discussion

AI systems demonstrate high accuracy (up to 95%) in recognizing tumor cells and assessing the degree of invasion.

Automated analysis allows to significantly reduce the processing time of biopsy materials.

AI helps standardize the assessment of receptor expression, reducing subjectivity and interobserver variability.

Digital platforms help improve educational programs for students and young doctors by providing access to extensive databases of virtual drugs with annotations.

Histological grading (according to the Nottingham / Elston-Ellis system):

Three parameters are assessed:

Tubular differentiation,

Nuclear polymorphism,

Mitotic activity.

Each parameter is given a score from 1 to 3. The sum gives the degree of malignancy:

G1 (low) - 3-5 points,

G2 (average) - 6-7 points,

G3 (high) – 8–9 points.

Immunohistochemistry (IHC):

It is very important for choosing therapy:

Marker	Meaning
ER (estrogen) and PR (progesterone)	Hormone dependence of tumors
HER2/ neu	Relevant for targeted therapy (Herceptin , etc.)
Ki-67	Proliferative activity (the higher, the more aggressive)
p53, E- cadherin , etc.	Additional markers

Conclusion

The introduction of digital technologies and artificial intelligence in histopathological diagnostics of breast cancer is a promising direction that can improve the quality of diagnostics, accelerate clinical decision-making and improve the training of specialists. These technologies are already helping to transform approaches to the detection and treatment of one of the most serious oncological diseases.

Histopathology is the main method for verifying breast cancer.

Determination of the type, degree and receptor status is the basis for choosing treatment.

Digital technologies and AI enhance accuracy, speed up analysis and make diagnostics more objective.